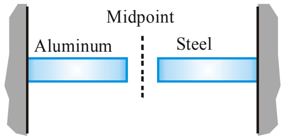
# SOLVED EXAMPLES

**Ex.1** The figure shows two thin rods, one made of aluminum [$\alpha = 23 \times 10^{-6}\ (C°)^{-1}$] and the other of steel [$\alpha = 12 \times 10^{-6}\ (C°)^{-1}$]. Each rod has the same length and the same initial temperature. They are attached at one end to two separate immovable walls. Temperature of both the rods is increased by the same amount, until the gap between the rods vanishes. Where do the rods meet when the gap vanishes?



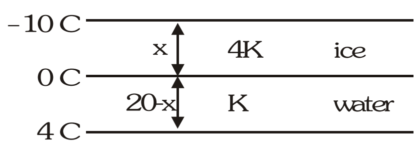

**(A)** The rods meet exactly at the midpoint.
**(B)** The rods meet to the right of the midpoint .
**(C)** The rods meet to the left of the midpoint.
**(D)** Information insufficient

**Sol.** As $\alpha_{A\ell} > \alpha_{steel}$ so expansion in aluminum rod is greater.

**Ex.2** In a 20m deep lake, the bottom is at a constant temperature of 4°C. The air temperature is constant at –10°C. The thermal conductivity of ice is 4 times that water. Neglecting the expansion of water on freezing, the maximum thickness of ice will be

**(A)** $\frac{20}{11}$ m **(B)** $\frac{200}{11}$ m **(C)** 20 m **(D)** 10 m

**Sol.** The rate of heat flow is the same through water and ice in the steady state so




$$\frac{KA(4-0)}{20-x} = \frac{4KA[0-(-10)]}{x} \Rightarrow x = \frac{200}{11} m$$

**Ex.3** Certain perfect gas is found to obey $PV^n$ = constant during adiabatic process. The volume expansion coefficient at temperature T is

**(A)** $\frac{1-n}{T}$ **(B)** $\frac{1}{(1-n)T}$ **(C)** $\frac{n}{T}$ **(D)** $\frac{1}{nT}$

**Sol.** $PV^n$ = constant & $PV = \mu RT$ $V \propto T^{\left(\frac{1}{1-n}\right)}$ $\Rightarrow \frac{\Delta V}{V} = \left(\frac{1}{1-n}\right)\frac{\Delta T}{T}$

$\Rightarrow$ volume expansion coefficient $= \frac{\Delta V}{V\Delta T} = \frac{1}{(1-n)T}$

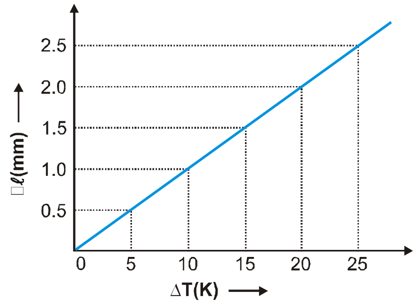
**Ex.4** The temperature of a body rises by 44°C when a certain amount of heat is given to it. The same heat when supplied to 22 g of ice at – 8°C, raises its temperature by 16°C. The water eqivalent of the body is
[Given : $s_{water}$ = 1 cal/g°C & $L_f$ = 80 cal/g, $s_{ice}$ = 0.5 cal/g°C]
**(A)** 25g **(B)** 50 g **(C)** 80 g **(D)** 100 g

**Sol.** Supplied heat = (22) (0.5) (8) + (22) (80) + (22) (1) (16) = 88 + 1760 + 352 = 2200 cal

Heat capacityof the body = $\frac{2200\ cal}{44\ C}$ = 50 cal/°C

Water equavalent of the body = $\frac{\text{Heat capacity of the body}}{\text{spcific heat capacity of water}} = \frac{50\ cal/\ C}{1\ cal/g\ C} = 50g$

**Ex.5** Figures shows the expansion of a 2m long metal rod with temperature. The volume expansion coefficient of the metal is :–




**(A)** $3 \times 10^{-4}\ K^{-1}$ **(B)** $1.5 \times 10^{-4}\ K^{-1}$ **(C)** $3 \times 10^{-5}\ K^{-1}$ **(D)** $1.5 \times 10^{-5}\ K^{-1}$

**Sol.** $\because\ \alpha = \frac{\Delta\ell}{\ell\Delta T} = \frac{0.5 \times 10^{-3}}{2(5)} = 5 \times 10^{-5}\ K^{-1} \Rightarrow \gamma = 3\alpha = 1.5 \times 10^{-4}\ K^{-1}$

**Ex.6** A refrigerator converts 100 g of water at 25°C into ice at – 10°C in one hour and 50 minutes. The quantity of heat removed per minute is (specific heat of ice = 0.5 cal/g°C, latent heat of fusion = 80 cal/g)

**(A)** 50 cal **(B)** 100 cal **(C)** 200 cal **(D)** 75 cal

**Sol.** Heat removed in cooling water from 25°C to 0°C = 100 × 1 × 25 = 2500 cal

Heat removed in converting water into ice at 0°C = 100 × 80 = 8000 cal

Heat removed in cooling ice from 0° to –15°C = 100 × 0.5 × 10 = 500 cal

Total heat removed in1 hr 50min = 2500 + 8000 + 500 = 11000 cal

Heat removed per minute $= \frac{11000}{110} = 100$ cal/min

**Ex.7** 540 g of ice at 0°C is mixed with 540 g of water at 80°C. The final temperature of the mixture is

*(Given latent heat of fusion of ice = 80 cal/g and specific heat capacity of water = 1 cal/g$^0$C)*

**(A)** 0°C **(B)** 40°C **(C)** 80°C **(D)** less than 0°C

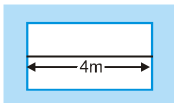
**Sol.** Heat taken by ice to melt at 0°C is $Q_2 = mL = 540 \times 80 = 43200$ cal

Heat given by water to cool upto 0°C is $Q_2 = ms\Delta\theta = 540 \times 1 \times (80–0) = 43200$ cal

Hence heat given by water is just sufficient to melt the whole ice and final temperature of mixture is 0°C.

**Ex.8** A fine steel wire of length 4m is fixed rigidly in a heavy brass frame as shown in figure. It is just taut at 20°C. The tensile stress developed in steel wire if whole system is heated to 120°C is :–

(Given $\alpha_{brass} = 1.8 \times 10^{-5}\ °C^{-1}$, $\alpha_{steel} = 1.2 \times 10^{-5}\ °C^{-1}$, $Y_{steel} = 2 \times 10^{11}\ Nm^{-2}$, $Y_{brass} = 1.7 \times 10^{7}\ Nm^{-2}$)




**(A)** $1.02 \times 10^{4}\ Nm^{-2}$ **(B)** $1.2 \times 10^{8}\ Nm^{-2}$ **(C)** $1.2 \times 10^{6}\ Nm^{-2}$ **(D)** $6 \times 10^{8}\ Nm^{-2}$

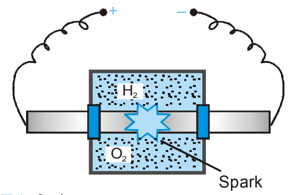
**Sol.** Stress = Y (strain) $= Y_S(\alpha_b – \alpha_s)\Delta T = (2 \times 10^{11})\ (0.6 \times 10^{-5})\ (100) = 1.2 \times 10^{8}\ Nm^{-2}$

**Ex.9** 5n, n and 5n moles of a monoatomic, diatomic and non-linear polyatomic gases (which do not react chemically with each other) are mixed at room temperature. The equivalent degree of freedom for the mixture is-

**(A)** $\frac{25}{7}$ **(B)** $\frac{48}{11}$ **(C)** $\frac{52}{11}$ **(D)** $\frac{50}{11}$

**Sol.** $f_{eq} = \frac{f_1 n_1 + f_2 n_2 + f_3 n_3}{n_1 + n_2 + n_3} = \frac{(5n)(3) + (n)(5) + (5n)(6)}{5n + n + 5n} = \frac{50}{11}$

**Ex.10** A vessel contains 14 g (7 moles) of hydrogen and 96 g (3 moles) of oxygen at STP. Chemical reaction is induced by passing electric spark in the vessel till one of the gases is consumed. The temperature is brought back to it's starting value 273 K. The pressure in the vessel is-



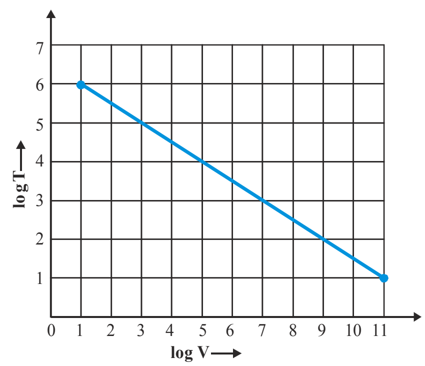

**(A)** 0.1 atm **(B)** 0.2 atm **(C)** 0.3 atm **(D)** 0.4 atm

**Sol.** When electric spark is passed, hydrogen reacts with oxygen to form water ($H_2O$). Each gram of hydrogen reacts with eight grams of oxygen. Thus 96 g of oxygen will be totally consumed together with 12 g of hydrogen.

The gas left in thevessel will be 2g of hydrogen i.e. number of moles $\mu = \frac{2}{2} = 1$ .

Using $PV = \mu RT \Rightarrow P \propto \mu \; \frac{P_2}{P_1} = \frac{\mu_2}{\mu_1} \Rightarrow \frac{P_2}{1} = \frac{1}{10} \Rightarrow P_2 = 0.1 atm$

**Ex.11** Figure shows the adiabatic curve on log–log scale performed on a ideal gas. The gas must be :–




**(A)** Monoatomic **(B)** Diatomic

**(C)** A mixture of monoatomic and diatomic **(D)** A mixture of diatomic and polyatomic

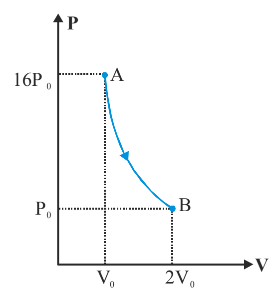
**Sol.** For adiabatic process $TV^{\gamma-1}$ = constant

$\Rightarrow \log T + (\gamma-1) \log V = \text{constant} \Rightarrow \text{slope} = -(\gamma-1) = -\left(\frac{5}{10}\right) \Rightarrow \gamma = \frac{3}{2}$

For monoatomic gas $\gamma = \frac{5}{3}$; For diatomic gas $\gamma = \frac{7}{5}$ As $\frac{7}{5} < \gamma = \frac{3}{2} < \frac{5}{3}$

Hence, the gas must be a mixture of monoatomic & diatomic gas.

**Ex.12** Figure demonstrates a polytropic process (i.e. $PV^n$ = constant) for an ideal gas. The work done by the gas will be in process AB is




**(A)** $\frac{15}{2}P_0V_0$ **(B)** $\frac{14}{3}P_0V_0$ **(C)** $8P_0V_0$ **(D)** Insufficient information

**Sol.** For a polytropic process $PV^n$ = constant $\Rightarrow 16P_0V_0^n = P_0(2V_0)^n \Rightarrow n = 4$

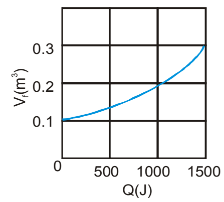
Work done $= \frac{P_1V_1 - P_2V_2}{n-1} = \frac{16P_0V_0 - P_0(2V_0)}{4-1} = \frac{14}{3}P_0V_0$

**Ex.13** The respective speeds of five molecules are 2,1.5,1.6,1.6 and 1.2 km/s. The most probable speed in km/s will be

**(A)** 2 **(B)** 1.58 **(C)** 1.6 **(D)** 1.31

**Sol.** Since maximum number of molecules travel with speed 1.6 km/s so $v_{mp}$ = 1.6 km/s

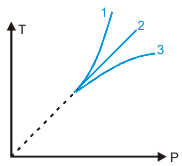
**Ex.14** Suppose 0.5 mole of an ideal gas undergoes an isothermal expansion as energy is added to it as heat Q. Graph shows the final volume $V_f$ versus Q. The temperature of the gas is (use $\ell n$ 9 = 2 and R= 25/3 J/mol-K)




**(A)** 293 K **(B)** 360 K **(C)** 386 K **(D)** 412 K

**Sol.** $Q = W = nRT\,\ell n\,\dfrac{V_f}{V_i}$ ; $T = \dfrac{Q}{nR\ell nV_f/V_i} = \dfrac{1500}{0.5\times 25/3\times \ell n3} = \dfrac{1500}{0.5\times 25/3\times 1} = 360K$

**Ex.15** Given T–P curve for three processes. If initial and final pressure are same for all processes then work done in process 1, 2 and 3 is $W_1$, $W_2$ & $W_3$ respectively. Correct order is




**(A)** $W_1 < W_2 > W_3$ **(B)** $W_1 > W_2 > W_3$ **(C)** $W_1 < W_2 < W_3$ **(D)** $W_1 = W_2 = W_3$

**Sol.** Here $T \propto P^n$ where for : graph-1, n >1 $\Rightarrow$ W > 0 ; graph-2, n =1 $\Rightarrow$ W = 0; graph-3, n <1 $\Rightarrow$ W < 0

**Ex.16** When water is boiled at 2 atm pressure, the latent heat of vaporization is 2.2 × $10^6$ J/kg and the boiling point is 120°C. At 2 atm pressure, 1 kg of water has volume of $10^{-3}$ $m^3$ and 1 kg of steam has a volume of 0.824 $m^3$. The increase in internal energy of 1 kg of water when it is converted into steam at 2 atm pressure and 120°C is [1 atm pressure = 1.013 × $10^5$ N/$m^2$]

**(A)** 2.033 J **(B)** 2.033 × $10^6$ J **(C)** 0.167 × $10^6$ J **(D)** 2.267 × $10^6$ J

**Sol.** Total heat given to correct convert water into steam at 120 °C is Q = mL = 1 × 2.2 × $10^6$ = 2.2 × $10^6$ J

The work done by the system against the surrounding is

$P\Delta V = 2\times 1.013\times 10^5(0.824\times 0.001) = 0.167\times 10^6$ J $\therefore$ $\Delta U = Q - W = 2.033\times 10^6$ J

**Ex.17** The acceleration of a particle moving rectilinearly varies with displacement as a = – 4x. At x =4 m and t =0, particle is at rest. Select the **incorrect** alternative

**(A)** The maximum speed of the particle is 8 m/s.

**(B)** The distance travelled by the particle in first second is 20 m.

**(C)** The velocity - acceleration graph of the particle is an ellipse.

**(D)** The kinetic energy-displacement graph of the particle is a parabola.

**Sol.** The equation shows a SHM : $a = -\omega^2 x \Rightarrow \omega = \sqrt{4} = 2 \Rightarrow$ Time period $= \dfrac{2\pi}{\omega} = \pi\sec$ $\therefore$ $x = A\sin(\omega t + \phi)$

From the given condition, $A = 4$ & $\phi = \dfrac{\pi}{2}$ ; $V_{P_{max}} = A\omega = 8m/s$

Distance travelled in first second < 2A or < 8 m

$KE = \dfrac{1}{2}m\omega^2\left(A^2 - x^2\right)$ which represent a parabola.

**Ex.18** One mole of an ideal gas undergoes a process whose molar heat capacity is 4R and in which work done by gas for small change in temperature is given by the relation dW = 2RdT, then the ratio $\frac{C_P}{C_V}$ is

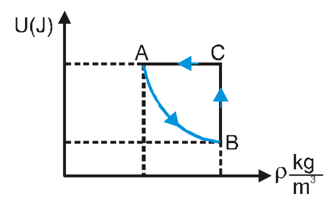
**(A)** 7/5 **(B)** 5/3 **(C)** 3/2 **(D)** 2

**Sol.** For small change dQ = dU + dW

$nCdT = nC_V dT + 2nRdT \therefore C = C_V + 2R; 4R = C_V + 2R \quad \therefore C_V = 2R$

Also $C_V = \frac{R}{\gamma - 1} \therefore \frac{R}{\gamma - 1} = 2R \Rightarrow 2\gamma - 2 = 1 \Rightarrow \gamma = \frac{3}{2}$

**Ex.19** Figure shows the variation of the internal energy U with density ρ of one mole of an ideal monatomic gas for thermodynamic cycle ABCA. Here process AB is a part of rectangular hyperbola :-




**(A)** process AB is isothermal & net work in cycle is done by gas.

**(B)** process AB is isobaric & net work in cycle is done by gas.

**(C)** process AB is isobaric & net work in cycle is done on the gas.

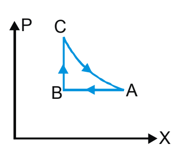
**(D)** process AB is adiabatic & net work in cycle is done by gas.

**Sol.** For the process AB : Uρ = constant (hyperbola)

$U = \frac{3}{2}RT$ (monoatomic ideal gas); $\frac{3}{2}\rho RT$ = constant

Comparing it with ideal gas equation $P = \left(\frac{1}{M}\right)\rho RT \Rightarrow$ P is constant.

P-V graph for the cycle is




. Thus work done in cycle is positive

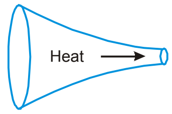
**Ex.20** A gas undergoes an adiabatic process in which pressure becomes $\left(\frac{8}{3\sqrt{3}}\right)$ times and volume become $\frac{3}{4}$ of initial volume. If initial absolute temperature was T, the final temperature is

**(A)** $\frac{32T}{9\sqrt{3}}$ **(B)** $\frac{2T}{\sqrt{3}}$ **(C)** $T^{3/2}$ **(D)** $\frac{\sqrt{3}T}{2}$

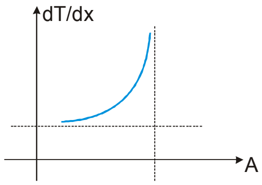
**Sol.** For adiabatic process, $P_1V_1^{\gamma} = P_2V_2^{\gamma} \Rightarrow P_0V_0^{\gamma} = \left(\frac{8}{3\sqrt{3}}P_0\right)\left(\frac{3}{4}V_0\right)^{\gamma}$ ......**(i)**

Also, $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1} \Rightarrow TV_0^{\gamma-1} = T_2\left(\frac{3}{4}V_0\right)^{\gamma-1}$ ...**(ii)** Solving **(i)** & **(ii)**, $T_2 = \frac{2T}{\sqrt{3}}$

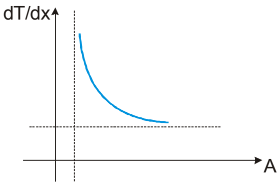
**Ex.21** An irregular rod of same uniform material as shown in figure is conducting heat at a steady rate. The temperature gradient at various sections versus area of cross section graph will be



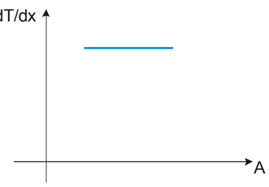

**(A)**



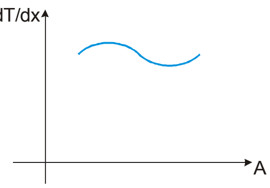

**(B)**




**(C)**



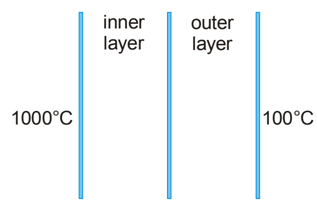

**(D)**




**Sol.** $H = KA\frac{dT}{dx}$ is same in steady state condition, $\therefore$ $A\frac{dT}{dx}$ = constant $\therefore$ rectangular hyperbolic graph

**Ex.22** The temperature drop through a two layer furnace wall is 900°C. Each layer is of equal area of cross–section. Which of the following action(S) will result in lowering the temperature $\theta$ of the interface?

**(A)** By increasing the thermal conductivity of outer layer.
**(B)** By increasing the thermal conductivity of inner layer.
**(C)** By increasing thickness of outer layer.
**(D)** By increasing thickness of inner layer.

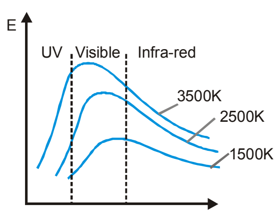



**Sol.** Rate of heat flow $\frac{K_iA(1000-\theta)}{\ell_i} = \frac{K_0A(\theta-100)}{\ell_0} \Rightarrow \frac{\theta-100}{900} = \frac{1}{1+\frac{K_0\ell_i}{K_i\ell_0}}$

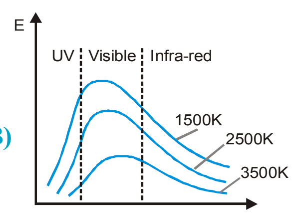
Now, we can see that $\theta$ can be decreased by increasing thermal conductivity of outer layer ($K_o$) and thickness of inner layer ($\ell_i$).

**Ex.23** Which of the following graph(S) shows the correct variation in intensity of heat radiations by black body and frequency at a fixed temperature–

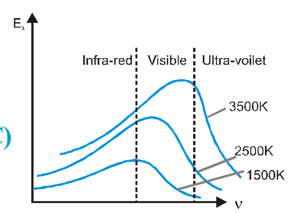
**(A)**



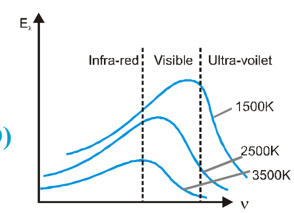

**(B)**




**(C)**




**(D)**



**Sol.** According to Wien's law $\lambda_m \propto \frac{1}{T} \Rightarrow \nu_m \propto T$. As the temperature of body increases, frequency corresponding to maximum energy in radiation ($\nu_m$) increases.

Also area under the curve $\int E_\lambda d\lambda \propto \int E_\nu d\nu \propto T^4$

**Ex.24** Water contained in a jar at room temperature (20°C) is intended to be cooled by method-I or method-II given below:

**Method -I :** By placing ice cubes and allowing it to float.

**Method-II :** By wrapping ice cubes in a wire mesh and allowing it to sink.

Choose best method(S) to cool the water.

**(A)** Method-I from 20°C to 4°C
**(B)** Method-I from 4°C to 0°C
**(C)** Method-II from 20°C to 4°C
**(D)** Method-II from 4°C to 0°C

**Sol.** Initially (above 4°C), a decrease in temperature, increases the density of water and consequently it descends, replacing the relatively warm water. Convention currents set up in this way demands the location of ice to be on the water surface.

Below 4°C, a decrease in temperature decreases the water density and as a result it ascends up displacing the relatively warm water. To setup convention currents in this way, the position of ice cubes should be at the bottom.

**Ex.25** 5 kg of steam at 100°C is mixed with 10 kg of ice at 0°C. Choose correct alternative/s

(Given $s_{water}$ = 1 cal/g°C, $L_F$ = 80 cal/g, $L_V$ = 540 cal/g)

**(A)** Equilibrium temperature of mixture is 160°C

**(B)** Equilibrium temperature of mixture is 100°C

**(C)** At equilibrium, mixture contains $13\frac{1}{3}$ kg of water

**(D)** At equilibrium, mixture contains $1\frac{2}{3}$ kg of steam

**Sol.** Required heat — Available heat

10 kg ice (0°C) — 5 kg steam (100°C)

↓ 800 kcal — ↓ 2700 cal

10 g water (0°C) — 5 g water (100°C)

↓ 1000 kcal

10 g water (100°C)

So available heat is more than required heat therefore final temperature will be 100°C.

Mass of heat condensed $= \frac{800+1000}{540} = \frac{10}{3}$ kg. Total mass of water $= 10 + \frac{10}{3} = \frac{40}{3} = 13\frac{1}{3}$ kg

Total mass of steam $= 5 - \frac{10}{3} = \frac{5}{3} = 1\frac{2}{3}$ kg

**Ex.26** n moles of an ideal triatomic linear gas undergoes a process in which the temperature changes with volume as $T = k_1V^2$ where $k_1$ is a constant. Choose correct alternative(S).

**(A)** At normal temperature $C_v = \frac{5}{2}R$

**(B)** At any temperature $C_p - C_v = R$

**(C)** At normal temperature molar heat capacity C = 3R

**(D)** At any temperature molar heat capacity C=3R

**Sol.** At normal temperature $C_v = \frac{f}{2}R = \frac{5}{2}R$ ; At any temperature $C_p - C_v = \left(\frac{f}{2}+1\right) - \frac{f}{2}R = R$

from process $T = k_1V^2$ & ideal gas equation PV = nRT we have $PV^{-1}$ = constant $\Rightarrow$ x =–1

$\Rightarrow C = C_V + \frac{R}{1-x} = C_V + \frac{R}{1+1} = C_V + \frac{R}{2}$ At normal temperature $C = \frac{5}{2}R + \frac{R}{2} = 3R$

**Ex.27** Which of the following processes must violate the first law of thermodynamics ($Q = W + \Delta E_{int}$)?

**(A)** $W > 0, Q < 0$ and $\Delta E_{int} > 0$

**(B)** $W > 0, Q < 0$ and $\Delta E_{int} < 0$

**(C)** $W < 0, Q > 0$ and $\Delta E_{int} < 0$

**(D)** $W > 0, Q > 0$ and $\Delta E_{int} < 0$

**Sol.** **For (A) :** $W > 0$ & $\Delta E_{int} > 0 \Rightarrow Q > 0$ **For (B) :** $W > 0$ & $\Delta E_{int} < 0 \Rightarrow Q > 0$ or $Q < 0$

**For (C) :** $W < 0$ & $\Delta E_{int} < 0 \Rightarrow Q < 0$ **For (D) :** $W > 0$ & $\Delta E_{int} < 0 \Rightarrow Q > 0$ or $Q < 0$

**Ex.28** An ideal gas expands in such a way that $PV^2$ = constant throughout the process. Select correct alternative

**(A)** This expansion is not possible without heating

**(B)** This expansion is not possible without cooling

**(C)** Internal energy remains constant in this expansion

**(D)** Internal energy increases in this expansion

**Sol.** PV = nRT & $PV^2$ = constant $\Rightarrow V \propto \frac{1}{T}$ $\Rightarrow$ gas can expand only if it cools

As tempeature decreases during expansion so internal energy will decrease.

**Ex.29** In Newton's law of cooling, $\frac{d\theta}{dt} = -k(\theta - \theta_0)$, the constant k is proportional to

**(A)** A, surface area of the body

**(B)** S, specific heat of the body

**(C)** $\frac{1}{m}$, m being mass of the body

**(D)** e, emissivity of the body

**Sol.** $\frac{dQ}{dt} = e\sigma A\left(\theta^4 - \theta_0^4\right) \approx \left(3e\sigma A\theta_0^3\right)\Delta\theta$

$\frac{dQ}{dt} = e\sigma A\left(\theta^4 - \theta_0^4\right) \approx \left(3e\sigma A\theta_0^3\right)\Delta\theta$

**Ex.30** In a process on a closed system of ideal gas, the initial pressure and volume is equal to the final pressure and volume

**(A)** initial internal energy must be equal to the final internal energy

**(B)** the work done on the system is zero

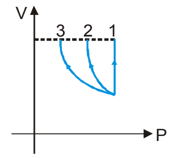
**(C)** the work done by the system is zero

**(D)** the initial temperature must be equal to final temperature

**Sol.** Here n = constant so if $P_2 = P_1$ and $V_2 = V_1$ then $T_2 = T_1$

Also work done by the system may be zero or may not be zero.

**Ex.31** The graph below shows V-P curve for three processes. Choose the correct statement(s)




**(A)** Work done is maximum in process 1.

**(B)** Temperature must increase in process 2 & 3.

**(C)** Heat must be supplied in process 1.

**(D)** If final volume of gas in process 1, 2 and 3 are same then temperature must be same.

**Sol.** Area under P-V curve and volume axis represent work.

Internal energy in 1 increases (expansion at constant pressure)

In process 2 and 3 internal energy may decrease depending on the process.

Since final pressure of 1, 2 & 3 are different, final temperature must also be different.

**Ex.32** During an experiment, an ideal gas is found to obey a condition $\frac{P^2}{\rho}$ = constant [ρ=density of the gas]. The gas is initially at temperature T, pressure P and density ρ. The gas expands such that density changes to $\frac{\rho}{2}$

**(A)** The pressure of the gas changes to $\sqrt{2}P$

**(B)** The temperature of the gas changes to $\sqrt{2}T$.

**(C)** The graph of the above process on the P-T diagram is parabola.

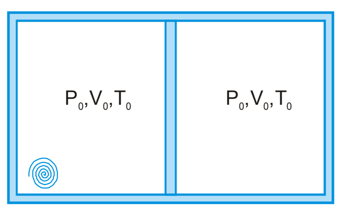
**(D)** The graph of the above process on the P-T diagram is hyperbola.

**Sol.** PV = nRT

$P \propto \rho T$ .....**(i)** $\quad T \propto \frac{1}{\sqrt{\rho}}$ ...**(ii)** $\quad T \propto \frac{1}{\sqrt{\rho}}$ ....**(iii)**

**Ex.33 to 35**

One mole of a monoatomic ideal gas occupies two chambers of a cylinder partitioned by means of a movable piston. The walls of the cylinder as well as the piston are thermal insulators. Initially equal amounts of gas fill both the chambers at ($P_0$, $V_0$, $T_0$). A coil is burnt in the left chamber which absorbs heat and expands, pushing the piston to the right. The gas on the right chamber is compressed until to pressure becomes 32 $P_0$.




**33.** The final volume of left chamber is

**(A)** $\frac{V_0}{8}$ **(B)** $\frac{15}{8}V_0$ **(C)** $\frac{7}{8}V_0$ **(D)** $\frac{9}{8}V_0$

**34.** The work done on the gas in the right chamber is

**(A)** $\frac{9}{2}P_0V_0$ **(B)** $-\frac{9}{2}P_0V_0$ **(C)** $\frac{13}{2}P_0V_0$ **(D)** $\frac{17}{2}P_0V_0$

**35.** The change in internal energy of the gas in the left chamber is

**(A)** $\frac{186}{4}RT_0$ **(B)** $\frac{177}{4}RT_0$ **(C)** $\frac{59}{2}RT_0$ **(D)** $\frac{131}{4}RT_0$

**Sol.**

**33.** Since the compression on the right is adiabatic so $P_0V_0^{\gamma} = P_RV_R^{\gamma}$

$$\Rightarrow P_0V_0^{5/3} = 32P_0V_R^{5/3} \Rightarrow V_R = \frac{V_0}{8} \Rightarrow V_L = V_0 + \frac{7}{8}V_0 = \frac{15}{8}V_0$$

**34.** Work done on the gas $= \dfrac{P_RV_R - P_0V_0}{\gamma - 1} = \dfrac{4P_0V_0 - P_0V_0}{5/3 - 1} = \dfrac{9}{2}P_0V_0$

**35.** For mechanical equilibrium $P_L = P_R = 32\ P_0$

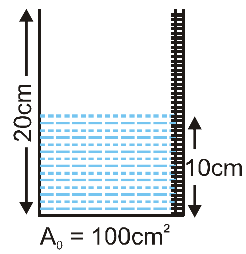
So $P_LV_L = (32P_0)\left(\dfrac{15V_0}{8}\right) = 60P_0V_0 = 60nRT_0 = nRT_L \Rightarrow T_L = 60T_0$

The change in the internal energy of the gas in the left chamber

$$\Delta U = nC_V\Delta T = \frac{1}{2}\times\frac{3}{2}R\times 59T_0 = \frac{177}{4}RT_0$$

**Ex.36 to 38**

At 20°C a liquid is filled upto 10 cm height in a container of glass of length 20 cm and cross-sectional area 100 cm² Scale is marked on the surface of container. This scale gives correct reading at 20°C. Given $\gamma_L = 5\times10^{-5}\ k^{-1}$, $\alpha_g = 1\times10^{-5}\ °C^{-1}$




**36.** The volume of liquid at 40°C is :–

**(A)** 1002 cc **(B)** 1001 cc **(C)** 1003 cc **(D)** 1000.5 cc

**37.** The actual height of liquid at 40°C is-

**(A)** 10.01 cm **(B)** 10.006 cm **(C)** 10.6 cm **(D)** 10.1 cm

**38.** The reading of scale at 40°C is-

**(A)** 10.01 cm **(B)** 10.004 cm **(C)** 10.006cm **(D)** 10.04 cm

**Sol.**

**36.** $V = V_0(1+\gamma_L\Delta T) = (10)(100)[1 + 5\times10^{-5}\times 20] = 1000(1 + 0.001) = 1001\ cm^3 = 1001$ cc

**37.** Cross sectional area of vessel at 40°C

$A = A_0(1 + 2\alpha_g\Delta T) = 100(1 + 2\times10^{-5}\times 20) = 100.04\ cm^2$

Actual height of liquid $= \dfrac{\text{Actual volume of liquid}}{\text{cross}-\text{sectional area of vessel}} = \dfrac{1001}{100.04} = (1001)(100 + 0.04)^{-1}$

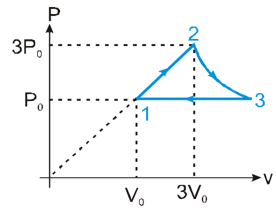
$$= \left(\frac{1001}{100}\right)\left(1+\frac{0.04}{100}\right)^{-1} = \frac{(1001)}{100}\left(1-\frac{0.04}{100}\right) = \frac{1}{100}(1001 - 0.4) = 10.006\ \text{cm}$$

**38.** $\because TV = SR(1 + \alpha_g\Delta T) = (TV)(1 - \alpha_g\Delta T)$

$\therefore SR = (TV)(1 + \alpha g\,\Delta T)^{-1} = (10.006)(1 - 10^{-5}\times 20) = 10.006 - 0.002 = 10.004$ c

**Ex.39 to 41**

One mole of an ideal monoatomic gas undergoes a cyclic process as shown in figure. Temperature at point 1 = 300 K and process 2-3 is isothermal.




**39.** Net work done by gas in complete cycle is

**(A)** $(9\ell n3+12)P_0V_0$ **(B)** $(9\ell n3+4)P_0V_0$

**(C)** $(9\ell n3-4)P_0V_0$ **(D)** $(9\ell n3-8)P_0V_0$

**40.** Heat capacity of process $1 \to 2$ is

**(A)** $\frac{R}{2}$ **(B)** $\frac{3R}{2}$

**(C)** $\frac{5R}{2}$ **(D)** 2R

**41.** The efficiency of cycle is

**(A)** $\left(\frac{9\ell n3+4}{9\ell n3+12}\right)$ **(B)** $\left(\frac{9\ell n3-4}{9\ell n3+12}\right)$ **(C)** $\left(\frac{9\ell n3-4}{9\ell n3+16}\right)$ **(D)** $\left(\frac{9\ell n3+12}{9\ell n3+16}\right)$

**Sol.**

**39.** $W = W_{12} + W_{23} + W_{31} = \frac{1}{2}(4P_0)(2V_0) + nRT\ell n(3) - P_0(8V_0) = -4P_0V_0 + 9P_0V_0\ell n3 = (9\ell n3-4)P_0V_0$

**40.** $C = \frac{\Delta Q}{n\Delta T} = \frac{n\left(\frac{3R}{2}.\Delta T\right) + \Delta W}{n\Delta T} = \frac{3R}{2} + \frac{4P_0V_0}{n\Delta T} = \frac{3R}{2} + \frac{P_0V_0}{n(2T_0)} = \frac{3R}{2} + \frac{R}{2} = 2R$

$\Delta Q_{123} = n(2R)(\Delta T_{12}) + (W_{23}) = n(2R)(8T_0) + nR(9T_0)\ell n(3) = nRT_0(16+9\ell n3)$

**41.** $\eta = \frac{W}{\Delta Q_{123}} = \left(\frac{9\ell n3-4}{9\ell n3+16}\right)$

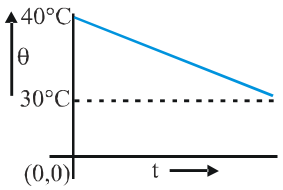
**Ex.42 to 44**

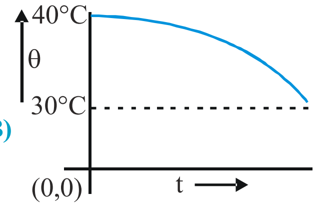
A body cools in a surrounding of constant temperature 30°C. Its heat capacity is 2J/°C. Initial temperature of the body is 40°C. Assume Newton's law of cooling is valid. The body cools to 36°C in 10 minutes.

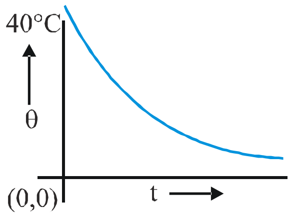
**42.** In further 10 minutes it will cool from 36°C to :

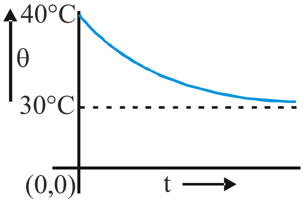
**(A)** 34.8°C **(B)** 32.1°C **(C)** 32.8°C **(D)** 33.6°C

**43.** The temperature of the body in °C denoted by θ the variation of θ versus time t is best denoted as

**(A)**



**(B)**



**(C)**



**(D)**



**44.** When the body temperature has reached 36°C, it is heated again so that it reaches to 40°C in 10 minutes. Assume that the rate of loss of heat at 38°C is the average rate of loss for the given time. The total heat required from a heater by the body is :

**(A)** 7.2 J  **(B)** 0.728 J  **(C)** 16 J  **(D)** 32 J

**Sol.**

**42.** $\frac{40-36}{10} = k(38-30)$ and $\frac{36-x}{10} = k\left(\frac{36+x}{2} - 30\right)$ $x = 33.6$

**43.** $\frac{d\theta}{dt} = -\frac{kA}{ms}(T - T_0)$ Magnitude of slope will decrease with time.

**44.** $\because \frac{40-36}{10} = k\ (38-30) \Rightarrow k = \frac{4}{10 \times 8} = \frac{1}{20}$

when the block is at 38°C and room temperature is at 30°C the rate of heat loss $ms \times \frac{d\theta}{dt} = ms\,k\,(38-30)$

Total heat loss in 10 minute $\Rightarrow \Delta Q = ms\,k\,(38-30) \times 10 = 2 \times \frac{1}{20} \times 8 \times 10 = 8\text{ J}$

Now heat agained by the object in the said 10 minutes. $Q = ms\,\Delta\theta = 2 \times 4 = 8\text{ J}$

Total heat required $= 8 + 8 = 16$ J

**Ex.45** An ideal gas whose adiabatic exponent equals to $\gamma = \frac{7}{5}$ is expanded according to the law P=2V. The initial volume of the gas is equal to $V_0$= 1 unit. As a result of expansion the volume increases 4 times. (Take $R = \frac{25}{3}$ units)

| | Column - I | | Column - II |
|---|---|---|---|
| **(A)** | Work done by the gas | **(P)** | 25 units |
| **(B)** | Increment in internal energy of the gas | **(Q)** | 45 units |
| **(C)** | Heat supplied to the gas | **(R)** | 75 units |
| **(D)** | Molar heat capacity of the gas in the process | **(S)** | 15 units |
| | | **(T)** | 55 units |

**Sol.** **Ans. (A) → (S); (B) → (R); (C) → (Q); (D) → (P)**

$$W = \int PdV = \int_{V_0}^{4V_0} 2VdV = \left(V^2\right)_{V_0}^{4V_0} = 15V_0^2 = 15 \text{ units}$$

From $PV = nRT,\ 2V^2 = nRT \Rightarrow 2\left(V_2^2 - V_1^2\right) = nR(\Delta T) \Rightarrow nR\Delta T = 30V_0^{\,2}$

$$\Delta U = nC_V\Delta T = \frac{nR}{\gamma - 1}\Delta T = \frac{30V_0^2}{\gamma - 1} = \frac{30(1)^2}{\frac{7}{5} - 1} = \frac{30}{2}(5) = 75 \text{ units}$$

$Q = W + \Delta U = 15 + 30 = 45$ units

Molar heat capacity : $C = C_V + \frac{R}{1 - x} = \frac{5}{2}R + \frac{R}{1 - (-1)} = \frac{5}{2}R + \frac{R}{2} = 3R = 3 \times \frac{25}{3} = 25$ units

**Ex.46**

| | Column I (Questions) | | Column II (Answers) |
|---|---|---|---|
| **(A)** | The temperature of an iron piece is increased from 20° to 70°. What is change in its temperature on the Fahrenheit scale (in °F)? | **(P)** | 20 |
| **(B)** | At what temperature (in °C) do the Celsius and Fahrenheit readings have the same numerical value? | **(Q)** | 40 |
| **(C)** | 100 g ice at 0°C is converted into steam at 100 °C. Find total heat required (in kcal) ($L_f = 80$ cal/g, $s_w = 1$ cal/g°C, $L_v = 540$ cal/g) | **(R)** | – 40 |
| **(D)** | A ball is dropped on a floor from a height of 5 m. After the collision it rises upto a height of 3m. Assume that 50% of the mechanical energy lost goes as thermal energy into the ball. Calculate the rise in temperature (in milli centigrade) of the ball in the collision. ($s_{ball} = 500$ J/K, $g = 10$ m/s$^2$) | **(S)** | 72 |
| | | **(T)** | 90 |

**Sol.** **Ans.(A) → (S); (B) → (R); (C) → (T); (D) → (P)**

**(A)** $\frac{C - 0}{100} = \frac{F - 32}{180} \Rightarrow \Delta F = \frac{9}{5}\Delta C = \frac{9}{5} \times 50 = 90°F$

**(B)** $\frac{x - 0}{100} = \frac{x - 32}{180}$ $x = -40$

**(C)** Total heat required $= mL_f + ms\Delta\theta + mL_v = 72000$ cal $= 72$ kcal

**(D)** $ms\Delta\theta = \frac{50}{100} \times mg\left(h_1 - h_2\right) \Rightarrow \Delta\theta = \frac{1}{50}°C = 20 \times 10^{-3}°C$

**Ex.47** In an industrial process 10 kg of water per hour is to be heated from 20°C to 80°C . To do this steam at 150°C is passed from a boiler into a copper coil immersed in water. The steam condenses in the coil and is returned to the boiler as water at 90°C. How many kg of steam is required per hour.

(Specific heat of steam = specific heat of water = 1 cal/g°C, Latent heat of vaporisation = 540 cal/g)

**Sol.** Suppose m kg steam is required per hour

Heat is released by steam in following three steps

**(i)** When 150°C steam $\xrightarrow{Q_1}$ 100°C steam $\quad Q_1 = mc_{steam}\,\Delta\theta = m \times 1\,(150–100) = 50$ m cal

**(ii)** When 100°C steam $\xrightarrow{Q_2}$ 100°C water $\quad Q_2 = mL_v = m\times 540 = 540$ m cal

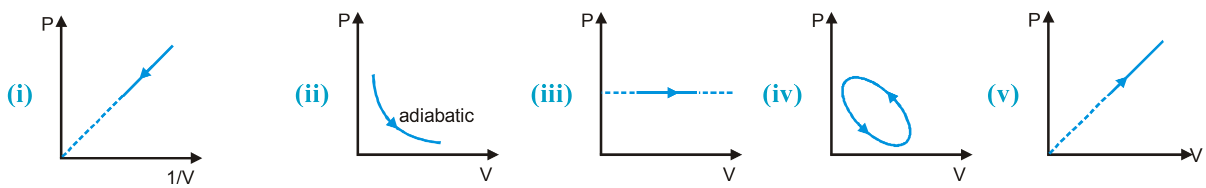
**(iii)** When 100 °C water $\xrightarrow{Q_2}$ 90°C water $\quad Q_3 = mc_W\Delta\theta = m \times 1 \times (100 – 90) = 10$ m cal

Hence total heat given by the steam $\quad Q = Q_1 + Q_2 + Q_3 = 600$ m cal ....(i)

Heat taken by 10 kg water $\quad Q' = mc_W\Delta\theta = 10 \times 10^3 \times 1 \times (80 – 20) = 600 \times 10^3$ cal

Hence $Q = Q' \Rightarrow 600\,m = 600 \times 10^3 \Rightarrow m = 10^3$ gm = 1 kg

**Ex.48** The figure given below show different process for a given amount for an ideal gas. W is work done by the system and ΔQ is heat absorbed by the system.




| | Column-I | | Column-II |
|---|---|---|---|
| **(A)** | $\Delta Q > 0$ | **(P)** | In figure **(i)** |
| **(B)** | $W < 0$ | **(Q)** | In figure **(ii)** |
| **(C)** | $\Delta Q < 0$ | **(R)** | In figure **(iii)** |
| **(D)** | $W > 0$ | **(S)** | In figure **(iv)** |
| | | **(T)** | In figure **(v)** |

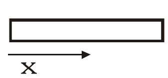
**Sol.** figure **(i)** $P \propto \dfrac{1}{V} \Rightarrow PV = \text{constant}$

Isothermal (T = constant), so $\Delta U = 0$

$\dfrac{1}{V}$ is decreasing; So V is increasing hence, $\Delta W > 0$

$\Delta Q = \Delta U + \Delta W = \Delta W > 0$

**Ex.49** A rod has variable co-efficient of linear expansion $\alpha = \dfrac{x}{5000}$. If length of the rod is 1m. Determine increase in length of the rod in (cm) on increasing temperature of the rod by 100°C.



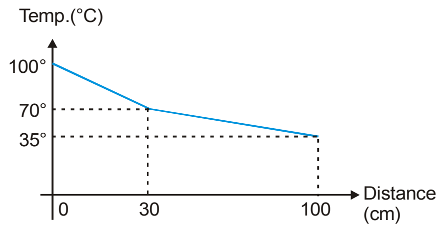

**Sol.** Increase in length of dx $= \mapsto \ell_0 \lambda T = \left(\dfrac{x}{5000}\right)(dx)(100) = \dfrac{x}{50}dx$

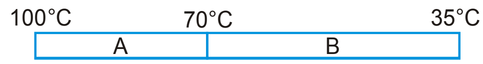
$$\text{Total thermal expansion} = \int_0^1 \frac{x}{50}dx = \left(\frac{x^2}{100}\right)_0^1 = \frac{1}{100}m = 1cm$$

**Ex.50** The specific heat of a metal at low temperatures varies according to $S = (4/5)T^3$ where T is the absolute temperature. Find the heat energy needed to raise unit mass of the metal from T = 1 K to T = 2 K.

**Sol.** $Q = \int mSdT = \dfrac{mT^4}{5} \Rightarrow \dfrac{Q}{m} = \dfrac{15}{5} = 3$

**Ex.51** Two different rods A and B are kept as shown in figure.



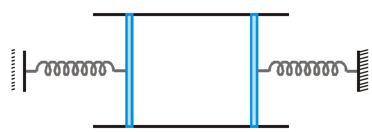

The variation of temperature of different cross sections is plotted in a graph shown in figure. Find the ratio of thermal conductivities of B to A.

**Sol.** $\because \left(\frac{\Delta Q}{\Delta t}\right)_A = \left(\frac{\Delta Q}{\Delta t}\right)_B \;\therefore\; \frac{K_A A(100-70)}{30} = \frac{K_B A(70-35)}{70} \Rightarrow K_A = \frac{K_B}{2} \Rightarrow \frac{K_B}{K_A} = 2$

**Ex.52** A clock pendulum made of invar has a period of 2 s at 20°C. If the clock is used in a climate where average temperature is 40°C, what correction (in seconds) may be necessary at the end of 10 days to the time given by clock ? ($\alpha_{invar} = 7 \times 10^{-7}$ °C$^{-1}$, 1 day = $8.64 \times 10^4$ s)

**Sol.** $T = 2\pi\sqrt{\frac{\ell}{g}} \Rightarrow \frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta \ell}{\ell} = \frac{1}{2}\alpha\Delta\theta \Rightarrow \Delta T = \frac{T}{2}(\alpha\Delta\theta) = \left(\frac{10 \times 8.64 \times 10^4}{2}\right)(7 \times 10^{-7})(20) = 6 \text{ s}$

**Ex.53** A cylinder of cross-section area A has two pistons of negligible mass separated by distances $\ell$ loaded with spring of negligible mass. An ideal gas at temperature $T_1$ is in the cylinder where the springs are relaxed. When the gas is heated by some means its temperature becomes $T_2$ and the springs get compressed by $\frac{\ell}{2}$ each. If $P_0$ is atmospheric pressure and spring constant $k = \frac{2P_0A}{\ell}$, then find the ratio of $T_2$ and $T_1$.



**Sol.** $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ where $V_1 = \ell A$ and $V_2 = 2\ell A$ and $P_1 = P_0$ and $P_2 = \frac{kx}{A} + P_0 = 2P_0 \Rightarrow \frac{T_2}{T_1} = \frac{P_2V_2}{P_1V_1} = 4$

**Ex.54** A body cools from 50°C to 49.9°C in 5 sec. It cools from 40°C to 39.9°C in t sec. Assuming Newtons law of cooling to be valid and temperature of surrounds at 30°C, value of t/5 will be?

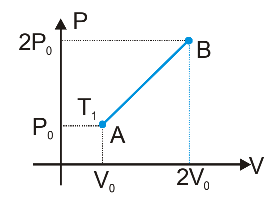
**Sol.** From $\frac{\theta_1 - \theta_2}{t} = k\left(\frac{\theta_1 + \theta_2}{2} - \theta_0\right)$

We have $\frac{0.1}{5} = k\left(\frac{39.5}{2}\right)$ and $\frac{0.1}{t} = k\left(\frac{19.5}{2}\right) \Rightarrow \frac{t}{5} = \frac{39.5}{19.5} = 2 \Rightarrow t = 10 \Rightarrow \frac{t}{5} = 2$

**Ex.55** One mole of a gas is taken from state A to state B as shown in figure.

Work done by the gas is $\alpha \times 10^{\beta}$ J. Find the value of $\alpha + \beta$.

(Given : $T_1$=320 K, R= $\frac{25}{3}$)



**Sol.** Work done = $\frac{1}{2}[P_0 + 2P_0][2V_0 - V_0] = \frac{3}{2}P_0V_0$

and $P_0V_0 = R \times 320$

So work done $\frac{3}{2} \times R \times 320 = \frac{3}{2} \times \frac{25}{3} \times 320 = 4000J = 4 \times 10^3 J \Rightarrow \alpha + \beta = 4 + 3 = 7$

**Ex.56** A vessel contains 1 mole of $O_2$ gas (molar mass 32) at a temperature T. The pressure of the gas is P. An identical vessel containing one mole of He gas (molar mass 4) at a temperature 2T has a pressure of xP. Find the value of x.

**Sol.** PV = nRT, V is constant

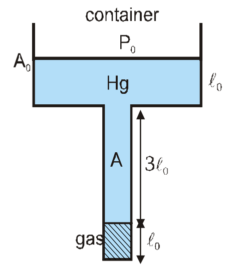
**Ex.57** The relation between internal energy U, pressure P and volume V of a gas in an adiabatic process is: U=a+bPV where a = b = 3. Calculate the greatest integer of the ratio of specific heats [$\gamma$].

**Sol.** For an adiabatic process, dQ=dU+PdV =0

$\Rightarrow$ d[a+bPV] + PdV=0 $\Rightarrow$ bPdV + bV dP + PdV = 0 $\Rightarrow$ (b + 1)PdV+bV dP=0 $\Rightarrow (b+1)\frac{dV}{V} + b\frac{dP}{P} = 0$

$\Rightarrow$ (b+1)logV + b logP= constant; $V^{b+1}P^b$=constant $\Rightarrow PV^{\frac{b+1}{b}}$ = constant $\quad \therefore \gamma = \frac{b+1}{b} = \frac{4}{3} = 1.33$

**Ex.58** A container having base area $A_0$. Contains mercury upto a height $\ell_0$. At its bottom a thin tube of length $4\ell_0$ and cross-section area A (A<<$A_0$) having lower end closed is attached. Initially the length of mercury in tube is $3\ell_0$. In remaining part 2 mole of a gas at temperature T is closed as shown in figure. Determine the work done (in joule) by gas if all mercury is displaced from tube by heating slowly the gas in the rear end of the tube by means of a heater. (Given : density of mercury = $\rho$, atmospheric pressure $P_0 = 2\ell_0\rho g$, $C_V$ of gas = 3/2 R, A= $(3/\rho)m^2$, $\ell_0$ = (1/9) m, all units in S.I.)




**Sol.** If x is length of mercury in tube then pressure of gas

$P' = P_0 + \rho g\ell_0 + \rho gx = 3\rho g\ell_0 + \rho gx \Rightarrow W = -\int_{3\ell_0}^{0}(3\rho g\ell_0 + \rho gx)Adx = 13.5\ \rho gA\ell_0^2 = 5$

**Ex.59** One mole of a monoatomic gas is enclosed in a cylinder and occupies a volume of 4 liter at a pressure 100 N/m$^2$. It is subjected to a process T = $\alpha V^2$, where $\alpha$ is a positive constant, V is volume of the gas and T is Kelvin temperature. Find the work-done by gas (in joule) in increasing the volume of gas to six times initial volume.

**Sol.** $W = \int PdV$ where $P = \frac{nRT}{V} = \alpha nRV \Rightarrow W = n\alpha R\int_{V_0}^{6V_0} VdV = \frac{n\alpha R}{2}\left[(6V_0)^2 - (V_0)^2\right]$

$\Rightarrow W = \frac{h\alpha R}{2}(35)V_0^2 = \frac{P_0V_0 \times 35}{2}\left(\because \alpha = \frac{P_0}{nRV_0}\right)$

**Ex.60** One mole of an ideal monatomic gas undergoes the process $P = \alpha T^{1/2}$, where $\alpha$ is constant. If molar heat capacity of the gas is $\beta R$ when R = gas constant then find the value of $\beta$.

**Sol.** $P \propto T^{1/2}$ and $PV = nRT \Rightarrow PV^{-1} = \text{constant}$ $\therefore$ $C = C_V + \dfrac{R}{1-(-1)} = \dfrac{3R}{2} + \dfrac{R}{2} = 2R$

**Ex. 61** Two identical metal plates are welded end to end as shown in figure-(i). 20 cal of heat flows through it in 4 minutes. if the plates are welded as shown in figure-(ii), find the time (in minutes) taken by the same amount of heat to flow through the plates.

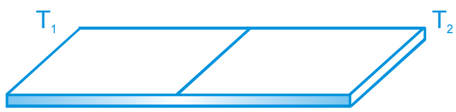


Fig. (i)

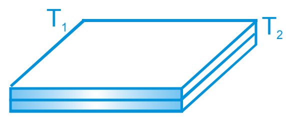


Fig. (ii)

**Sol.** Rate of heat flow $\dfrac{\Delta Q}{\Delta t} = \dfrac{kA\left(T_1 - T_2\right)}{\ell} \Rightarrow \Delta t \propto \dfrac{\ell}{A}$

**Ex. 62** Two taps A and B supply water at temperatures 10º and 50° C respectively. Tap A alone fills the tank in 1 hour and tap B alone fills the tank in 3 hour. If we open both the taps together in the empty tank, if the final temperature of the water in the completely filled tank is found to be $5\alpha$ (in °C). Find the value of $\alpha$. Neglect loss of heat to surrounding and heat capacity of the tank.

**Sol.** $m(T-10)\,s = \dfrac{m}{3} S(50 - T) \Rightarrow T = 20°$

# Exercise # 1

**[Single Correct Choice Type Questions]**

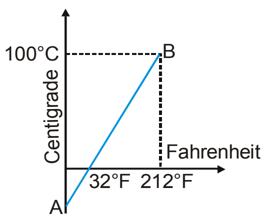
**1.** A centigrade and a Fahrenheit thermometer are dipped in boiling water. The water temperature is lowered until the Fahrenheit thermometer registers 140°F What is the temperature as registered by the centigrade thermometer :–

**(A)** 30° **(B)** 40° **(C)** 60° **(D)** 80°

**2.** On an X temperature scale, water freezes at –125.0° X and boils at 375.0° X. On a Y temperature scale, water freezes at –70.0° Y and boils at –30.0° Y. The value of temperature on X–scale equal to the temperature of 50.0°Y on Y–scale is :–

**(A)** 455.0°X **(B)** –125.0°X **(C)** 1375.0°X **(D)** 1500.0°X

**3.** The graph AB shown in figure is a plot of temperature of a body in degree Celsius and degree Fahrenheit. Then :–




**(A)** Slope of line AB is 9/5

**(B)** Slope of line AB is 5/9

**(C)** Slope of line AB is 1/9

**(D)** slope of line AB is 3/9

**4.** A faulty thermometer reads freezing point and boiling point of water as –5°C and 95°C respectively. What is the correct value of temperature as it reads 60°C on faulty thermometer?

**(A)** 60°C **(B)** 65°C **(C)** 64°C **(D)** 62°C

**5.** Two absolute scales X and Y assigned numerical values 200 and 450 to the triple point of water. What is the relation between $T_X$ and $T_Y$ ?

**(A)** $9T_X = 4T_Y$ **(B)** $4T_X = 9T_Y$ **(C)** $T_X = 3T_Y$ **(D)** None of these

**6.** At 4°C, 0.98 of the volume of a body is immersed in water. The temperature at which the entire body gets immersed in water is (neglect the expansion of the body) $(\gamma_w = 3.3 \times 10^{-4} K^{-1})$ :–

**(A)** 40.8°C **(B)** 64.6°C **(C)** 60.6°C **(D)** 58.8°C

**7.** A meter washer has a hole of diameter $d_1$ and external diameter $d_2$, where $d_2=3d_1$. On heating, $d_2$ increases by 0.3%. Then $d_1$ will :–

**(A)** decrease by 0.1% **(B)** decrease by 0.3% **(C)** increase by 0.1% **(D)** increase by 0.3%.

**8.** A steel scale is to be prepared such that the millimeter intervals are to be accurate within $6 \times 10^{-5}$ mm. The maximum temperature variation during the ruling of the millimeter marks is ($\alpha=12\times10^{-6}C^{-1}$):–

**(A)** 4.0°C **(B)** 4.5°C **(C)** 5.0°C **(D)** 5.5°C.

**9.** Two metal rods of the same length and area of cross–section are fixed ends to end between rigid supports. The materials of the rods have Young moduli $Y_1$ and $Y_2$, and coefficients of linear expansion $\alpha_1$ and $\alpha_2$. When rods are cooled the junction between the rods does not shift if:–

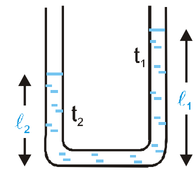
**(A)** $Y_1\alpha_1 = Y_2\alpha_2$ **(B)** $Y_1\alpha_2 = Y_2\alpha_1$ **(C)** $Y_1\alpha^2_1 = Y_2\alpha^2_2$ **(D)** $Y^2_1\alpha_1 = Y^2_2\alpha_2$

**10.** A brass disc fits simply in a hole of a steel plate. The disc from the hole can be loosened if the system ($\alpha_{brass} > \alpha_{steel}$)

**(A)** First heated then cooled  **(B)** First cooled then heated

**(C)** Is heated  **(D)** Is cooled

**11.** In a vertical U–tube containing a liquid, the two arms are maintained at different temperatures, $t_1$ and $t_2$. The liquid columns in the two arms have heights $\ell_1$ and $\ell_2$ respectively. The coefficient of volume expansion of the liquid is equal to:–




**(A)** $\frac{\ell_1 - \ell_2}{\ell_2 t_1 - \ell_1 t_2}$  **(B)** $\frac{\ell_1 - \ell_2}{\ell_1 t_1 - \ell_2 t_2}$  **(C)** $\frac{\ell_1 + \ell_2}{\ell_2 t_1 + \ell_1 t_2}$  **(D)** $\frac{\ell_1 + \ell_2}{\ell_1 t_1 + \ell_2 t_2}$

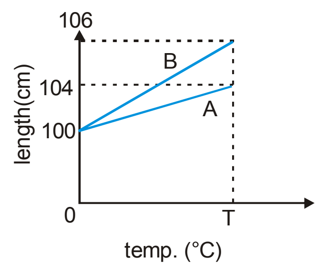
**12.** A steel rod of length 1 m is heated from 25°C to 75°C keeping its length constant. The longitudinal strain developed in the rod is:– (Given : Coefficient of linear expansion of steel = 12 x $10^{-6}$/°C)

**(A)** $6 \times 10^{-6}$  **(B)** $-6 \times 10^{-5}$  **(C)** $-6 \times 10^{-4}$  **(D)** zero

**13.** A steel tape is placed around the earth at the equator when the temperature is 10°C. What will be the clearance between the tape and the ground (assumed to be uniform) if the temperature of the tape rises to 40°C ? Neglect expansion of the earth. Radius of earth at equator is 6400 km & $\alpha_{steel} = 1.2 \times 10^{-5}$ K$^{-1}$

**(A)** 2.3 m  **(B)** 2.1 m  **(C)** 2.3 km  **(D)** 230 m

**14.** The variation of lengths of two metal rods A and B with change in temperature is shown in figure. The ratio of $\frac{\alpha_A}{\alpha_B}$ is:–

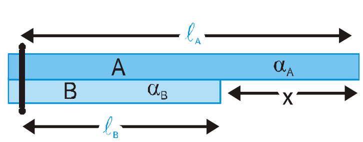



**(A)** $\frac{3}{2}$  **(B)** $\frac{2}{3}$  **(C)** $\frac{4}{3}$  **(D)** $\frac{3}{4}$

**15.** A metal rod A of length $\ell_0$ expands by $\Delta\ell$ when its temperature is raised by 100°C. Another rod B of different metal of length $2\ell_0$ expands by $\Delta\ell/2$ for same rise in temperature. A third rod C of length $3\ell_0$ is made up of pieces of rods A and B placed end to end expands by $2\Delta\ell$ on heating through 100 K. The length of each portion of the composite rod is:–

**(A)** $\frac{5}{3}\ell_0, \frac{4}{3}\ell_0$  **(B)** $\ell_0, 2\ell_0$  **(C)** $\frac{3\ell_0}{2}, \frac{3\ell_0}{2}$  **(D)** $\frac{2}{3}\ell_0, \frac{7}{3}\ell_0$

**16.** Bars of two different metals are bolted together, as shown in figure. The distance x does not change with temperature if:–




**(A)** $\frac{\ell_A}{\ell_B} = \frac{\alpha_A}{\alpha_B}$  **(B)** $\frac{\ell_A}{\ell_B} = \frac{\alpha_B}{\alpha_A}$  **(C)** $\frac{\ell_A^2}{\ell_B^2} = \frac{\alpha_A}{\alpha_B}$  **(D)** $\frac{\ell_A^2}{\ell_B^2} = \frac{\alpha_B}{\alpha_A}$

**17.** The coefficient of linear expansion 'α' of a rod of length 2m varies with the distance x from the end of the rod as $\alpha = \alpha_0 + \alpha_1 x$ where $\alpha_0 = 1.76 \times 10^{-5}\ °C^{-1}$ and $\alpha_1 = 1.2 \times 10^{-6} m^{-1}\ °C^{-1}$. The increase in the length of the rod, when heated through 100°C is:–

**(A)** 2cm **(B)** 3.76mm **(C)** 1.2 mm **(D)** None of these

**18.** A clock with a metallic pendulum gains 6 seconds each day when the temperature is 20°C and loses 6 second when the temperature is 40°C. Find the coefficient of linear expansion of the metal.

**(A)** $1.4 \times 10^{-5}\ °C^{-1}$ **(B)** $1.4 \times 10^{-6}\ °C^{-1}$ **(C)** $1.4 \times 10^{-4}\ °C^{-1}$ **(D)** $0.4 \times 10^{-6}\ °C^{-1}$

**19.** The coefficient of linear expansion α of the material of a rod of length $\ell_0$ varies with absolute temperature as $\alpha = aT - bT^2$ where a & b are constants. The linear expansion of the rod when heated from $T_1$ to $T_2 = 2T_1$ is:–

**(A)** $\left(\frac{3}{2}aT_1^2 - \frac{7b}{3}T_1^3\right)L_0$ **(B)** $\left(4a - \frac{7b}{3}\right)T_1 L_0$ **(C)** $\left(2aT_1^2 - \frac{7b}{3}T_1^3\right)L_0$ **(D)** None of these

**20.** The coefficient of apparent expansion of a liquid when determined using two different vessels A and B are $\gamma_1$ and $\gamma_2$ respectively. If the coefficient of linear expansion of the vessel A is $\alpha_1$, the coefficient of linear expansion of the vessel B is:–

**(A)** $\frac{\alpha_1\gamma_1\gamma_2}{\gamma_1 + \gamma_2}$ **(B)** $\frac{\gamma_1 - \gamma_2}{2\alpha_1}$ **(C)** $\frac{\gamma_1 + \gamma_2 + \alpha}{3}$ **(D)** $\frac{\gamma_1 - \gamma_2 + 3\alpha_1}{3}$

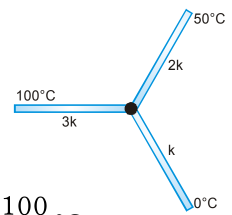
**21.** A steel scale measures the length of a copper rod as $\ell_0$ when both are at 20°C, which is the calibration temperature for the scale. The scale reading when both are at 40°C, is:–

**(A)** $(1 + 20\alpha_C)\ell_0$ **(B)** $(1 + 20\alpha_S)\ell_0$ **(C)** $\left(\frac{1 + 20\alpha_S}{1 + 20\alpha_C}\right)\ell_0$ **(D)** $\left(\frac{1 + 20\alpha_C}{1 + 20\alpha_S}\right)\ell_0$

**22.** A cup of tea cools from 80°C to 60°C in one minute. The ambient temperature is 30°C. In cooling from 60°C to 50°C. It will take :–

**(A)** 50 s **(B)** 90 s **(C)** 60 s **(D)** 48 s

**23.** Three rods of the same dimensions have thermal conductivities 3k, 2k and k. They are arranged as shown, with their ends at 100°C, 50°C and 0°C. The temperature of their junction is:–




**(A)** 75°C **(B)** $\frac{200}{3}$°C **(C)** 40°C **(D)** $\frac{100}{3}$°C

**24.** There is a small hole in a container. At what temperature should it be maintained in order that it emits one calorie of energy per second per $meter^2$ :–

**(A)** 10K **(B)** 500K **(C)** 200K **(D)** 100K

**25.** Ice starts forming in lake with water at 0°C when the atmospheric temperature is –10°C. If the time taken for 1 cm of ice be 7 hours, then the time taken for the thickness of ice to change from 1 cm to 2 cm is :–

**(A)** 7 hours **(B)** 14 hours **(C)** less than 7 hours **(D)** more than 7 hours

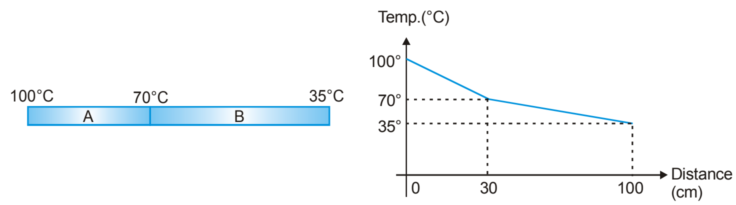
**26.** A blackened metallic foil is kept at a distance d from a spherical heater. The power absorbed by the foil is P. If the temperature of heater and distance both are doubled, then the power absorbed by the foil will be:–

**(A)** 8P **(B)** 4P **(C)** 2P **(D)** P

**27.** The area of cross–section of rod is given by $A = A_0(1 + \alpha x)$ where $A_0$ & $\alpha$ are constant and x is the distance from one end. If the thermal conductivity of the material is K, what is the thermal resistance of the rod if its length is $\ell_0$?

**(A)** $KA_0\alpha\,\ell n(1+\alpha\ell_0)$ **(B)** $\frac{1}{KA_0\alpha}\ell n(1+\alpha\ell_0)$ **(C)** $\frac{\alpha}{KA_0}\ell n(1+\alpha\ell_0)$ **(D)** $\frac{KA_0}{\alpha}\ell n(1+\alpha\ell_0)$

**28.** Two different rods A and B are kept as shown in figure. The variation of temperature of different cross sections with distance is plotted in a graph shown in figure. The ratio of thermal conductivities of A and B is-

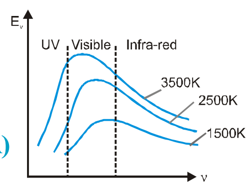


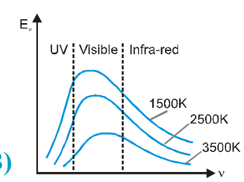

**(A)** 2 **(B)** 0.5 **(C)** 1 **(D)** 2/3

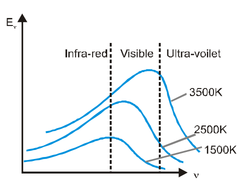
**29.** A red star and a green star radiate energy at the same rate which star is bigger.

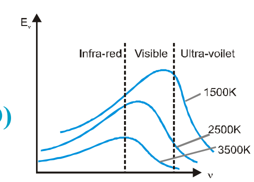
**(A)** Red **(B)** Green **(C)** Both have same size **(D)** Can't be say anything

**30.** Which of the following graph shows the correct variation in intensity of heat radiations by black body and frequency at a fixed temperature:–

**(A)**



**(B)**



**(C)**



**(D)**



**31.** Two identical masses of 5 kg each fall on a wheel from a height of 10m. The wheel disturbs a mass of 2 kg water, the rise in temperature of water will be :–

**(A)** 2.6° C **(B)** 1.2° C **(C)** 0.32° C **(D)** 0.12° C

**32.** 250 g of water and an equal volume of alcohol of mass 200 g are placed successively in the same calorimeter and cools from 60°C to 55°C in 130 sec and 67 sec respectively. If the water equivalent of the calorimeter is 10 g then the specific heat of alcohol in cal/g°C is :–

**(A)** 1.30 **(B)** 0.67 **(C)** 0.62 **(D)** 0.985

**33.** The weight of a person is 60 kg. If he gets 10 calories of heat through food and the efficiency of his body is 28%, then upto what height he can climb ? Take $g = 10\ m\ s^{-2}$

**(A)** 100 cm **(B)** 1.96 cm **(C)** 400 cm **(D)** 1000 cm

**34.** If $H_C$, $H_K$ and $H_F$ are heat required to raise the temperature of one gram of water by one degree in Celsius, Kelvin and Fahrenheit temperature scales respectively then :–

**(A)** $H_K > H_C > H_F$ **(B)** $H_F > H_C > H_K$ **(C)** $H_K = H_C > H_F$ **(D)** $H_K = H_C = H_F$

**35.** Hailstone at 0°C falls from a height of 1 km on an insulating surface converting whole of its kinetic energy into heat. What part of it will melt:– [$g = 10\ m/s^2$, $L_{ice} = 330 \times 10^3\ J\ kg^{-1}$]

**(A)** $\frac{1}{33}$ **(B)** $\frac{1}{8}$ **(C)** $\frac{1}{33} \times 10^{-4}$ **(D)** All of it will melt

**36.** Water is used to cool the radiators of engines in cars because :–

**(A)** of its low boiling point **(B)** of its high specific heat
**(C)** of its low density **(D)** of its easy availability

**37.** Steam at 100°C is passed through 1.1 kg of water contained in a calorimeter of water equivalent 0.02 kg at 15°C till the temperature of the calorimeter and its contents rises to 80°C. The mass of the steam condensed in kg is :–

**(A)** 0.130 **(B)** 0.065 **(C)** 0.260 **(D)** 0.135

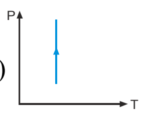
**38.** If the intermolecular forces vanish away, the volume occupied by the molecules contained in 4.5 kg. water at standard temperature and pressure will be given by :–

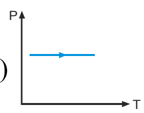
**(A)** 5.6 $m^3$ **(B)** 4.5 $m^3$ **(C)** 11.2 litre **(D)** 11.2 $m^3$

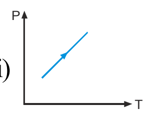
**39.** If mass–energy equivalence is taken into account, when water is cooled to form ice, the mass of water should:– (**Note :** The mass energy of an object is the energy equivalent of its mass, as given by $E = mc^2$, where m = mass of object & c = speed of light)

**(A)** increase **(B)** remain unchanged
**(C)** decrease **(D)** first increase then decrease

**40.** Pressure versus temperature graphs of an ideal gas are as shown in figure. Choose the wrong statement:–

(i)



(ii)


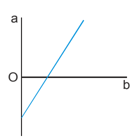

(iii)



**(A)** Density of gas is increasing in graph (i) **(B)** Density of gas decreasing in graph (ii)
**(C)** Density of gas is constant in graph (iii) **(D)** None of the above

**41.** A refrigerator converts 100 g of water at 25°C into ice at – 10°C in one hour and 50 minutes. The quantity of heat removed per minute is:– (Specific heat of ice = 0.5 cal/g°C, latent heat of fusion = 80 cal/g)

**(A)** 50 cal **(B)** 100 cal **(C)** 200 cal **(D)** 75 cal

**42.** The expansion of unit mass of a perfect gas at constant pressure is shown in the diagram. Here:–




**(A)** a = volume, b = °C temperature **(B)** a = volume, b = K temperature
**(C)** a = °C temperature, b = volume **(D)** a = K temperature, b = volume

**43.** In a process the density of a gas remains constant. If the temperature is doubled, then the change in the pressure will be:–

**(A)** 100 % increase **(B)** 200 % increase **(C)** 50 % decrease **(D)** 25 % decrease

**44.** One mole of an ideal gas undergoes a process $P = \frac{P_0}{1 + (V_0 / V)^2}$ Here $P_0$ and $V_0$ are constants. Change in temperature of the gas when volume is changed from $V = V_0$ to $V = 2V_0$ is :–

**(A)** $-\frac{2P_0V_0}{5R}$ **(B)** $\frac{11P_0V_0}{10R}$ **(C)** $-\frac{5P_0V_0}{4R}$ **(D)** $P_0V_0$

**45.** Air is filled at 60° C in a vessel of open mouth. The vessel is heated to a temperature T so that $\frac{1}{4}^{th}$ part of air escapes. The value of T is :–

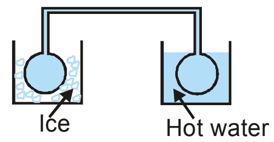
**(A)** 80° C **(B)** 444° C **(C)** 333° C **(D)** 171° C

**46.** A gas has volume V and pressure P. The total translational kinetic energy of all the molecules of the gas is:–

**(A)** $\frac{3}{2}$ PV only if the gas is monoatomic. **(B)** $\frac{3}{2}$ PV only if the gas is diatomic.

**(C)** $> \frac{3}{2}$ PV if the gas is diatomic. **(D)** $\frac{3}{2}$ PV in all cases.

**47.** Two identical glass bulbs are interconnected by a thin glass tube at 0°C. A gas is filled at N.T.P. in these bulb is placed in ice and another bulb is placed in hot bath, then the pressure of the gas becomes 1.5 times. The temperature of hot bath will be :–




**(A)** 100°C **(B)** 182°C **(C)** 256°C **(D)** 546°C

**48.** Four containers are filled with monoatomic ideal gases. For each container, the number of moles, the mass of an individual atom and the rms speed of the atoms are expressed in terms of n, m and $v_{rms}$ respectively. If $T_A$, $T_B$, $T_C$ and $T_D$ are their temperatures respectively then which one of the options correctly represents the order ?

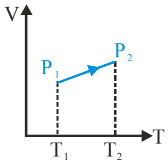
| | A | B | C | D |
|---|---|---|---|---|
| Number of moles | n | 3n | 2n | n |
| Mass | 4m | m | 3m | 2m |
| Rms speed | $v_{rms}$ | $2v_{rms}$ | $v_{rms}$ | $2v_{rms}$ |
| Temperature | $T_A$ | $T_B$ | $T_C$ | $T_D$ |

**(A)** $T_B = T_C > T_A > T_D$ **(B)** $T_D > T_A > T_C > T_B$ **(C)** $T_D > T_A = T_B > T_C$ **(D)** $T_B > T_C > T_A > T_D$

**49.** A mixture of $n_1$ moles of monoatomic gas and $n_2$ moles of diatomic gas has $\frac{C_P}{C_V} = \gamma = 1.5$ :–

**(A)** $n_1 = n_2$ **(B)** $2n_1 = n_2$ **(C)** $n_1 = 2n_2$ **(D)** $2n_1 = 3n_2$

**50.** From the following V–T diagram we can conclude:–




**(A)** $P_1 = P_2$ **(B)** $P_1 > P_2$

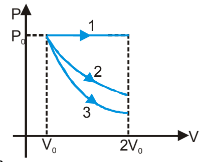
**(C)** $P_1 < P_2$ **(D)** Can't say anything

**51.** $10^{23}$ molecules of a gas strike a target of area 1 m² at angle 45° to normal and rebound elastically with speed 1 kms$^{-1}$. The impulse normal to wall per molecule is:– [Given : mass of molecule = $3.32 \times 10^{-27}$kg]

**(A)** $4.7 \times 10^{-24}$ kg ms$^{-1}$ **(B)** $7.4 \times 10^{-24}$ kg ms$^{-1}$

**(C)** $3.32 \times 10^{-24}$ kg ms$^{-1}$ **(D)** 2.33 kg ms$^{-1}$

**52.** A gas is expanded from volume $V_0$ to $2V_0$ under three different processes. Process 1 is isobaric process, process 2 is isothermal and process 3 is adiabatic. Let $\Delta U_1$, $\Delta U_2$ and $\Delta U_3$, be the change in internal energy of the gas is these processes. Then :–




**(A)** $\Delta U_1 > \Delta U_2 > \Delta U_3$ **(B)** $\Delta U_1 < \Delta U_2 < \Delta U_3$

**(C)** $\Delta U_2 < \Delta U_1 < \Delta U_3$ **(D)** $\Delta U_2 < \Delta U_3 < \Delta U_1$

**53.** The density in grams per litre of ethylene ($C_2H_4$) at STP is :–

**(A)** 1.25 **(B)** 2.50 **(C)** 3.75 **(D)** 5.25

**54.** For an ideal gas $PT^{11}$ = constant then volume expansion coefficient is equal to :–

(A) $\frac{11}{T}$ (B) $\frac{1}{T}$ (C) $\frac{12}{T}$ (D) $\frac{2}{T}$

**55.** Some of the thermodynamic parameters are state variables while some are process variables. Some grouping of the parameters are given. Choose the correct one.

(A) State variables : Temperature, No of moles
Process variables : Internal energy, work done by the gas.

(B) State variables : Volume, Temperature
Process variables : Internal energy, work done by the gas.

(C) State variables : Work done by the gas, heat rejected by the gas
Process variables : Temperature, volume.

(D) State variables : Internal energy, volume
Process variables : Work done by the gas, heat absorbed by the gas.

**56.** When water is heated from 0°C to 4°C and $C_P$ and $C_V$ are its specific heats at constant pressure and constant volume respectively, then :–

(A) $C_P > C_V$ (B) $C_P < C_V$ (C) $C_P = C_V$ (D) $C_P - C_V = R$

**57.** The internal energy of a gas is given by U = 5 + 2PV. It expands from $V_0$ to $2V_0$ against a constant pressure $P_0$. The heat absorbed by the gas in the process is :–

(A) $-3P_0V_0$ (B) $3P_0V_0$ (C) $2P_0V_0$ (D) $P_0V_0$

**58.** 5n, n and 5n moles of a monoatomic, diatomic and non-linear polyatomic gases (which do not react chemically with each other) are mixed at room temperature. The equivalent degree of freedom for the mixture is :–

(A) $\frac{25}{7}$ (B) $\frac{48}{11}$ (C) $\frac{52}{11}$ (D) $\frac{50}{11}$

**59.** The molar specific heat of the process $V \propto T^4$ for $CH_4$ gas at room temperature is:–

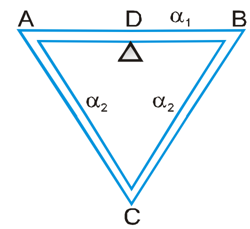
(A) 4R (B) 7R (C) 3R (D) 8R

**60.** The internal energy of a gas in an adiabatic process is given by U = a + bPV, find γ :–

(A) $\frac{a+1}{a}$ (B) $\frac{b+1}{b}$ (C) $\frac{b+1}{a}$ (D) $\frac{a}{b+1}$

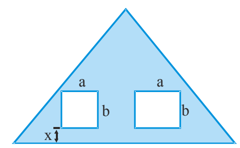
# Exercise # 2 Part # I [Multiple Correct Choice Type Questions]

**1.** Three rods of equal length are joined to form an equilateral triangle ABC.D is the midpoint of AB. The coefficient of linear expansion is $\alpha_1$ for AB, and $\alpha_2$ for AC and BC. If the distance DC remains constant for small changes in temperature:–




**(A)** $\alpha_1 = \alpha_2$ **(B)** $\alpha_1 = 2\alpha_2$ **(C)** $\alpha_1 = 4\alpha_2$ **(D)** $\alpha_1 = \frac{1}{2}\alpha_2$

**2.** A triangular plate has two cavities, one square and one rectangular as shown in figure. The plate is heated.




**(A)** a increase, b decrease **(B)** a and b both increase
**(C)** a and b increase, x and $\ell$ decrease **(D)** a, b, x and $\ell$ all increase

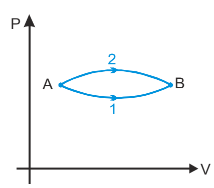
**3.** If water at 0°C, kept in a container with an open top, is placed in a large evacuated chamber:–
**(A)** All the water will vaporize.
**(B)** All the water will freeze.
**(C)** Part of the water will vaporize and the rest will freeze.
**(D)** Ice, water and water vapour will be formed and reach equilibrium at the triple point.

**4.** Which of the following statements is/are correct ?
**(A)** A gas has two specific heats only
**(B)** A material will have only one specific heat, if and only if its coefficient of thermal expansion is equal to zero.
**(C)** A gas has infinite number of specific heats.
**(D)** None of these

**5.** In the previous question, if the specific latent heat of vaporization of water at 0°C is η times the specific latent heat of freezing of water at 0°C, the fraction of water that will ultimately freeze is:–

**(A)** $\frac{1}{\eta}$ **(B)** $\frac{\eta}{\eta+1}$ **(C)** $\frac{\eta-1}{\eta}$ **(D)** $\frac{\eta-1}{\eta+1}$

**6.** The figure shows two paths for the change of state of a gas from A to B. The ratio of molar heat capacities in path 1 and path 2 is:–




**(A)** > 1 **(B)** < 1 **(C)** 1 **(D)** Data insufficient

**7.** Two identical beakers are filled with water to the same level at 4°C. If one say A is heated while the other B is cooled, then:–
**(A)** water level in A will rise **(B)** water level in B will rise
**(C)** water level in A will fall **(D)** water level in B will fall

**8.** When two samples at different temperatures are mixed, the temperature of the mixture can be :–
**(A)** lesser than lower or greater than higher temperature
**(B)** equal to lower or higher temperature
**(C)** greater than lower but lesser than higher temperature
**(D)** average of lower and higher temperatures.

**9.** During the melting of a slab of ice at 273 K at atmospheric pressure:–

**(A)** Positive work is done by the ice–water system on the atmosphere.

**(B)** Positive work is done on the ice–water system by the atmosphere.

**(C)** The internal energy of ice–water system increases.

**(D)** The internal energy of the ice–water system decreases.

**10.** A partition divides a container having insulated walls into two compartments I and II.The same gas fills the two compartments whose initial parameters are given. The partition is a conducting wall which can move freely without friction. Which of the following statements is/are correct, with reference to the final equilibrium position ?

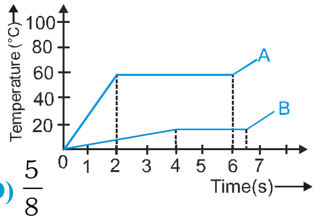

**(A)** The pressure in the two compartments are equal.

**(B)** Volume of compartment I is $\frac{3V}{5}$

**(C)** Volume of compartment II is $\frac{12V}{5}$

**(D)** Final pressure in compartment I is $\frac{5P}{3}$

**11.** Two substances A and B of equal mass m are heated by uniform rate of 6 cal $s^{-1}$ under similar conditions. A graph between temperature and time is shown in figure. Ratio of heat absorbed $H_A / H_B$ by them for complete fusion is:–




**(A)** $\frac{9}{4}$ **(B)** $\frac{4}{9}$ **(C)** $\frac{8}{5}$ **(D)** $\frac{5}{8}$

**12.** Three closed vessels A, B and C at the same temperature T and contain gases which obey the Maxwellian distribution of velocities. Vessel A contains only $O_2$, B only $N_2$ and C a mixture of equal quantities of $O_2$ and $N_2$. If the average speed of the $O_2$ molecules in vessel A is $v_1$, that of the $N_2$ molecules in vessel B is $v_2$, the average speed of $O_2$ molecules in vessel C is where M is the mass of an oxygen molecule:–

**(A)** $(v_1+v_2)/2$ **(B)** $v_1$ **(C)** $(v_1 v_2)^{1/2}$ **(D)** $\sqrt{3kT/M}$

**13.** An ideal gas can be expanded from an initial state to a certain volume through two different processes (i) $PV^2$ = constant and (ii) $P = KV^2$ where K is a positive constant. Then:–

**(A)** Final temperature in (i) will be greater than in (ii)

**(B)** Final temperature in (ii) will be greater than in (i)

**(C)** Total heat given to the gas in (i) case is greater than in (ii)

**(D)** Total heat given to the gas in (ii) case is greater than in (i)

**14.** During experiment, an ideal gas is found to obey a condition $P^2/\rho$= constant [ $\rho$ = density of the gas]. The gas is initially at temperature T, pressure P and density $\rho$. The gas expands such that density changes to $\rho/2$

**(A)** The pressure of the gas changes to $\sqrt{2}$ P

**(B)** The temperature of the gas changes to $\sqrt{2}$ T

**(C)** The graph of the above process on the P–T diagram is parabola

**(D)** The graph of the above process on the P–T diagram is hyperbola

**15.** When unit mass of water boils to become steam at $100^0$C, it absorbs Q amount of heat. The densities of water and steam at $100^0$C are $\rho_1$ and $\rho_2$ respectively and the atmospheric pressure is $P_0$. The increase in internal energy of the water is:–

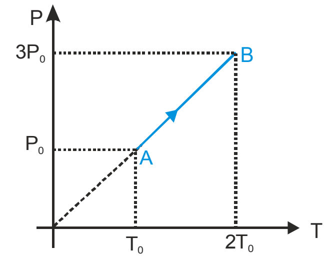
**(A)** Q

**(B)** $Q + P_0\left(\frac{1}{\rho_1} - \frac{1}{\rho_2}\right)$

**(C)** $Q + P_0\left(\frac{1}{\rho_2} - \frac{1}{\rho_1}\right)$

**(D)** $Q - P_0\left(\frac{1}{\rho_1} + \frac{1}{\rho_2}\right)$

**16.** Pressure versus temperature graph of an ideal gas is shown in figure. Density of the gas at point A is $\rho_0$. Density at B will be:–




**(A)** $\frac{3}{4}\rho_0$ **(B)** $\frac{3}{2}\rho_0$ **(C)** $\frac{4}{3}\rho_0$ **(D)** $2\rho_0$

**17.** At temperature T, N molecules of gas A each having mass m and at the same temperature 2 N molecules of gas B each having mass 2 m are filled in a container. The mean square velocity of molecules of gas B is $v^2$ and x component of mean square velocity of molecules of gas A is $w^2$. The ratio of $w^2 / v^2$ is :–

**(A)** 1 **(B)** 2 **(C)** 1/3 **(D)** 2/3

**18.** A closed vessel contains a mixture of two diatomic gases A and B. Molar mass of A is 16 times that of B and mass of gas A contained in the vessel is 2 times that of B. Which of the following statements are true?

**(A)** Average kinetic energy per molecule of A is equal to that of B

**(B)** Root mean square value of translational velocity of B is four times that of A

**(C)** Pressure exerted by B is eight times of that exerted by A

**(D)** Number of molecules of B in the cylinder is eight times that of A

**19.** A vessel is partitioned in two equal halves by a fixed diathermic separator. Two different ideal gases are filled in left (L) and right (R) halves. The rms speed of the molecules in L part is equal to the mean speed of molecules in the R part. Then the ratio of the mass of a molecule in L part to that of a molecule in R part is:–


**(A)** $\sqrt{\frac{3}{2}}$ **(B)** $\sqrt{\pi/4}$ **(C)** $\sqrt{2/3}$ **(D)** $3\pi/8$

**20.** Let $\bar{v}$, $v_{rms}$ and $v_p$ respectively denote the mean speed, the root–mean–square speed, and the most probable speed of the molecules in an ideal monoatomic gas at absolute temperature T. The mass of a molecule is m:–

**(A)** No molecule can have speed greater than $v_{rms}$ **(B)** No molecule can have speed less than $\frac{v_p}{\sqrt{2}}$

**(C)** $v_p < \bar{v} < v_{rms}$ **(D)** The average kinetic energy of a molecule is $\frac{3}{4}mv_p^2$

**21.** N(<100) molecules of a gas have velocities 1,2,3.... N, km/s respectively. Then:–

**(A)** rms speed and average speed of molecules are same

**(B)** Ratio of rms speed to average speed is $\frac{\sqrt{(2N+1)(N+1)}}{6N}$

**(C)** Ratio of rms speed to average speed is $\frac{\sqrt{(2N+1)(N+1)}}{6}$

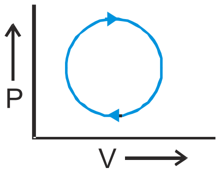
**(D)** Ratio of rms speed to average speed of a molecule $\frac{2}{\sqrt{6}}\sqrt{\frac{(2N+1)}{(N+1)}}$

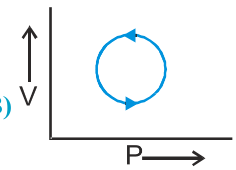
**22.** The internal energy of a system remains constant when it undergoes :–

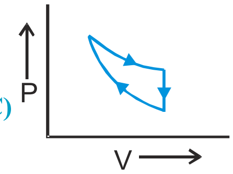
**(A)** a cyclic process **(B)** an isothermal process **(C)** an adiabatic process

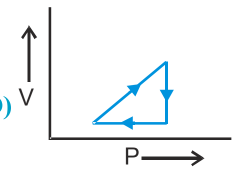
**(D)** any process in which the heat given out by the system is equal to the work done on the system

**23.** The following are the P–V diagrams for cyclic processes for a gas. In which of these processes is heat absorbed by the gas ?

**(A)** 


**(B)** 


**(C)** 


**(D)** 


**24.** An ideal gas is heated from temperature $T_1$ to $T_2$ under various conditions. The correct statement(s) is/are:–

**(A)** $\Delta U = nC_V (T_2 - T_1)$ for isobaric, isochoric and adiabatic process

**(B)** Work is done at expense of internal energy in an adiabatic process and both have equal values

**(C)** $\Delta U = 0$ for an isothermal process

**(D)** $C = 0$ for an adiabatic process

**25.** $C_P$ is always greater than $C_V$ due to the fact that :–

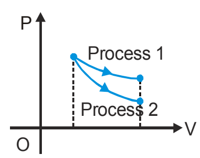
**(A)** No work is being done on heating the gas at constant volume.

**(B)** When a gas absorbs heat at constant pressure its volume must change so as to do some external work.

**(C)** The internal energy is a function of temperature only for an ideal gas.

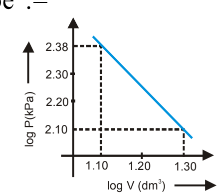
**(D)** For the same rise of temperature, the internal energy of a gas changes by a smaller amount at constant volume than at constant pressure.

**26.** The indicator diagram for two process 1 and 2 carried on an ideal gas is shown in figure.If $m_1$ and $m_2$ be the slopes $\left(\frac{dP}{dV}\right)$ for process 1 and process 2 respectively, then:–




**(A)** $m_1 = m_2$ **(B)** $m_1 > m_2$ **(C)** $m_1 < m_2$ **(D)** $m_2C_V = m_1C_P$

**27.** Logarithms of readings of pressure and volume for an ideal gas were plotted on a graph as shown in Figure. By measuring the gradient, It can be shown that the gas may be :–



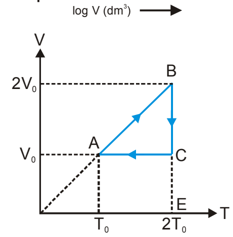

**(A)** Monoatomic and undergoing an adiabatic change.

**(B)** Monoatomic and undergoing an isothermal change.

**(C)** Diatomic and undergoing an adiabatic change.

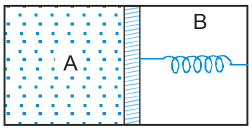
**(D)** Triatomic and undergoing an isothermal change.

**28.** An ideal monoatomic gas undergoes a cycle process ABCA as shown in the fig. The ratio of heat absorbed during AB to the work done on the gas during BC is:–




**(A)** $\frac{5}{2\ell n 2}$ **(B)** $\frac{5}{3}$ **(C)** $\frac{5}{4\ \ell n 2}$ **(D)** $\frac{5}{6}$

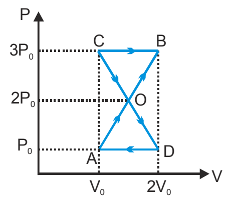
**29.** A thermally insulated chamber of volume $2V_0$ is divided by a frictionless piston of area S into two equal parts A and B. Part A has an ideal gas at pressure $P_0$ and temperature $T_0$ and in part B is vacuum. A massless spring of force constant k is connected with piston and the wall of the container as shown. Initially spring is unstretched. Gas in chamber A is allowed to expand. Let in equilibrium spring is compressed by $x_0$. Then:–




**(A)** Final pressure of the gas is $\frac{kx_0 6}{S}$ **(B)** Work done by the gas is $\frac{1}{2}kx^2_0$

**(C)** Change in internal energy of the gas is $\frac{1}{2}kx^2_0$ **(D)** Temperature of the gas is decreased.

**30.** A thermodynamic system undergoes cyclic process ABCDA as shown in figure. The work done by the system is :–




**(A)** $P_0V_0$ **(B)** $2P_0V_0$ **(C)** $\frac{P_0V_0}{2}$ **(D)** zero

**31.** Two cylinders A and B fitted with piston contain the equal amount of an ideal diatomic gas at 300K. The piston of A is free to move, while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of the gas in A is 30K, then the rise in the temperature of the gas in B is:–

**(A)** 30 K **(B)** 10 K **(C)** 50 K **(D)** 42 K

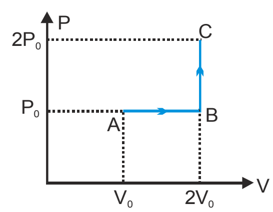
**32.** One mole of an ideal monatomic gas is taken from A to C along the path ABC. The temperature of the gas at A is $T_0$. For the process ABC :–

**(A)** Work done by the gas is $RT_0$

**(B)** Change in internal energy of the gas is $\frac{11}{2}RT_0$

**(C)** Heat absorbed by the gas is $\frac{11}{2}RT_0$

**(D)** Heat absorbed by the gas is $\frac{13}{2}RT_0$




**33.** The specific heats of a gas are $C_P$=0.2 cal/g °C & $C_V$ = 0.15 cal/g °C. [ Take R=2 cal/mole$^0$ C ]

**(A)** The molar mass of the gas is 40 g

**(B)** The molar mass of the gas cannot be determined from the data given

**(C)** The number of degrees of freedom of the gas molecules is 6

**(D)** The number of degrees of freedom of the gas molecules is 8

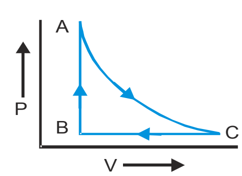
**34.** One mole of ideal gas undergoes a cyclic process ACBA as shown in figure. Process AC is adiabatic. The temperatures at A, B and C are 300, 600 and 450K respectively:–

**(A)** In process CA change in internal energy is 225R.

**(B)** In process AB change in internal energy is –150R.

**(C)** In process BC change in internal energy is –225R.

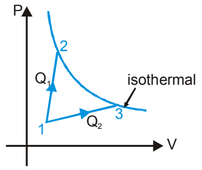
**(D)** Change in internal energy during the whole cyclic process is +150R.



**35.** One mole of an ideal gas at an initial temperature of T K does 6 R joules of work adiabatically. If the ratio of specific heats of this gas at constant pressure and at constant volume is 5/3, the final temperature of gas will be:–

**(A)** (T + 2.4) K **(B)** (T – 2.4) K **(C)** (T + 4) K **(D)** (T – 4) K

**36.** A gas takes part in two processes in which it is heated from the same initial state 1 to the same final temperature. The processes are shown on the P–V diagram by the straight line 1–2 and 1–3.2 and 3 are the points on the same isothermal curve. $Q_1$ and $Q_2$ are the heat transfer along the two processes. Then :–




**(A)** $Q_1 = Q_2$ **(B)** $Q_1 < Q_2$ **(C)** $Q_1 > Q_2$ **(D)** insufficient data

**37.** A gas expands such that its initial and final temperatures are equal. Also, the process followed by the gas traces a straight line on the P–V diagram :–

**(A)** The temperature of the gas remains constant throughout.
**(B)** The temperature of the gas first increases and then decreases.
**(C)** The temperature of the gas first decreases and then increases.
**(D)** The straight line has a negative slope.

**38.** A point source of heat of power *P* is placed at the center of a spherical shell of mean radius *R*. The material of the shell has thermal conductivity *k*. If the temperature difference between the outer and the inner surface of the shell is not to exceed *T*, then the thickness of the shell should not be less than :–

**(A)** $\frac{2\pi R^2 kT}{P}$ **(B)** $\frac{4\pi R^2 kT}{P}$ **(C)** $\frac{\pi R^2 kT}{P}$ **(D)** $\frac{\pi R^2 kT}{4P}$

**39.** Radiation from a black body at the thermodynamic temperature $T_1$ is measured by a small detector at distance $d_1$ from it. When the temperature is increased to $T_2$ and the distance to $d_2$, the power received by the detector is unchanged. What is the ratio $d_2/d_1$?

**(A)** $\frac{T_2}{T_1}$ **(B)** $\left(\frac{T_2}{T_1}\right)^2$ **(C)** $\left(\frac{T_1}{T_2}\right)_2^2$ **(D)** $\left(\frac{T_2}{T_1}\right)^4$

**40.** The emissive power of a black body at T=300 K is 100 Watt/m$^2$. Consider a body B of area A = 10 m$^2$, coefficient of reflectivity r = 0.3 and coefficient of transmission t=0.5. Its temperature is 300 K. Then which of the following is incorrect:–

**(A)** The emissive power of B is 20 W/m$^2$
**(B)** The emissive power of B is 200 W/m$^2$
**(C)** The power emitted by B is 200 Watt
**(D)** The emissivity of B is = 0.2

**41.** A black body emits radiation at the rate P when its temperature is T. At this temperature the wavelength at which the radiation has maximum intensity is $\lambda_0$. If at another temperature T' the power radiated is 'P' and wavelength at maximum intensity is $\frac{\lambda_0}{2}$ then:–

**(A)** P' T' = 32 PT **(B)** P' T' = 16 PT **(C)** P' T' = 8 PT **(D)** P' T' = 4 PT

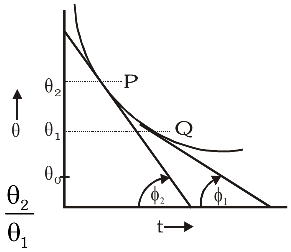
**42.** A hollow copper sphere & a hollow copper cube of same surface area & negligible thickness , are filled with warm water of same temperature and placed in an enclosure of constant temperature , a few degrees below that of the bodies . Then in the beginning :–

**(A)** The rate of energy lost by the sphere is greater than that by the cube
**(B)** The rate of energy lost by the two are equal
**(C)** The rate of energy lost by the sphere is less than that by the cube
**(D)** The rate of fall of temperature for sphere is less than that for the cube .

**43.** A metallic sphere having radius 0.08 m and mass m = 10 kg is heated to a temperature of 227°C and suspended inside a box whose walls are at a temperature of 27°C. The maximum rate at which its temperature will fall is:– (Take e = 1, Stefan's constant $\sigma$ = 5.8 x $10^{-8}$ $Wm^{-2}$ $K^{-4}$ and specific heat of the metal s = 90 cal/kg/deg, J = 4.2 J/Calorie)

**(A)** 0.055 °C/s **(B)** 0.066 °C/s **(C)** 0.044 °C/s **(D)** 0.03 °C/s

**44.** A body cools in a surrounding which is at a constant temperature of $\theta_0$. Assume that it obeys Newton's law of cooling. Its temperature $\theta$ is plotted against time t. Tangent are drawn to the curve at the points P($\theta = \theta_2$) and Q($\theta = \theta_1$). These tangents meet the time axis at angles of $\phi_2$ and $\phi_1$ as shown, then:–




**(A)** $\frac{\tan\phi_2}{\tan\phi_1} = \frac{\theta_1 - \theta_0}{\theta_2 - \theta_0}$ **(B)** $\frac{\tan\phi_2}{\tan\phi_1} = \frac{\theta_2 - \theta_0}{\theta_1 - \theta_0}$ **(C)** $\frac{\tan\phi_1}{\tan\phi_2} = \frac{\theta_1}{\theta_2}$ **(D)** $\frac{\tan\phi_1}{\tan\phi_2} = \frac{\theta_2}{\theta_1}$

**45.** Two long, thin, solid cylinders are identical in size, but they are made of different substances with two different thermal conductivities. The two cylinders are connected in series between a reservoir at temperature $T_{hot}$ and a reservoir at temperature $T_{cold}$. The temperature at the boundary between the two cylinders is $T_b$. One can conclude that:–

**(A)** $T_b$ is closer to $T_{hot}$ than it is to $T_{cold}$.
**(B)** $T_b$ is closer to $T_{cold}$ than it is to $T_{hot}$.
**(C)** $T_b$ is closer to the temp. of the reservoir that is in contact with the cylinder with the lower thermal conductivity.
**(D)** $T_b$ is closer to the temp. of the reservoir that is in contact with the cylinder with the higher thermal conductivity.

**46.** A rod of length L with sides fully insulated is of a material whose thermal conductivity varies with temperature as $K = \frac{\alpha}{T}$, where $\alpha$ is a constant. The ends of the rod are kept at temperature $T_1$ and $T_2$. The temperature T at x, where x is the distance from the end whose temperature is $T_1$ is:–

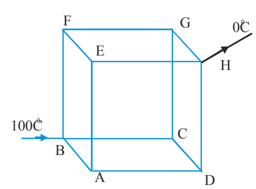
**(A)** $T_1\left(\frac{T_2}{T_1}\right)^{\frac{x}{L}}$ **(B)** $\frac{x}{L}\ell n\frac{T_2}{T_1}$ **(C)** $T_1 e^{\frac{T_2 x}{T_1 L}}$ **(D)** $T_1 + \frac{T_2 - T_1}{L}x$

**47.** A spherical body with an initial temperature $T_1$ is allowed to cool in surroundings at temperature $T_0$ ($<T_1$). The mass of the body is m, its gram specific heat is c, density $\rho$, area A. If $\sigma$ be the Stefan's constant then the temperature T of the body at time t can be best represented by:–

**(A)** $T = (T_1 - T_0)\,e^{-kt}$ where $k = \frac{12\sigma A T_0^3}{r\rho c}$ **(B)** $T = (T_1 - T_0)\,\ell n(kt)$ where $k = \frac{\sigma A T_0}{mc^3}$

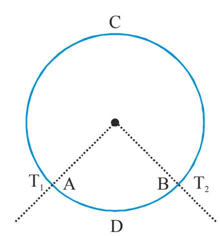
**(C)** $T = T_0 + (T_1 - T_0)\,e^{-kt}$ where $k = \frac{12\sigma T_0^3}{r\rho c}$ **(D)** $T = T_1 e^{-kt} - T_0$ where $k = \frac{\sigma A T_0^3}{r\rho c}$

**48.** Twelve conducting rods form the sides of a uniform cube of side $\ell$. If in steady state, B and H ends of the cube are at $100^0$C and $0^0$C respectively. Find the temperature of the junction 'A' :–



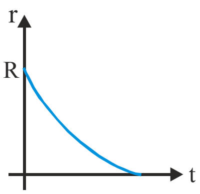

**(A)** $80^0$C **(B)** $60^0$C **(C)** $40^0$C **(D)** $70^0$C

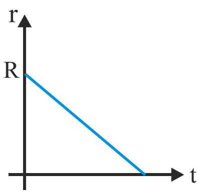
**49.** A ring consisting of two parts ADB and ACB of same conductivity k carries an amount of heat H. The ADB part is now replaced with another metal keeping the temperatures $T_1$ and $T_2$ constant. The heat carried increases to 2H. What should be the conductivity of the new ADB part? Given $\frac{ACB}{ADB} = 3$

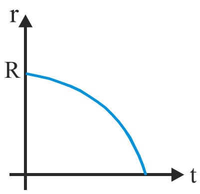


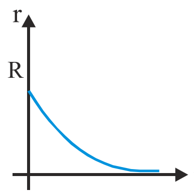

**(A)** $\frac{7}{3}$k **(B)** 2k **(C)** $\frac{5}{2}$k **(D)** 3k

**50.** A sphere of ice at $0^0$C having initial radius R is placed in an environment having ambient temperature > $0^0$C. The ice melts uniformly, such that shape remains spherical. After a time 't' the radius of the sphere has reduced to r. Which graph best depicts r(T)

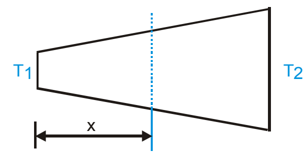
**(A)** 

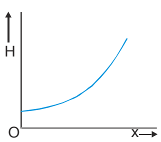
**(B)** 

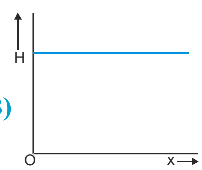
**(C)** 

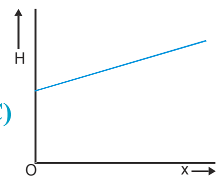
**(D)** 

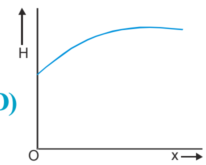

**51.** Radius of a conductor increases uniformly from left end to right end as shown in Fig. Material of the conductor is isotropic and its curved surface is thermally isolated from surrounding. Its ends are maintained at temperatures $T_1$ and $T_2$ ($T_1 > T_2$). If, in steady state, heat flow rate is equal to H, then which of the following graphs is correct?




**(A)** 

**(B)** 

**(C)** 

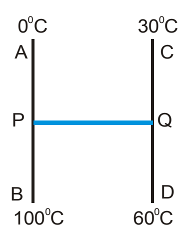
**(D)** 


**52.** Three bodies A, B and C have equal surface area and thermal emissivities in the ratio $e_A : e_B : e_C = 1 : \frac{1}{2} : \frac{1}{4}$. All the three bodies are radiating at same rate. Their wavelengths corresponding to maximum intensity are $\lambda_A$ , $\lambda_B$ and $\lambda_C$ respectively and their temperatures are $T_A$, $T_B$ and $T_C$ on kelvin scale, then select the incorrect statement

**(A)** $\sqrt{T_A T_C} = T_B$  **(B)** $\sqrt{\lambda_A \lambda_C} = \lambda_B$

**(C)** $\sqrt{e_A T_A}\ \sqrt{e_C T_C} = e_B T_B$  **(D)** $\sqrt{e_A \lambda_A T_A . e_B \lambda_B T_B} = e_C \lambda_C T_C$

**53.** Three identical rods AB, CD and PQ are joined as shown. P and Q are mid points of AB and CD respectively. Ends A, B, C and D are maintained at $0^0$C, $100^0$C, $30^0$C and $60^0$C respectively. The direction of heat flow in PQ is:–




**(A)** From P to Q  **(B)** From Q to P

**(C)** Heat does not flow in PQ  **(D)** Data not sufficient

**54.** In a 10–metre–deep lake, the bottom is at a constant temperature of 4°C. The air temperature is constant at –4°C. The thermal conductivity of ice is 3 times that of water. Neglecting the expansion of water on freezing, the maximum thickness of ice will be:–

**(A)** 7.5 m  **(B)** 6 m  **(C)** 5 m  **(D)** 2.5 m

**55.** A and B are two points on a uniform metal ring whose centre is C. The angle ACB = θ. A and B maintained at two different constant temperatures. When θ = 180°, the rate of total heat flow from A to B is 1.2 W. When θ = 90°, this rate will be:–

**(A)** 0.6 W **(B)** 0.9 W **(C)** 1.6 W **(D)** 1.8 W

**56.** A system S receives heat continuously from an electrical heater of power 10W. The temperature of S becomes constant at 50°C when the surrounding temperature is 20°C. After the heater is switched off, S cools from 35.1°C to 34.9°C in 1 minute. The heat capacity of S is:–

**(A)** 100 J/°C **(B)** 300 J/°C **(C)** 750 J/°C **(D)** 1500 J/°C

**57.** The solar constant for the earth is Σ. The surface temperature of the sun is T K. The sun subtends an angle θ at the earth:–

**(A)** $\Sigma \propto T^4$ **(B)** $\Sigma \propto T^2$ **(C)** $\Sigma \propto \theta^2$ **(D)** $\Sigma \propto \theta$

**58.** Temperature of black body is 3000K when black body cools, then change in wevelength $\Delta\lambda = 9$ micron corresponding to maximum energy density. Now temperature of black body is :–

**(A)** 300 K **(B)** 2700 K **(C)** 270 K **(D)** 1800 K

**59.** If the absorption coefficient and reflection coefficient of a surface of a body are 0.4 and 0.6 respectively then:–

**(A)** Emissive power will be 0.2 **(B)** Transmission power will be 0.2

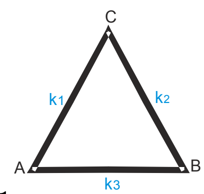
**(C)** Body will be totally transparent **(D)** Body will be totally opaque.

**60.** Two Plates of equal areas are placed in contact with each other. Their thickness are 2cm and 3cm respectively. Temperature of external surface of first plate is –25° C and that of external surface of second plate is 25° C What will be temperature of contact surface if the plates :–

(i) Are of same material (ii) Have thermal Conductivity in ratio 2 : 3.

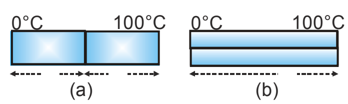
**(A)** (i) –5°C (ii) 0°C **(B)** (i) 5°C (ii) 0°C **(C)** (i) 0°C (ii) –5°C **(D)** None of these

**61.** Three rods of same dimensions are arranged as shown in the figure. They have thermal conductivities $k_1$, $k_2$ & $k_3$. The points A and B are maintained at different temperatures. For the heat to flow at the same rate along ACB and AB :–



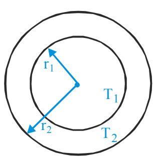

**(A)** $k_3 = 2(k_1 + k_2)$ **(B)** $k_3 = \frac{k_1 k_2}{k_1 + k_2}$ **(C)** $k_3 = k_1 + k_2$ **(D)** $k_3 = \frac{1}{2}(k_1 + k_2)$

**62.** Two identical square rods of metal are welded end to end as shown in figure **(A)** 20 calories of heat flows through it in 4 minutes. If the rods are welded as shown in figure **(B)**, the same amount of heat will flow through the rods in :–



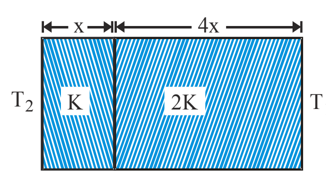

**(A)** 1 minute **(B)** 2 minutes **(C)** 4 minutes **(D)** 16 minutes

**63.** The figure shows a system of two concentric spheres of radii $r_1$ and $r_2$ and kept at temperatures $T_1$ and $T_2$, respectively. The radial rate of flow of heat in a substance between the two concentric spheres, is proportional to:–




**(A)** $\frac{(r_2 - r_1)}{(r_1 r_2)}$ **(B)** $\ell n\left(\frac{r_2}{r_1}\right)$ **(C)** $\frac{r_1 r_2}{(r_2 - r_1)}$ **(D)** $(r_2 - r_1)$

**64.** The temperature of the two outer surfaces of a composite slab, consisting of two materials having coefficients of thermal conductivity K and 2K and thickness x and 4x, respectively are $T_2$ and $T_1$ $(T_2 > T_1)$. The rate of heat transfer through the slab, in a steady state is $\left(\frac{A(T_2 - T_1)K}{x}\right)f$, with f equals to:–




**(A)** 1 **(B)** 1/2 **(C)** 2/3 **(D)** 1/3

**65.** A thermally insulated vessel contains some water at $0^0$C. The vessel is connected to a vacuum pump to pump out water vapour. This results in some water getting frozen. It is given latent heat of vaporization of water at $0°C = 21 \times 10^5$ J/kg and latent heat of freezing of water $= 3.36 \times 10^5$ J/kg. The maximum percentage amount of water that will be solidified in this manner will be:–

**(A)** 86.2% **(B)** 33.6% **(C)** 21% **(D)** 24.36%

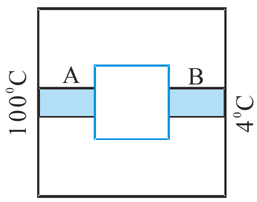
**66.** The pressure of one mole of an ideal gas varies according to the law $P = P_0 - aV^2$, where $P_0$ and a are positive constants. The highest temperature that the gas may attain is:–

**(A)** $\frac{2P_0}{3R}\left(\frac{P_0}{3a}\right)^{1/2}$ **(B)** $\frac{3P_0}{2R}\left(\frac{P_0}{3a}\right)^{1/2}$ **(C)** $\frac{P_0}{R}\left(\frac{P_0}{3a}\right)^{1/2}$ **(D)** $\frac{P_0}{R}\left(\frac{P_0}{3a}\right)^{1/2}$

**67.** Three identical adiabatic containers have helium, neon and oxygen gases at the same pressure. The gases are compressed to half their original volume. Then:–

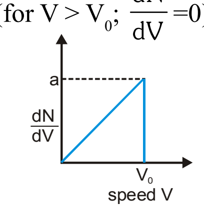
**(A)** The final temperature of the gas in each container is same
**(B)** The final pressure of the gas in each container is same
**(C)** The final temperature of both helium and neon is same
**(D)** The final pressure of both helium and neon is same

**68.** A closed cubical box made of perfectly insulating material has walls of thickness 8 cm and the only way for heat to enter or leave the box is through two solid metal plugs A and B, each of cross–sectional area 12 $cm^2$ and length 8 cm fixed in the opposite walls of the box as shown in the figure. Outer surface A is kept at 100°C while the outer surface B is kept at 4°C. The thermal conductivity of the material of the plugs is 0.5 $cals^{-1}cm^{-1}$ $(°C^{-1})$. A source of energy generating 36 $cals^{-1}$ is enclosed inside the box. The equilibrium temperature of the inner surface of the box (assuming that it is same at all points on the inner surface) is:–




**(A)** 38°C **(B)** 57°C **(C)** 76°C **(D)** 85°C

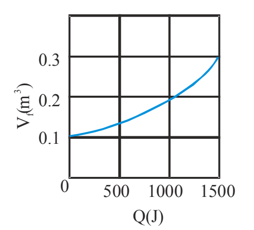
**69.** Graph shows a hypothetical speed distribution for a sample of N gas particle :–(for $V > V_0$; $\frac{dN}{dV} = 0$)




**(A)** The value of $V_0$ is 2N.
**(B)** The ratio $V_{avg}/V_0$ is equal to 2/3.
**(C)** The ratio $V_{rms}/V_0$ is equal to $1/\sqrt{2}$
**(D)** Three fourth of the total particle has a speed between 0.5 $V_0$ and $V_0$.

**70.** Suppose 0.5 mole of an ideal gas undergoes an isothermal expansion as energy is added to it as heat Q. Graph shows the final volume $V_f$ versus Q. The temperature of the gas is :–

(use $\ell$n 9 = 2 and R= $\frac{25}{3}$ J/mol-K)




**(A)** 293 K **(B)** 360 K **(C)** 386 K **(D)** 412 K

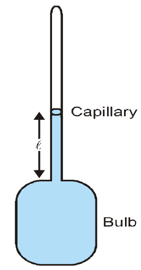
**71.** A glass rod when measured with a zinc scale, both being at 30°C, appears to be of length 100 cm. If the scale shows correct reading at 0°C, then the true length of glass rod at 30°C and 0°C are:–
$(\alpha_{glass} = 8\times 10^{-6}\ °C^{-1}, \alpha_{zinc} = 26 \times 10^{-6}\ K^{-1})$

**(A)** 100.054 cm, 100.054 cm **(B)** 100.078 cm, 100.078 cm
**(C)** 100.078 cm, 100.054 cm **(D)** 100.054 cm, 100.078 cm

**72.** The temperature of an isotropic cubical solid of length $\ell_0$, density $\rho_0$ and coefficient of linear expansion $\alpha$ is increased by 20°C. Then at higher temperature, to a good approximation:–

**(A)** Length is $\ell_0$ $(1+20\alpha)$ **(B)** Total surface area is $\ell_0^2$ $(1+40\alpha)$
**(C)** Total volume is $\ell_0^3$ $(1+60\alpha)$ **(D)** Density is $\frac{\rho_0}{1+60\alpha}$

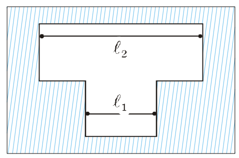
**73.** In a mercury–glass thermometer the cross–section of the capillary portion is $A_0$ and the volume of the bulb is $V_0$ at 273 K. If $\alpha$ and $\gamma$ are the coefficients of linear and cubical expansion coefficients of glass and mercury respectively then length of mercury in the capillary at temperature t°C is (Ignore the increase in cross–sectional area of capillary)




**(A)** $\frac{V_0}{A_0}(\gamma - 3\alpha)t$ **(B)** $\frac{V_0}{A_0}(2\gamma - 3\alpha)t$

**(C)** $\frac{V_0}{A_0}(\gamma - 3\alpha)(t + 273)$ **(D)** $\frac{V_0 \gamma t}{A_0}$

**74.** Two fine steel wires, fastened between the projections of a heavy brass bar, are just taut when the whole system is at 0°C. What is the tensile stress in the steel wires when the temperature of the system is raised by 200°C? ($\alpha_{brass} = 2 \times 10^{-5}$ °C$^{-1}$, $\alpha_{steel} = 1.2 \times 10^{-5}$ °C$^{-1}$, $Y_{steel} = 200$ GNm$^{-2}$)




**(A)** 3.2 Nm$^{-2}$ **(B)** $3.2 \times 10^8$ Nm$^{-2}$ **(C)** $32 \times 10^8$ Nm$^{-2}$ **(D)** 0.48 Nm$^{-2}$

**75.** n moles of an ideal triatomic linear gas undergoes a process in which the temperature changes with volume as $T = k_1V^2$ where $k_1$ is a constant. Choose incorrect alternative:–

**(A)** At normal temperature $C_v = \frac{5}{2}R$ **(B)** At any temperature $C_p - C_v = R$

**(C)** At normal temperature molar heat capacity C=3R **(D)** At any temperature molar heat capacity C=3R

**76.** 5g of steam at 100°C is mixed with 10 g of ice at 0°C. Choose correct alternative/s) :–(Given $s_{water}$ = 1 cal/g°C, $L_F$ = 80 cal/g, $L_V$ = 540 cal/g)

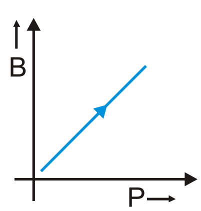
**(A)** Equilibrium temperature of mixture is 160°C **(B)** Equilibrium temperature of mixture is 100°C

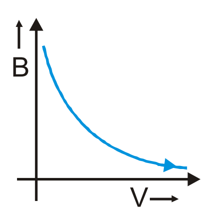
**(C)** At equilibrium, mixture contain $13\frac{1}{3}$ g of water **(D)** At equilibrium, mixture contain $1\frac{2}{3}$ g of steam

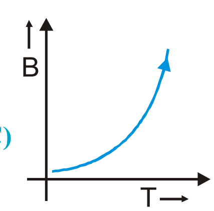
**77.** Four moles of hydrogen, two moles of helium and one mole of water vapour form an ideal gas mixture. What is the molar specific heat at constant pressure of mixture ?

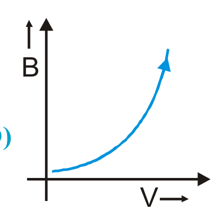
**(A)** $\frac{16}{7}R$ **(B)** $\frac{23}{7}R$ **(C)** $\frac{19}{7}R$ **(D)** $\frac{26}{7}R$

**78.** A sample of gas follows process represented by $PV^2$ = constant. Bulk modulus for this process is B, then which of the following graph is correct?

**(A)**



**(B)**



**(C)**



**(D)**



**79.** A inert gas obeys the law $PV^x$ = constant. For what value of x, it has negative molar specific heat–

**(A)** $x > 1.67$ **(B)** $x < 1.67$ **(C)** $1 < x < 1.4$ **(D)** $1 < x < 1.67$

## Part # II [Assertion & Reason Type Questions]

These questions contains, Statement 1 (assertion) and Statement II (reason).

**(A)** Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

**(B)** Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for Statement–I

**(C)** Statement–I is true, Statement–II is false

**(D)** Statement–I is false, Statement–II is true

**1.** **Statement–I :** The ratio $\frac{C_P}{C_V}$ for a monatomic gas is more than for a diatomic gas.

**Statement–II :** The molecules of a monatomic gas have more degrees of freedom than those of a diatomic gas.

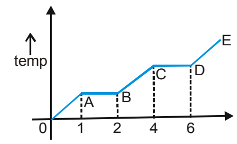
**2.** **Statement–I :** A real gas behaves as an ideal gas at high temperature and low pressure.

**Statement–II :** Liquid state of an ideal gas is impossible

**3.** **Statement–I :** In adiabatic expansion of monoatomic ideal gas, if volume increases by 24% then pressure decreases by 40%.

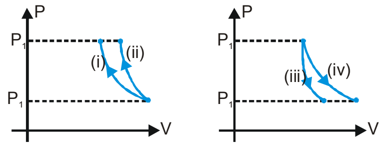
**Statement–II :** For adiabatic process $PV^{\gamma}$ = constant

**4.** **Statement–I :** A solid material is supplied heat at a constant rate. The temp. of the material is changing with the heat input as shown in figure. Latent heat of vaporization of substance is double that of fusion (given CD = 2AB).




**Statement–II :** $L_f \propto AB$ and $L_v \propto CD$

**5.** **Statement–I** : In following figure curve (i) and (iv) represent isothermal process while (ii) & (iii) represent adiabatic process.




**Statement–II :** The adiabatic at any point has a steeper slope than the isothermal through the same point.

**6.** **Statement–I :** Air quickly leaking out of a balloon becomes cooler.

**Statement–II :** The leaking air undergoes adiabatic expansion.

**7.** **Statement–I :** Change in internal energy in the melting process is due to change in internal potential energy.

**Statement–II :** This is because in melting, distance between molecules increase but temperature remains constant.

**8.** **Statement–I :** Water kept in an open vessel will quickly evaporate on the surface of the Moon.

**Statement–II :** The temperature at the surface of the moon is much higher than boiling point of water at Earth.

**9.** **Statement–I :** Absolute zero temperature is not the temperature of zero energy.

**Statement–II :** Only the internal kinetic energy of the molecules is represented by temperature.

**10.** **Statement–I :** The steam at 100°C causes more severe burn to human body than the water at 100°C.

**Statement–II :** The steam has greater internal energy due to latent heat of vaporization.

**11.** **Statement–I :** An ideal gas has infinitely many molar specific heats.

**Statement–II :** Specific heat is amount of heat needed to raise the temperature of 1 mole of gas by 1 K.

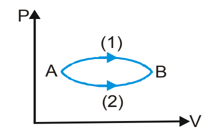
**12.** **Statement–I :** The bulb of one thermometer is spherical while that of the other is cylindrical. Both have equal amount of mercury. The response of the cylindrical bulb thermometer will be quicker.

**Statement–II :** Heat conduction in a body is directly proportional to cross–sectional area.

**13.** **Statement–I :** On sudden expansion a gas cools.

**Statement–II :** On sudden expansion, no heat is supplied to system and hence gas does work at the expense of its internal energy.

**14.** **Statement–I :** A gas is taken from state A to state B through two different paths. Molar specific heat capacity in path (A) is more as compared to (B).




**Statement–II :** Specific heat $C = \frac{Q}{n\Delta T}$ & $Q = \Delta U + W$ and W is equal to area under P–V diagram.

**15.** **Statement–I :** In a process if initial volume is equal to the final volume, work done by the gas is zero.

**Statement–II :** In an isochoric process work done by the gas is zero.

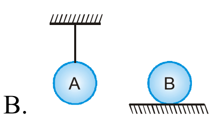
**16.** **Statement–I :** The isothermal curves intersect each other at a certain point.

**Statement–II :** The isothermal change are done slowly, so the isothermal curves have very little slope.

**17.** **Statement–I :** Two solid cylindrical rods of identical size and different thermal conductivity $K_1$ and $K_2$ are connected in series. Then the equivalent thermal conductivity of two rod system is less than the value of thermal conductivity of either rod.


**Statement–II :** For two cylindrical rods of identical size and different thermal conductivity $K_1$ and $K_2$ connected in series, the equivalent thermal conductivity K is given by $\frac{2}{K} = \frac{1}{K_1} + \frac{1}{K_2}$

**18.** **Statement–I :** Equal amount of heat is supplied to two identical spheres A & B (see figure). The increment in temperature for sphere A is more than sphere B.




**Statement–II :** Work done due to gravity on sphere A is positive while on sphere B is negative.

**19.** **Statement–I :** When a bottle of cold carbonated drink is opened, a slight fog forms around the opening.

**Statement–II :** Adiabatic expansion of the gas causes lowering of temperature and condensation of water vapours.

**20.** **Statement–I :** A cloudy night is hotter than a clear sky night.

**Statement–II :** Clouds are bad absorbers of heat.

**21.** **Statement–I :** Temperatures near the sea–coast are moderate.

**Statement–II :** Water has a high thermal conductivity compared to ice.

**22.** **Statement–I :** Potential energy of water at 0°C is more than ice at 0°C.

**Statement–II :** Heat given to melt ice at 0°C is used up in increasing the potential energy of water molecules formed at 0°C.

23. **Statement–I :** When hot water is poured in a beaker of thick glass, the beaker cracks.
**Statement–II :** Glass is a bad conductor of heat and outer surface of the beaker does not expand.

24. **Statement–I :** Snow is better insulator than ice.
**Statement–II :** Snow contain air packet and air is a bad conductor of heat.

25. **Statement–I :** When an electric fan is switched on in a closed room, the air of the room is cooled.
**Statement–II :** When fan is switched on, the speed of the air molecules will increase.

26. **Statement–I :** Animals curl into a ball, when they feel very cold.
**Statement–II :** Animals by curling their body reduces the surface area.

27. **Statement–I :** High thermal conductivity of metals is due to presence of free electrons.
**Statement–II :** Electrons at same temperature have very high average velocity than atoms.

28. **Statement–I :** A sphere, a cube and a thin circular plate made of same material and of same mass are initially heated to 200°C, the plate will cool at fastest rate.
**Statement–II :** Rate of cooling = $\frac{\rho A \sigma}{ms}(T^4 - T_0^4) \propto$ surface area. Surface area is maximum for circular plate.

29. **Statement–I :** Water is considered unsuitable for use in thermometers.
**Statement–II :** Thermal Expansion of water is non uniform.

30. **Statement–I :** Liquids usually expand more than solids.
**Statement–II :** The intermolecular forces in liquids are weaker than in solids.

31. **Statement–I :** Coolant coils are fitted at the top of a refrigerator, for formation of convection current.
**Statement–II :** Air becomes denser on cooling.

32. **Statement–I :** Temperature of a rod is increased and again cooled to same initial temperature then its final length is equal to original length provided there is no deformation take place.
**Statement–II :** For a small temperature change, length of a rod varies as $\ell=\ell_0(1+\alpha\Delta T)$ provided $\alpha\Delta T<<1$. Here symbol have their usual meaning.

# Exercise # 3 Part # I [Matrix Match Type Questions]

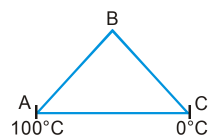
**1.**

| | Column–I | | Column–II |
|---|---|---|---|
| (A) | Isobaric process | (P) | No heat exchange |
| (B) | Isothermal process | (Q) | Constant pressure |
| (C) | Isoentropy process | (R) | Constant internal energy |
| (D) | Isochoric process | (S) | Work done is zero |

**2.** Three liquids A, B and C having same specific heat and mass m, 2m and 3m have temperature 20°C, 40°C and 60°C respectively. Temperature of the mixture when :

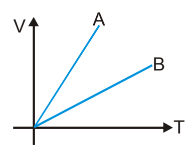
| | Column I | | Column II |
|---|---|---|---|
| (A) | A and B are mixed | (P) | 35°C |
| (B) | A and C are mixed | (Q) | 52°C |
| (C) | B and C are mixed | (R) | 50°C |
| (D) | A, B and C all three are mixed | (S) | 45°C |
| | | (T) | None |

**3.** Three rods of equal length of same material are joined to form an equilateral triangle ABC as shown in figure. Area of cross–section of rod AB is S, of rod BC is 2S and that of AC is S, then




| | Column I | | Column II |
|---|---|---|---|
| (A) | Temperature of junction B | (P) | Greater than 50°C |
| (B) | Heat current in AB | (Q) | Less than 50°C |
| (C) | Heat current in BC | (R) | Is equal to heat current in BC |
| | | (S) | Is $\frac{2}{3}$ times heat current in AC |
| | | (T) | None |

**4.** In the V–T graph shown in figure:

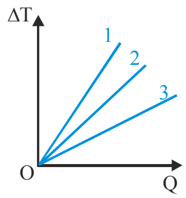



| | Column I | | Column II |
|---|---|---|---|
| (A) | Gas A is ... and gas B is ... | (P) | monoatomic, diatomic |
| (B) | $P_A / P_B$ is | (Q) | diatomic, monoatomic |
| (C) | $n_A / n_B$ is | (R) | > 1 |
| | | (S) | < 1 |
| | | (T) | cannot say any thing |

**5.**

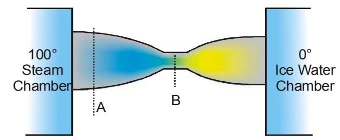
| | Column I | | Column II |
|---|---|---|---|
| (A) | In $P = \frac{2}{3}E$, E is | (P) | Change in internal energy is only in isochoric process |
| (B) | In U=3RT for an monoatomic gas U is | (Q) | Translational kinetic energy of unit volume |
| (C) | In $W = P(V_f - V_i)$, W is | (R) | Internal energy of one mole |
| (D) | In $\Delta U = nC_v\Delta T$, $\Delta U$ is | (S) | Work done in isobaric process |
| | | (T) | None |

**6.** The straight lines in the figure depict the variations in temperature $\Delta T$ as a function of the amount of heat supplied Q in different process involving the change of state of a monoatomic and a diatomic ideal gas. The initial states (P,V,T) of the two gases are the same. Match the processes as described, with the straight lines in the graph as numbered.




| | Column-I | | Column-II |
|---|---|---|---|
| **(A)** | Iosbaric process of monoatomic gas. | **(P)** | 1 |
| **(B)** | Isobaric process of diatomic gas | **(Q)** | 2 |
| **(C)** | Isochoric process of monoatomic gas | **(R)** | 3 |
| **(D)** | Isochoric process of diatomic gas | **(S)** | x-axis (i.e. 'Q' axis) |

**7.** A copper rod (initially at room temperature 20°C) of non–uniform cross section is placed between a steam chamber at 100°C and ice–water chamber at 0°C. A and B are cross sections as shown in figure. Then match the statements in column–I with results in column–II using comparing only between cross section A and B. (The mathematical expressions in column–I have usual meaning in heat transfer).




| | Column I | | Column II |
|---|---|---|---|
| **(A)** | Initially rate of heat flow $\left(\frac{dQ}{dt}\right)$ will be | **(P)** | Maximum at section A |
| **(B)** | At steady state rate of heat flow $\left(\frac{dQ}{dt}\right)$ will be | **(Q)** | Maximum at section B |
| **(C)** | At steady state temperature gradient $\left|\left(\frac{dT}{dx}\right)\right|$ will be | **(R)** | Minimum at section B |
| **(D)** | At steady state rate of change of temperature $\left(\frac{dT}{dt}\right)$ at a certain point will be | **(S)** | Same for all section |

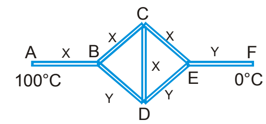
**8.** For one mole of a monoatomic gas :–

| | Column I | | Column II |
|---|---|---|---|
| **(A)** | Isothermal bulk modulus | **(P)** | $-\frac{RT}{V^2}$ |
| **(B)** | Adiabatic bulk modulus | **(Q)** | $-\frac{5P}{3V}$ |
| **(C)** | Slope of P–V graph in isothermal process | **(R)** | T/V |
| **(D)** | Slope of P–V graph in adiabatic process | **(S)** | 4T/3V |
| | | **(T)** | None |

**9.** An ideal gas whose adiabatic exponent equals to $\gamma = \frac{7}{5}$ is expanded according to the law $P = 2V$. The initial volume of the gas is equal to $V_0 = 1$ unit. As a result of expansion the volume increases 4 times. (Take $R = \frac{25}{3}$ units)

| | Column – I | | Column – II |
|---|---|---|---|
| **(A)** | Work done by the gas | **(P)** | 25 units |
| **(B)** | Increment in internal energy of the gas | **(Q)** | 45 units |
| **(C)** | Heat supplied to the gas | **(R)** | 75 units |
| **(D)** | Molar heat capacity of the gas in the process | **(S)** | 15 units |

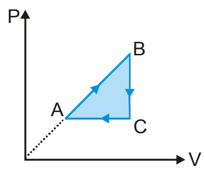
**10.** Four rods of material X and three rods of material Y are connected as shown in figure. All the rods are of identical lengths and cross-sectional area. Given thermal resistance of rod of material X, $R_x = R$ and thermal conductivities of materials are related by relation $K_Y = 2K_X$.

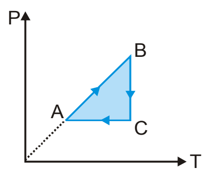


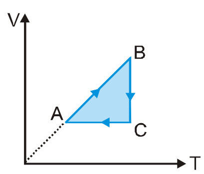

| | Column I | | Column II |
|---|---|---|---|
| (A) | Thermal resistance between B and E | (P) | $\frac{500}{13}$°C |
| (B) | Thermal resistance between A and F | (Q) | $\frac{700}{13}$°C |
| (C) | Temperature of junction B | (R) | $\frac{2R}{3}$ |
| (D) | Temperature of junction D | (S) | $\frac{13R}{6}$ |

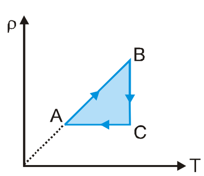
**11.** For a ideal monoatomic gas match the following graphs for constant mass in different processes ($\rho$ = Density of gas)

**Column I**

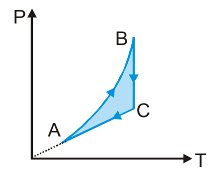
(A) 

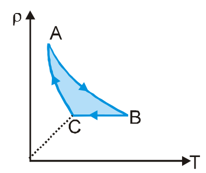

(B) 

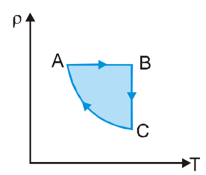

(C) 

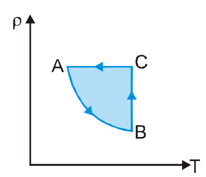

(D) 


**Column II**

(P) 


(Q) 


(R) 


(S) 

## Part # II [Comprehension Type Questions]

### Comprehension # 1

Molar heat capacity of an ideal gas in the process $PV^x$ = constant, is given by : $C = \frac{R}{\gamma - 1} + \frac{R}{1 - x}$. An ideal diatomic gas with $C_V = \frac{5R}{2}$ occupies a volume $V_1$ at a pressure $P_1$. The gas undergoes a process in which the pressure is proportional to the volume. At the end of the process the rms speed of the gas molecules has doubled from its initial value.

**1.** The molar heat capacity of the gas in the given process is :–

**(A)** 3 R **(B)** 3.5 R **(C)** 4 R **(D)** 2.5 R

**2.** Heat supplied to the gas in the given process is :

**(A)** 7 $P_1V_1$ **(B)** 8 $P_1V_1$ **(C)** 9 $P_1V_1$ **(D)** 10 $P_1V_1$

### Comprehension # 2

A certain amount of ice is supplied heat at a constant rate for 7 min. For the first one minute the temperature rises uniformly with time. Then it remains constant for the next 4 min and again the temperature rises at uniform rate for the last 2 min. Given $S_{ice}$ = 0.5 cal/g°C, $L_f$ = 80 cal/g :

**1.** The initial temperature of ice is :–

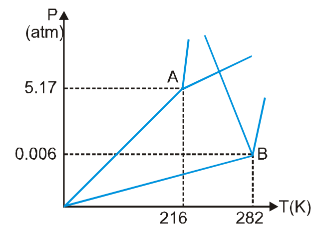
**(A)** –10°C **(B)** –20°C **(C)** –30°C **(D)** –40°C

**2.** Final temperature at the end of 7 min is :

**(A)** 10°C **(B)** 20°C **(C)** 30°C **(D)** 40°C

### Comprehension # 3

Each phase of a material can exist only in certain regions of pressure and temperature. P–T phase diagrams, in which pressure is plotted versus temperature, show the regions corresponding to various phases and phase transformations. P–V diagrams, on the other hand, can be used to study pressure volume relationships at a constant temperature.




If the liquid and gaseous phases of a pure substances are heated together in a closed container, both the temperature and the vapor pressure will increase until a point is reached at which the two phases can no longer be distinguished from one another. The temperature and pressure at which this occurs are called the critical temperature and pressure. Exceeding either of these parameters, by itself, will cause the gas/liquid phase transition to disappear. If the other variable is then changed as well, while the first variable is maintained above its critical point, a gradual transition will occur between the gaseous and liquid phases, with no clear boundary. (The liquid and solid phases, on the other hand, maintain a distinct boundary at all pressures above the triple point.) Shown in figure is a combined P–T phase diagram for materials A and B.

**1.** If heat is added to solids A and B, each in a container that is open to the atmosphere :–

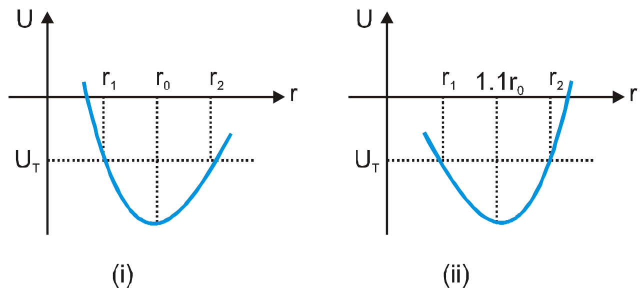
**(A)** A will boil and B will melt **(B)** A will sublime and B will melt, then boil

**(C)** A will melt and B will sublime **(D)** Both A and B will first melt, then boil

**2.** Which is true about the substances in figure ?
**(A)** At 2 atm pressure and 220 K temperature, A is a gas and B is solid
**(B)** At 6 atm pressure and 280 K temperature, A is a gas and B is a solid
**(C)** At 5 atm pressure and 100 K temperature, A is a gas and B is a solid
**(D)** At 4 atm pressure and 300 K temperature, both A and B are liquids

## Comprehension # 4

Consider a hypothetical situation where we are comparing the properties of two crystals made of atom A and atom B. Potential energy (U) v/s interatomic separation (R) graph for atom A and atom B is shown in figure (i) and (ii) and respectively.




**1.** Choose correct statement
**(A)** Volume of A and B expand on heating

**(B)** Volume of A and B contract on heating

**(C)** A expands on heating and B contracts on heating

**(D)** A contracts on heating and B expands on heating

**2.** When we heat the crystal of either atoms, the atom undergo oscillation. Choose correct statement for atoms of crystal A

**(A)** Their equilibrium position remains unchanged but average separation decreases

**(B)** Their equilibrium position remains unchanged but average separation increases

**(C)** Their separation at equilibrium position as well as average separation increases

**(D)** Their separation at equilibrium position decreases but average separation increases

**3.** It is seen that the potential energy can reach a maximum value of $U_T$ at temperature T=10K. If $r_1$ and $r_2$ are 0.9999 $r_0$ and 1.0003 $r_0$ for atoms of crystal A, its approximate coefficient of linear expansion can be :–

**(A)** $4 \times 10^{-5}$ /K **(B)** $1\times 10^{-5}$ /K **(C)** $2 \times 10^{-5}$ /K **(D)** $3 \times 10^{-5}$ /K

## Comprehension # 5

Solids and liquids both expand on heating. The density of substance decreases on expanding according to the relation

$\rho_2 = \dfrac{\rho_1}{1+\gamma(T_2 - T_1)}$, where, $\rho_1 \rightarrow$ density at $T_1$, $\rho_2 \rightarrow$ density at $T_2$, $\gamma \rightarrow$ coefficient of volume expansion of substances.

When a solid is submerged in a liquid, liquid exerts an upward force on solid which is equal to the weight of liquid displaced by submerged part of solid.

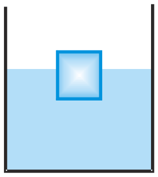
Solid will float or sink depends on relative densities of solid and liquid.
A cubical block of solid floats in a liquid with half of its volume submerged in liquid as shown in figure (at temperature T)

$\alpha_S \rightarrow$ Coefficient of linear expansion of solid

$\gamma_L \rightarrow$ Coefficient of volume expansion of liquid

$\rho_S \rightarrow$ Density of solid at temperature T

$\rho_L \rightarrow$ Density of liquid at temperature T



**1.** The relation between densities of solid and liquid at temperature T is

**(A)** $\rho_S = 2\rho_L$ **(B)** $\rho_S = (1/2)\rho_L$ **(C)** $\rho_S = \rho_L$ **(D)** $\rho_S = (1/4)\rho_L$

**2.** If temperature of system increases, then fraction of solid submerged in liquid

**(A)** increases **(B)** decreases **(C)** remains the same **(D)** inadequate information

**3.** Imagine friction submerged does not change on increasing temperature the relation between $\gamma_L$ and $\alpha_S$ is

**(A)** $\gamma_L = 3\alpha_S$ **(B)** $\gamma_L = 2\alpha_S$ **(C)** $\gamma_L = 4\alpha_S$ **(D)** $\gamma_L = (3/2)\alpha_S$

**4.** Imagine the depth of the block submerged in the liquid does not change on increasing temperature then

**(A)** $\gamma_L = 2\alpha$ **(B)** $\gamma_L = 3\alpha$ **(C)** $\gamma_L = (3/2)\alpha$ **(D)** $\gamma_L = (4/3)\alpha$

**5.** Assume block does not expand on heating. The temperature at which the block just begins to sink in liquid is

**(A)** $T + \frac{1}{\gamma_L}$ **(B)** $T + \frac{1}{(2\gamma_L)}$ **(C)** $T + \frac{2}{(\gamma_L)}$ **(D)** $T + \frac{\gamma_L}{2}$

## Comprehension # 6

Most substances contract on freezing. However, water does not belong to this category. We know that water expands on freezing. Further, coefficient of volume expansion of water in the temperature range from 0°C to 4°C is negative and above 4°C it is positive. This behaviour of water shapes the freezing of lakes as the atmospheric temperature goes down and it is still above 4°C.

**1.** As the atmospheric temperature goes down, but it is still above 4°C

**(A)** Cooled water at the surface flows downward because of its greater density

**(B)** Cooled water at the surface does not flow downward and remains at the surface because its smaller density

**(C)** Cooled water at the surface, through it remains on the surface because of its smaller density, will conduct heat from the interior to the atmosphere

**(D)** Cooled water at the surface flows to the bottom because of its smaller density

**2.** As the atmospheric temperature goes below 4°C

**(A)** Cooled water at the surface flows downward because of its greater density

**(B)** Cooled water at the surface does not flow downward and remains at the surface because of its smaller density

**(C)** Cooled water at the surface downward because of its smaller density

**(D)** Temperature of water in the lake reduces with depth

**3.** If the atmospheric temperature is below 0°C and ice begins to form at t = 0, thickness of ice sheet formed up to a time 't' will be directly proportional to a time 't' will be directly proportional to

**(A)** $t^4$ **(B)** $t^2$ **(C)** t **(D)** $t^{1/2}$

**4.** If the atmospheric temperature is below 0°C

**(A)** Ice will form from the bottom upward and the plants and animals in the lake will be displaced to the upper part of the lake.

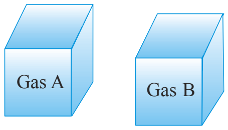
**(B)** Ice will form in a random manner throughout the volume of the lake and with the passage of time, different segments of ice will join together to result in a collective ice mass

**(C)** Ice will form from the surface downward and plant and animal life will survive in the water beneath

**(D)** Water in the lake does not freeze. In fact, water in the atmosphere freezes and fall into the lake and floats on the surface of lake as ice.

## Comprehension # 7

Two closed identical conducting containers are found in the laboratory of an old scientist. For the verification of the gas some experiments are performed on the two boxes and the results are noted.




**Experiment 1.** When the two containers are weighed $W_A = 225$ g, $W_B = 160$ g and mass of evacuated container $W_c$=100g.

**Experiment 2.** When the two containers are given same amount of heat same temperature rise is recorded. The pressure change found are $\Delta P_A = 2.5$ atm. $\Delta P_B = 1.5$ atm

**Required data for unknown gas :**

| | | | | | | |
|---|---|---|---|---|---|---|
| Mono (molar mass) | He 4g | Ne 20g | Ar 40g | Kr 84g | Xe 131g | Rd 222g |
| Dia (molar mass) | $H_2$ 2g | $F_2$ 19g | $N_2$ 28g | $O_2$ 32g | $Cl_2$ 71g | |

**1.** Identify the type of gas filled in container A and B respectively

**(A)** Mono, Mono **(B)** Dia, Dia **(C)** Mono, Dia **(D)** Dia, Mono

**2.** Identify the gas filled in the container A and B

**(A)** $N_2$, Ne **(B)** He, $H_2$ **(C)** $O_2$, Ar **(D)** Ar, $O_2$

**3.** Total number of molecules in 'A' (Here $N_A$ = avagadro number)

**(A)** $\frac{125}{64}N_A$ **(B)** 3.125 $N_A$ **(C)** $\frac{125}{28}N_A$ **(D)** 31.25 $N_A$

**4.** The initial internal energy of the gas in container 'A', If the containers were at room temperature 300K initially.

**(A)** 1406.25 cal **(B)** 1000 cal **(C)** 2812.5 cal **(D)** None of these

**5.** If the gases have initial temperature 300 K and they are mixed in an adiabatic container having the same volume as the previous containers. Now the temperature of the mixture is T and pressure is P. Then

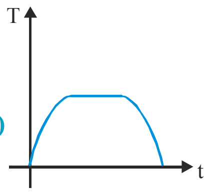
**(A)** $P > P_A$, $T > 300$ K **(B)** $P > P_B$ , $T = 300$ K

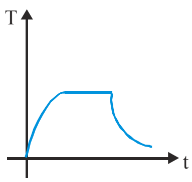
**(C)** $P < P_A$, $T = 300$ K **(D)** $P > P_A$. $T < 300$ K

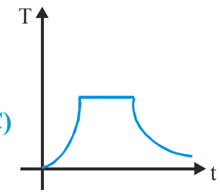
## Comprehension # 8

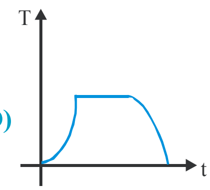
In a home experiment, Ram brings a new electric kettle with unknown power rating. He puts 1 litre water in the kettle and switches on. But to his dismay, the temperature becomes constants at $60^0$C after some time. The room temperature is $20^0$C. Ram gets bored and switches off the kettle. He sees that during first 20 s water cools down by $2^0$C.

**1.** Which is the best graph for temperature v/s time?

**(A)** 


**(B)** 


**(C)** 


**(D)** 


**2.** What is the wattage of the kettle
**(A)** 840W **(B)** 1W **(C)** 100W **(D)** 420 W

**3.** What is the time taken for the water to cool to $40^0$C. (Approx)
**(A)** 510 s **(B)** 270 s **(C)** 120 s **(D)** 410 s

## Comprehension # 9

Five moles of helium are mixed with two moles of hydrogen to form a mixture. Take molar mass of helium $M_1$=4g and that of hydrogen $M_2$=2g

**1.** The equivalent molar mass of the mixture is
**(A)** 6g **(B)** $\frac{13g}{7}$ **(C)** $\frac{18g}{7}$ **(D)** None

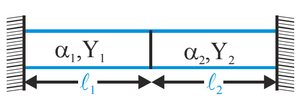
**2.** The equivalent degree of freedom f of the mixture is
**(A)** 3.57 **(B)** 1.14 **(C)** 4.4 **(D)** None

**3.** The equivalent value of $\gamma$ is
**(A)** 1.59 **(B)** 1.53 **(C)** 1.56 **(D)** None

**4.** If the internal energy of He sample is 100J and that of the hydrogen sample is 200J, then the internal energy of the mixture is
**(A)** 900 J **(B)** 128.5 J **(C)** 171.4J **(D)** 300J

## Comprehension # 10

Two rods of equal cross sections area are joined end the end as shown in figure. These are supported between two rigid vertical walls. Initially the rods are unstrained.




**1.** If temperature of system is increased by $\Delta T$ then junction will not shift if–
**(A)** $Y_1\alpha_1 = Y_2\alpha_2$ **(B)** $Y_1\alpha_1\ell_1 = Y_2\alpha_2\ell_2$ **(C)** $\alpha_1 = \alpha_2$ **(D)** $Y_2\alpha_1\ell_1 = Y_1\alpha_2\ell_2$

**2.** If temperature of system is increased by $\Delta T$ then thermal stress developed in first rod–
**(A)** is equal to thermal stress developed in second rod
**(B)** is greater than thermal stress developed in second rod
**(C)** is less than thermal stress developed in second rod
**(D)** None of these

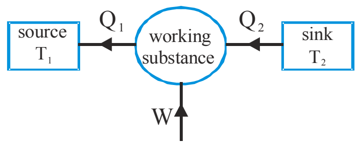
**3.** If temperature of system is increased by $\Delta T$ then shifting in junction if $Y_1\alpha_1 > Y_2\alpha_2$ is given by–

**(A)** $\dfrac{\ell_1\ell_2(Y_1\alpha_2 - Y_2\alpha_1)}{Y_1\ell_1 + Y_2\ell_2}$ **(B)** $\dfrac{\ell_1\ell_2(Y_1\alpha_1 - Y_2\alpha_2)}{Y_1\ell_2 + Y_2\ell_1}$ **(C)** $\dfrac{\ell_1\ell_2(Y_1\alpha_1 - Y_2\alpha_2)}{Y_1\ell_1 + Y_2\ell_2}$ **(D)** None of these

## Comprehension # 11

Refrigerator is an apparatus which takes heat from a cold body, work is done on it and the work done together with the heat absorbed is rejected to the source. An ideal refrigerator can be regarded as Carnot's ideal heat engine working in the reverse direction. The coefficient of performance of refrigerator is defined as

$$\beta = \frac{\text{Heat extracted from cold reservoir}}{\text{work done on working substance}} = \frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2} = \frac{T_2}{T_1 - T_2}$$




A Carnot's refrigerator takes heat from water at 0°C and discards it to a room temperature at 27°C. 1kg of water at 0°C is to be changed into ice at 0°C. ($L_{ice}$ = 80 kcal/kg)

**1.** How many calories of heat are discarded to the room ?

**(A)** 72.8 kcal **(B)** 87.9 kcal **(C)** 80 kcal **(D)** 7.9 kcal

**2.** What is the work done by the refrigerator in this process (1 cal = 4.2 joule)

**(A)** 7.9 kJ **(B)** 33.18 kJ **(C)** 43.18 kJ **(D)** 23.18 kJ

**3.** What is the coefficient of performance of the machine ?

**(A)** 11.1 **(B)** 10.1 **(C)** 9.1 **(D)** 8.1

## Comprehension # 12

Entropy **(S)** is a thermodynamic variable like pressure P, volume V and temperature T. Entropy of a thermodynamic system is a measure of disorder of molecular motion. Greater is disorder, greater is entropy. Change in entropy of a thermodynamic system is the ratio of heat supplied to absolute temperature. In an adiabatic reversible process, entropy remains constant while in any irreversible process entropy increases. In nature the processes are irreversible; therefore entropy of universe is continuously increasing.

**1.** The unit of entropy in S–I system is–

**(A)** cal/K **(B)** joule/kg **(C)** joule/K **(D)** kilocal/°C

**2.** When milk is heated, its entropy :

**(A)** increases **(B)** decreases **(C)** remains unchanged **(D)** may decrease or increase

**3.** After a long–long time, the energy available for work will be :

**(A)** as much as present value **(B)** much less than present value

**(C)** much more than present value **(D)** can not say

## Comprehension # 13

A substance is in the solid form at 0°C. The amount of heat added to this substance and its temperature is plotted in the graph. The specific heat capacity of the solid substance is 0.5 cal/g°C.

**1.** The mass of the substance is-

**(A)** 6g **(B)** 12g **(C)** 3g **(D)** Can't be calculated

**2.** Latest heat capacity in melting process is-

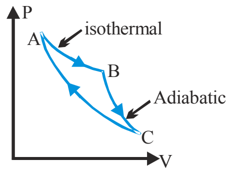
**(A)** cal/g **(B)** 175/3 cal/g **(C)** 400/3 cal/g **(D)** Can't say

**3.** Specific heat capacity in the liquid state is-

**(A)** 5/27 cal/g°C **(B)** 5/27 cal/gK **(C)** 10/27 cal/g°C **(D)** Can't say

## Comprehension # 14

A cyclic process for an ideal gas is shown in figure. Given $W_{AB} = +700$ J, $W_{BC} = +400$ J, $Q_{CA} = -100$J.



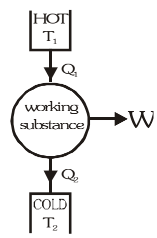

**1.** Find $\Delta U_{BC}$
**(A)** –700 J **(B)** –400 J **(C)** –100 J **(D)** 400 J

**2.** Find $W_{CA}$
**(A)** –500 J **(B)** 500 J **(C)** 400 J **(D)** –400 J

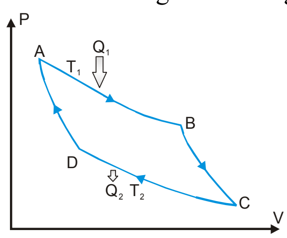
**3.** The efficiency of the cycle is -
**(A)** 100% **(B)** 83.44% **(C)** 85.71% **(D)** 81.11%

## Comprehension # 15

The efficiency of a heat engine is defined as the ratio of the mechanical work done by the engine in one cycle to the heat absorbed from the high temperature source. $\eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1}$ Cornot devised an ideal engine which is based on a reversible cycle of four operations in succession : isothermal expansion, adiabatic expansion, isothermal compression and adiabatic compression.




For carnot cycle $\frac{Q_1}{T_1} = \frac{Q_2}{T_2}$ . Thus $\eta = \frac{Q_1 - Q_2}{Q_1} = \frac{T_1 - T_2}{T_1}$ According to carnot theorem "No irreversible engine can have efficiency greater than carnot reversible engine working between same hot and cold reservoirs".




**1.** A carnot engine whose low temperature reservoir is at 7°C has an efficiency of 50%. It is desired to increase the efficiency to 70%. By how many degrees should the temperature of the high temperature reservoir be increased?
**(A)** 273 K **(B)** $\frac{1120}{3}$K **(C)** 140 K **(D)** None of these

**2.** An inventor claims to have developed an engine working between 600K and 300K capable of having an efficiency of 52%, then-
**(A)** It is impossible **(B)** It is possible **(C)** It is nearly possible **(D)** Data is insufficient

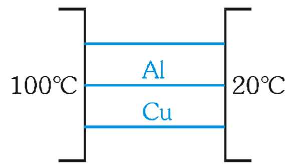
**3.** Efficiency of a carnot's cycle change from $\frac{1}{6}$ to $\frac{1}{3}$ when source temperature is raised by 100 K. The temperature of the sink is-
**(A)** $\frac{1000}{3}$K **(B)** $\frac{500}{3}$K **(C)** 250 K **(D)** 100 K

# Exercise # 4 [Subjective Type Questions]

**1.** A bimetallic strip of thickness d and length L is clamped at one end at temperature $t_1$. Find the radius of curvature of the strip if it consists of two different metals of expansivity $\alpha_1$ and $\alpha_2$ ($\alpha_1 > \alpha_2$) when its temperature rises to $t_2$°C.

**2.** Two rods each of length $L_2$ and coefficient of linear expansion $\alpha_2$ each are connected freely to a third rod of length $L_1$ and coefficient of expansion $\alpha_1$ to form an isosceles triangle. The arrangement is supported on a knife–edge at the midpoint of $L_1$ which is horizontal. What relation must exist between $L_1$ and $L_2$ so that the apex of the isosceles triangle is to remain at a constant height from the knife edge as the temperature changes?

**3.** Two metal cubes with 3 cm–edges of copper and aluminium are arranged as shown in figure. Find

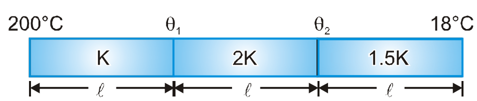



**(i)** The total thermal current from one reservoir to the other.
**(ii)** The ratio of the thermal current carried by the copper cube to that carried by the aluminium cube.

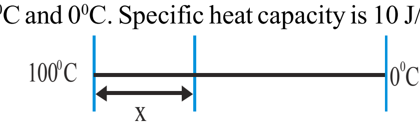
Thermal conductivity of copper is 60 W/m–K and that of aluminium is 40 W/m–K.

**4.** A 'thermacole' icebox is a cheap and efficient method for storing small quantities of cooked food in summer in particular. A cubical icebox of side 30 cm has a thickness of 5.0 cm. If 4.0 kg of ice is put in the box, estimate the amount of ice remaining after 6 h. The outside temperature is 45 °C, and co–efficient of thermal conductivity of thermacole is 0.01 J $s^{-1}$ $m^{1}$ °$C^{-1}$. [Heat of fusion of water = 335 × $10^3$ J $kg^{-1}$]

**5.** Calculate $\theta_1$ and $\theta_2$ in shown situation.

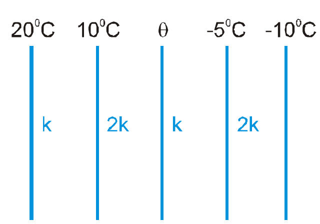



**6.** A lagged stick of cross section area 1 $cm^2$ and length 1m is initially at a temperature of $0^0$C. It is then kept between 2 reservoirs of temperature $100^0$C and $0^0$C. Specific heat capacity is 10 J/kg$^0$C and linear mass density is 2kg/m. Find




**(i)** Temperature gradient along the rod in steady state
**(ii)** Total heat absorbed by the rod to reach steady state

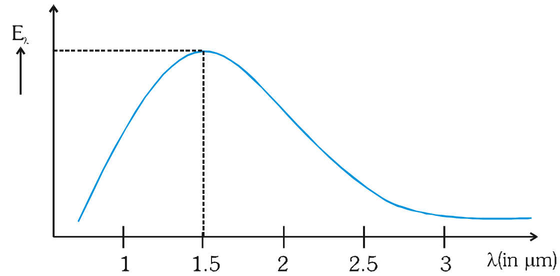
**7.** The figure shows the face and interface temperature of a composite slab containing of four layers of two materials having identical thickness. Under steady state condition, find the value of temperature θ.




k=thermal conductivity

**8.** An electric heater is used in a room of total wall area 137 $m^2$ to maintain a temperature of +20°C inside it, when the outside temperature is –10°C. The walls have three different layers materials. The innermost layer is of wood of thickness 2.5 cm, the middle layer is of cement of thickness 1.0 cm and the outermost layer is of brick of thickness 25.0 cm. Find the power of the electric heater. Assume that there is no heat loss through the floor and the ceiling. The thermal conductivities of wood, cement and brick are 0.125, 1.5 and 1.0 W/m/°C respectively.

**9.** Calculate the temperature of the black body from given graph.




**10.** In an industrial process 10 kg of water per hour is to be heated from $20^0C$ to $80^0C$. To do this, steam at $150^0C$ is passed from a boiler into a copper coil immersed in water. The steam condenses in the coil and is returned to the boiler as water at $90^0C$. How many kg of steam are required per hour? Specific heat of steam = 1 kilocal $kg^{-1}\ {}^0C^{-1}$. Latent heat of steam = 540 kilocal $kg^1$.

**11.** Two bodies A and B have thermal emissivities of 0.01 and 0.81 respectively. The outer surface areas of the two bodies are same, the two bodies emit total radiant power at the same rate. The wavelength $\lambda_B$ corresponding to maximum spectral radiance from B is shifted from the wavelength corresponding to maximum spectral radiancy in the radiation from A by 1.0 μm. If the temperature of A is 5802K, Calculate :–

**(i)** The temperature of **(ii)** Wavelength $\lambda_B$

**12.** **Answer the following questions in brief :**

**(i)** A poor emitter has a large reflectivity. Explain why.

**(ii)** A copper tumbler feels much colder than a wooden block on a cold day. Explain why.

**(iii)** The earth would become so cold that life is not possible on it in the absence of the atmosphere. Explain why?

**(iv)** Why clear nights are cooler than cloudy nights ?

**(v)** Why does a piece of red glass when heated and taken out glow with green light ?

**(vi)** Why does the earth not become as hot as the sun although it has been receiving heat from the sun for ages ?

**(vii)** Animals curl into a ball when they are very cool. Why ?

**(viii)** Heat is generated continuously in an electric heater but its temperature becomes constant after some time. Explain why ?

**(ix)** A piece of paper wrapped tightly on a wooden rod is observed to get charred quickly when held over a flame as compared to a similar piece of paper when wrapped on a brass rod. Explain why ?

**(x)** Liquid in a metallic pot boils quickly whose base is made black and rough than in a pot whose base is highly polished. Why ?

**13.** The temperature of equal masses of three different liquids A, B and C are $12^0C$, $19^0C$ and $28^0C$ respectively. The temperature when A and B are mixed is $16^0C$ and when B and C are mixed it is $23^0C$. What will be the temperature when A and C are mixed?

**14.** Aluminium container of mass 10 g contains 200 g of ice at $-20^0C$. Heat is added to the system at the rate of 100 calories per second. What is the temperature of the system after four minutes? Draw a rough sketch showing the variation of the temperature of the system as a function of time. Given :

Specific heat of ice = 0.5 cal $g^{-1}\ ({}^0C)^{-1}$

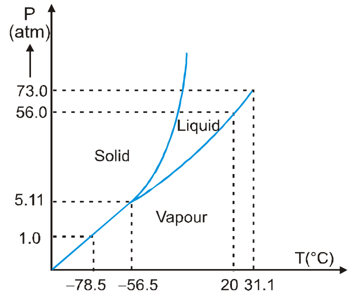
Specific heat of aluminium = 0.2 cal $g^{-1}\ ({}^0C)^{-1}$

Latent heat of fusion of ice = 80 cal $g^{-1}$

**15.** The temperature of 100 g of water is to be raised from 24°C to 90°C by adding steam to it. Calculate the mass of the steam required for this purpose.

**16.** A lead bullet just melts when stopped by an obstacle. Assuming that 25 percent of the heat is absorbed by the obstacle, find the velocity of the bullet if its initial temperature is 27°C.
(Melting point of lead = 327°C, Specific heat of lead = 0.03 cal/g°C,
Latent heat of fusion of lead = 6 cal/g, J = 4.2 J/cal.

**17.** Answer the following questions based on the P–T phase diagram of carbon dioxide




**(i)** At what temperature and pressure can the solid, liquid and vapour phases of $CO_2$ co–exist in equilibrium
**(ii)** What is the effect of decrease of pressure on the fusion and boiling point of $CO_2$?
**(iii)** What are the critical temperature and pressure for $CO_2$ ? What is their significance?
**(iv)** Is $CO_2$ solid, liquid or gas at (A) –70 °C under 1 atm, (B) – 60 °C under 10 atm, (C) 15 °C under 56 atm ?

**18.** A thin tube of uniform cross–section is sealed at both ends. It lies horizontally, the middle 5 cm containing mercury and the two equal ends containing air at the same pressure P. When the tube is held at an angle of 60° with the vertical direction, the length of the air column above and below the mercury column are 46 cm and 44.5 cm respectively. Calculate the pressure P in centimetres of mercury. (The temperature of the system is kept at 30°C).

**19.** Two glass bulbs of equal volume are connected by a narrow tube and are filled with a gas at 0°C and a pressure of 76 cm of mercury. One of the bulbs is then placed in melting ice and the other is placed in a water bath maintained at 62°C. What is the new value of the pressure inside the bulbs ? The volume of the connecting tube is negligible.

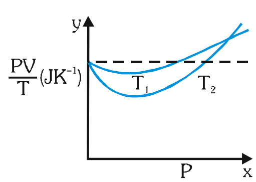
**20.** An oxygen cylinder of volume 30 litres has an initial gauge pressure of 15 atm and a temperature of 27° C. After some oxygen is with drawn from the cylinder, the gauge pressure drops to 11 atm and its temperature drops to 17°C. Estimate the mass of oxygen taken out of the cylinder. ($R = 8.31\ J\ mol^{-1} K^{-1}$, molecular mass of $O_2 = 32$ u.)

**21.** A closed container of volume 0.2 $m^3$ contains a mixture of neon and argon gases, at a temperature of 27°C and pressure of $1 \times 10^5\ Nm^{-2}$. The total mass of the mixture is 28 g. If the molar masses of neon and argon are 20 and 40 g $mol^{-1}$ respectively, find the masses of the individual gases in the container assuming them to be ideal (Universal gas constant R = 8.314 J/mol–K).

**22.** For a gas $\frac{R}{C_P} = 0.4$ . For this gas calculate the following **(i)** Atomicity and degree of freedom **(ii)** Value of $C_V$ and $\gamma$

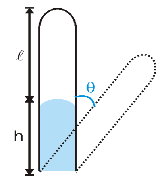
**(iii)** Mean gram – molecular kinetic energy at 300 K temperature

**23.** Figure shows plot of PV/T versus P for $1.00 \times 10^{-3}$ kg of oxygen gas at two different temperatures.



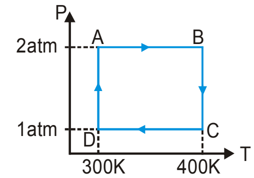

**(i)** What does the dotted plot signify ?
**(ii)** Which is true. $T_1 > T_2$ or $T_1 < T_2$ ?
**(iii)** What is the value of PV/T where the curves meet on the y–axis ?

**24.** An ideal gas is enclosed in a tube and is held in the vertical position with the closed end upward. The length of the pellet of mercury entrapping the gas is h = 10 cm and the length of the tube occupied by gas is $\ell$ = 40 cm. Calculate the length occupied by the gas when it is turned through $\theta = 60^0$ and $90^0$. Atmospheric pressure, H = 76 cm of mercury.



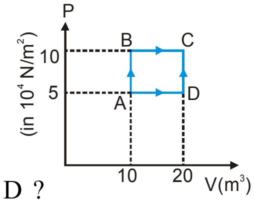

**25.** One gram mole of oxygen at 27°C and one atmospheric pressure is enclosed in a vessel. **(i)** Assuming the molecules to be moving with $v_{rms}$, find the number of collisions per second which the molecules make with one square metre area of the vessel wall. **(ii)** The vessel is next thermally insulated and moved with a constant speed $v_0$. It is then suddenly stopped. The process results in a rise of the temperature of the gas by 1°C. Calculate the speed $v_0$.

**26.** Two moles of helium gas undergo a cyclic process as shown in figure. Assuming the gas to be ideal, calculate the following quantities in this process.



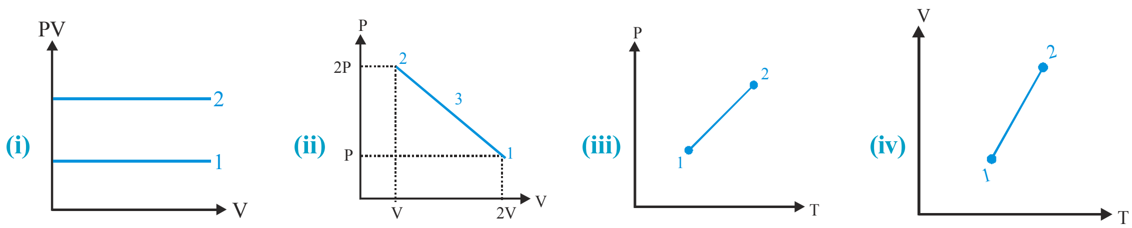

**(i)** The net change in the heat energy.
**(ii)** The net work done **(iii)** The net change in internal energy

**27.** A sample of 2 kg monoatomic helium (assumed ideal) is taken from A to C through the process ABC and another sample of 2 kg of the same gas is taken through the process ADC (see fig). Given molecular mass of helium = 4.




**(i)** What is the temperature of helium in each of the states A, B, C and D ?
**(ii)** Is there any way of telling afterwards which sample of helium went through the process ABC and which went through the process ADC ? Write Yes and No.
**(iii)** How much is the heat involved in the process ABC and ADC ?

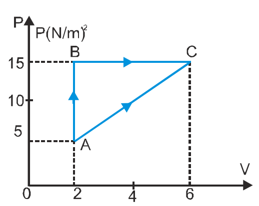
**28.** Examine the following plots and predict whether in **(i)** $P_1 < P_2$ and $T_1 > T_2$, in **(ii)** $T_1 = T_2 < T_3$, in **(iii)** $V_1 > V_2$, in **(iv)** $P_1 > P_2$ or $P_2 > P_1$




**29.** The pressure in monoatomic gas increases linearly from 4× 10⁵ N/m² to 8× 10⁵ N/m² when its volume increases from 0.2 m³ to 0.5 m³ . Calculate the following –

**(i)** Work done by the gas **(ii)** Increase in internal energy
**(iii)** Amount of heat supplied **(iv)** Molar specific heat of the gas

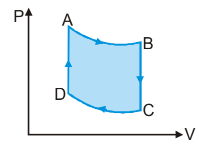
**30.** In the given figure an ideal gas changes its state from A to state C by two paths ABC and AC.




**(i)** Find the path along which work done is the least.
**(ii)** The internal energy of gas at A is 10J and amount of heat supplied to change its state to C through the path AC is 200J. Calculate the internal energy at C.
**(iii)** The internal energy of gas at state B is 20J. Find the amount of heat supplied to the gas from A to B.

**31.** Three moles of an ideal gas ($C_P = \frac{7}{2}R$) at pressure, $P_A$ and temperature $T_A$ is isothermally expanded to twice its initial volume. It is then compressed at constant pressure to its original volume. Finally gas is compressed at constant volume to its original pressure $P_A$.
**(i)** Sketch P–V and P–T diagrams for the complete process.
**(ii)** Calculate the net work done by the gas, and net heat supplied to the gas during the complete process.

**32.** On mole of a monoatomic ideal gas is taken through the cycle shown in figure.




$A \to B$ : Adiabatic expansion $\quad B \to C$ : Cooling at constant volume
$C \to D$ : Adiabatic compression $\quad D \to A$ : Heating at constant volume
The pressure and temperature at A, B, etc., are denoted by $P_A$, $T_A$, $P_B$, $T_B$ etc., respectively. Given that $T_A = 1000$ K, $P_B = \left(\frac{2}{3}\right)P_A$ and $P_C = \left(\frac{1}{3}\right)P_A$.
Calculate the following quantities : **(i)** The work done by the gas in the process $A \to B$ **(ii)** The heat lost by the gas in the process $B \to C$ **(iii)** The temperature $T_D$. (Given : $\left(\frac{2}{3}\right)^{2/5} = 0.85$)

**33.** At 27°C two moles of an ideal monoatomic gas occupy a volume V. Then gas is adiabatically expanded until its volume becomes 2V. Calculate : **(i)** The final temperature of the gas **(ii)** Change in its internal energy **(iii)** The work done by the gas during this process

**34.** Two moles of helium gas ($\gamma = 5/3$) are initially at temperature 27°C and occupy a volume of 20 L. The gas is first expanded at constant pressure until the volume is doubled. Then it undergoes an adiabatic change until the temperature returns to its initial value. **(i)** Sketch the process on a P–V diagram **(ii)** What are the final volume and pressure of the gas ? **(iii)** What is the work done by the gas ?

**35.** An ideal gas having initial pressure P, volume V and temperature T is allowed to expand adiabatically until its volume becomes 5.66 V while its temperature falls to $\frac{T}{2}$. **(i)** How many degrees of freedom do gas molecules have? **(ii)** Obtain the work done by the gas during the expansion as a function of the initial pressure P and volume V. [Take $(5.66)^{0.4}=2$]

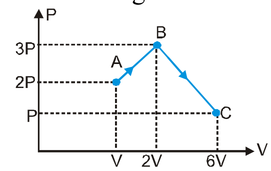
**36.** Calculate the work done when one mole of a perfect gas is compressed adiabatically. The initial pressure and volume of the gas are $10^5$ N/m$^2$ and 6L respectively. The final volume of the gas is 2L, molar specific heat of the gas at constant volume is $\frac{3R}{2}$.

**37.** An ideal gas has a specific heat at constant pressure $C_P = \frac{5R}{2}$. The gas is kept in a closed vessel of volume 0.0083 m$^3$, at a temperature of 300 K and a pressure of $1.6 \times 10^6$ N/m$^2$. An amount of $2.49 \times 10^4$ J of heat energy is supplied to the gas. Calculate the final temperature and pressure of the gas.

**38.** An ideal gas is taken through a cyclic thermodynamic process through four steps. The amounts of heat involved in these steps are $Q_1 = 5960$ J, $Q_2 = -5585$ J, $Q_3 = -2980$ J and $Q_4 = 3645$ J respectively. The corresponding quantities of work involved are $W_1 = 2200$ J, $W_2 = -825$ J, $W_3 = -1100$ J and $W_4$ respectively.
**(i)** Find the value of $W_4$. **(ii)** What is the efficiency of the cycle ?

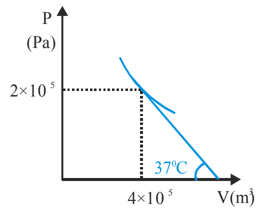
**39.** A gaseous mixture enclosed in a vessel of volume V consists of one gram mole of gas A with $\gamma = \frac{C_P}{C_V} = \frac{5}{3}$) an another gas B with $\gamma = \frac{7}{5}$ at a certain temperature T. The gram molecular weights of the gases A and B are 4 and 32 respectively. The gases A and B do not react with each other and are assumed to be ideal. The gaseous mixture follows the equation $PV^{19/13}$ = constant, in adiabatic process. Find the number of gram moles of the gas B in the gaseous mixture.

**40.** One mole of monoatomic ideal gas undergoes a process ABC as shown in figure. The maximum temperature of the gas during the process ABC is in the form $\frac{xPV}{R}$. Find x.




**41.** A gas has molar heat capacity C = 37.35 J $mole^{-1}K^{-1}$ in the process PT = constant. Find the number of degree of freedom of molecules in the gas.

**42.** P–V graph for an ideal gas undergoing polytropic process $PV^m$ = constant is shown here. Find the value of m.

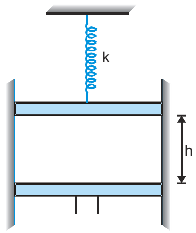



**43.** An ideal monoatomic gas occupies volume 10–3 m3 at temperature 3K and pressure 103 Pa. The internal energy of the gas is taken to be zero at this point. It undergoes the following cycle : The temperature is raised to 300 K at constant volume, the gas is then expanded adiabatically till the temperature is 3K, followed by isothermal compression to the original volume. Plot the process on a PV diagram. Calculate **(i)** The work done and the heat transferred in each process and the internal energy at the end of each process, **(ii)** The thermal efficiency of the cycle.

**44.** A vertical cylinder of cross–sectional area 0.1 $m^2$ closed at both ends is fitted with a frictionless piston of mass M dividing the cylinder into two parts. Each part contains one mole of an ideal gas in equilibrium at 300K. The volume of the upper part is 0.1 $m^3$ and that of the lower part is 0.05 $m^3$. What force must be applied to the piston so that the volumes of the two parts remain unchanged when the temperature is increased to 500K?

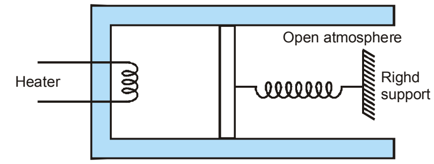
**45.** One mole of an ideal gas is heated isobarically from the freezing point to the boiling point of water each under normal pressure. Find out the work done by the gas and the change in its internal energy. The amount of heat involved is 1kJ.

**46.** An ideal gas at NTP is enclosed in a adiabatic vertical cylinder having area of cross section A = 27 $cm^2$, between two light movable pistons as shown in the figure. Spring with force constant k = 3700 N/m is in a relaxed state initially. Now the lower piston is moved upwards a height $\frac{h}{2}$, being the initial length of gas column. It is observed that the upper piston moves up by a distance $\frac{h}{16}$. Find h taking $\gamma$ for the gas to be 1.5. Also find the final temperature of the gas.



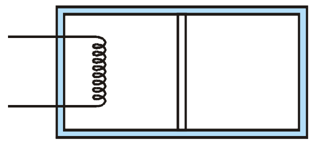

**47.** There is a soap bubble of radius $2.4 \times 10^{-4}$ m in air cylinder which is originally at the pressure of $10^5$ $Nm^{-2}$. The air in the cylinder is now compressed isothermally until the radius of the bubble is halved. Calculate now the pressure of air in the cylinder. The surface tension of the soap film is 0.08 N/m.

**48.** An ideal monoatomic gas is confined in a cylinder by a spring–located position of cross–section $8.0 \times 10^{-3}$ $m^2$. Initially the gas is at 300 K and occupies a volume of $2.4 \times 10^{-3}$ $m^3$ and the spring is in its relaxed (unstretched, uncompressed) state. The gas is heated by a small electric heater until the piston moves out slowly by 0.1 m. Calculate the final temperature of the gas and the heat supplied (in joules) by the heater.




The force constant of the spring is 8000 N/m, and the atmospheric pressure $1.0 \times 10^5$ $Nm^{-2}$. The cylinder and the piston are thermally insulated. The piston is massless and there is no friction between the piston and the cylinder. Neglect heat loss through the lead wires of the heater. The heat capacity of the heater coil is negligible. Assume the spring to the massless.

**49.** The rectangular box shows in figure has a partition which can slide without friction along the length of the box. Initially each of the two chambers of the box has one mole of a monoatomic ideal gas ($\gamma = 5/3$) at a pressure $P_0$, volume $V_0$ and temperature $T_0$. The chamber on the left is slowly heated by an electric heater. The walls of the box and the partition are



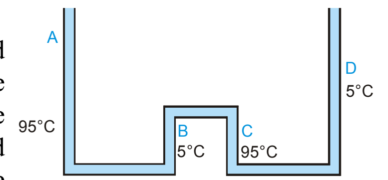
thermally insulated. Heat loss through the lead wires of the heater is negligible. The gas in the left chamber expands pushing the partition until the final pressure in both chambers becomes $\frac{243P_0}{32}$. Determine **(i)** the final temperature of the gas in each chamber and **(ii)** the work done by the gas in the right chamber.

**50.** One mole of a diatomic ideal gas ($\gamma = 1.4$) is taken through a cyclic process starting from point A. The process $A \to B$ is an adiabatic compression. $B \to C$ is isobaric expansion, $C \to D$ an adiabatic expansion and $D \to A$ is isochoric. The volume ratio are $\frac{V_A}{V_B} = 16$ and $\frac{V_C}{V_D} = 2$ and the temperature at A is $T_A = 300$ K. Calculate the temperature of the gas at the points B and D and find the efficiency of the cycle.

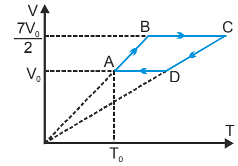
**51.** A cylindrical block of length 0.4 m and area of cross–section 0.04 $m^2$ is placed coaxially on a thin metal disc of mass 0.4 kg and of the same cross–section. The upper face of the cylinder is maintained at a constant temperature of 400 K and the initial temperature of the disc is 300 K. If the thermal conductivity of the material of the cylinder is 10 V/mK and the specific heat capacity of the material of the disc is 600 J/kg–K, how long will it take for the temperature of the disc of increase to 350 K? Assume, for purposes of calculation, the thermal conductivity of the disc to be very high and the system to be thermally insulated except for the upper face of the cylinder.

**52.** A double–pane window used for insulating a room thermally from outside consists of two glass sheets each of area 1 $m^2$ and thickness 0.01 m separated by a 0.05 m thick stagnant air space. In the steady state, the room glass interface and the glass–outdoor interface are at constant temperatures of 27°C and 0°C respectively. Calculate the rate of heat flow through the window pane. Also find the temperatures of other interfaces. Given thermal conductivities of glass and air as 0.8 and 0.08 $W\,m^{-1}K^{-1}$ respectively.

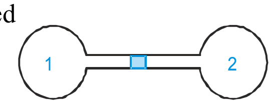
**53.** The apparatus shown in figure consists of four glass columns connected by horizontal sections. The height of two central columns B and C are 49 cm each. The two outer columns A and D are open to the atmosphere. A and C are maintained at a temperature of 95°C while the columns B and D are maintained at 5°C. The height of the liquid in A and D measured from the base line are 52.8 cm and 51 cm respectively. Determine the coefficient of thermal expansion of the liquid.



**54.** A sample of an ideal non linear triatomic gas has a pressure $P_0$ and temperatur $T_0$ taken through the cycle as shown starting from A. Pressure for process $C \rightarrow D$ is 3 times $P_0$. Calculate heat absorbed in the cycle and work done.




**55.** Two spherical flasks having total volume $V_0$ = 1.0 L containing air are connected by a tube diameter d = 6 mm and length $\lambda$ = 1m. A small droplet of mercury contained in the tube is at its middle at 0°C. By what distance do the mercury droplets move if the flask 1 is heated by 2°C while flask 2 is cooled by 2°C. Ignore any expansion of flask wall.



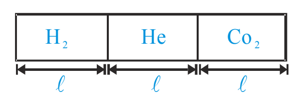

**56.** A weightless piston divides a thermally insulated cylinder into two parts of volumes V and 3V.2 moles of an ideal gas at pressure P=2 atmosphere are confined to the part with volume V=1 litre. The remainder of the cylinder is evacuated. The piston is now released and the gas expands to fill the entire space of the cylinder. The piston is then pressed back to the initial position. Find the increase in internal energy in the process and final temperature of the gas. The ratio of the specific heat of the gas $\gamma$ = 1.5.

**57.** Two moles of an ideal monoatomic gas are confined within a cylinder by a massless and frictionless spring loaded piston of cross–sectional area $4 \times 10^{-3}$ $m^2$. The spring is, initially in its relaxed state. Now the gas is heated by an electric heater, placed inside the cylinder, for some time. During this time, the gas expands and does 50 J of work in moving the piston through a distance 0.10 m. The temperature of the gas increases by 50 K. Calculate the spring constant and the heat supplied by the heater.

**58.** A barometer is faulty. When the true barometer reading are 73 cm and 75 cm of Hg, the faulty barometer reads 69 cm and 70 cm respectively **(i)** What is the total length of the barometer tube? **(ii)** What is the true reading when the faulty barometer reads 69.5 cm? **(iii)** What is the faulty barometer reading when the true barometer reads 74 cm?

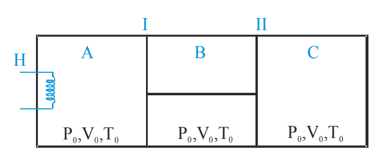
**59.** Two vertical cylinders are connected by a small tube at the bottom. It contains a gas at constant temperature. Initially the pistons are located at the same height. The diameters of the two cylinders are different. Outside the cylinder the space is vacuum. Gravitational acceleration is g. $h_0$ = 20 cm, $m_1$ = 2 kg and $m_2$ = 1 kg. The pistons are initially in equilibrium. If the masses of the piston are interchanged find the separation between the two pistons when they are again in equilibrium. Assume constant temperature.


**60.** A non–conducting cylindrical vessel of length $3\ell$ is placed horizontally & is divided into three parts by two easily moving piston having low thermal conductivity as shown in figure. These parts contains $H_2$, He and $CO_2$ gas at initial temp. $\theta_1 = 372^0C, \theta_2 = -15^0C$ and $\theta_3 = 157^0C$ respectively. If initial length and pressure of each part are $\ell$ and $P_0$ respectively, calculate final pressure and length of each part. Use : $\gamma_{CO_2}$ = 7/5.




**61.** An ideal diatomic gas undergoes a process in which its internal energy relates to the volume as $U = a\sqrt{V}$, where a is a constant. **(i)** find the work performed by the gas and the amount of heat to be transferred to this gas to increase its internal energy by 100J. **(ii)** find the molar specific heat of the gas for this process.

**62.** The figure shows an insulated cylinder divided into three parts, A, B & C. Pistons I and II are connected by a rigid rod and can move without friction inside the cylinder. Piston I is perfectly conducting while piston II is perfectly insulating. The initial state of the gas $(\gamma = 1.5)$ present in each compartment A, B and C is as shown. Now, compartment A is slowly given heat through a heater H such that the final volume of C becomes $\frac{4V_0}{9}$. Assume the gas to be ideal and find. **(i)** final pressure in each compartment A,B and C **(ii)** final temperatures in each compartment A,B and C **(iii)** heat supplied by the heater **(iv)** work done by gas in A and B **(v)** heat flowing across piston I



# Exercise # 5 Part # I [Previous Year Questions] [AIEEE/JEE-MAIN]

## K.T.G. CALORIMETRY

**1.** Cooking gas containers are kept in a lorry moving with uniform speed. The temperature of the gas molecules inside will- **[AIEEE - 2002]**

(1) increase (2) decrease
(3) remains same (4) decrease for some, while increase for others

**2.** At what temperature is the rms velocity of a hydrogen molecule equal to that of an oxygen molecules at 47° C? **[AIEEE-2002]**

(1) 80 K (2) –73 K (3) 3 K (4) 20 K

**3.** 1 mole of a gas with $\gamma = 7/5$ is mixed with 1 mole of a gas with $\gamma = 5/3$, then the value of $\gamma$ for the resulting mixture is **[AIEEE-2002]**

(1) 7/5 (2) 2/5 (3) 24/16 (4) 12/7

**4.** During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its absolute temperature. The ratio $C_P/C_V$ for the gas is- **[AIEEE -2003]**

(1) 4/3 (2) 2 (3) 5/3 (4) 3/2

**5.** One mole of ideal monoatomic gas ($\gamma = 5/3$) is mixed with one mole of diatomic gas ($\gamma = 7/5$). What is $\gamma$ for the mixture ? $\gamma$ denotes the ratio of specific heat at constant pressure, to that at constant volume- **[AIEEE - 2004]**

(1) 3/2 (2) 23/15 (3) 35/23 (4) 4/3

**6.** A gaseous mixture consists of 16 g of helium and 16 g of oxygen. The ratio $\frac{C_p}{C_v}$ of the mixture is-

(1) 1.59 (2) 1.62 (3) 1.4 (4) 1.54

**7.** If $C_P$ and $C_V$ denote the specific heats of nitrogen per unit mass at constant pressure and constant volume respectively, then- **[AIEEE - 2007]**

(1) $C_P - C_V = R/28$ (2) $C_P - C_V = R/14$ (3) $C_P - C_V = R$ (4) $C_P - C_V = 28\,R$

**8.** An insulated container of gas has two chambers separated by an insulating partition. One of the chambers has volume $V_1$ and contains ideal gas at pressure $P_1$ and temperature $T_1$. The other chamber has volume $V_2$ and contains ideal gas at pressure $P_2$ and tempeature $T_2$. If the partition is removed without doing any work on the gas, the final equilibrium temperature of the gas in the container will be- **[AIEEE - 2008]**

(1) $\frac{T_1T_2(P_1V_1 + P_2V_2)}{P_1V_1T_2 + P_2V_2T_1}$ (2) $\frac{P_1V_1T_1 + P_2V_2T_2}{P_1V_1 + P_2V_2}$ (3) $\frac{P_1V_1T_2 + P_2V_2T_1}{P_1V_1 + P_2V_2}$ (4) $\frac{T_1T_2(P_1V_1 + P_2V_2)}{P_1V_1T_1 + P_2V_2T_2}$

**9.** The speed of sound in oxygen ($O_2$) at a certain tempeature is 460 $ms^{-1}$. The speed of sound in helium (He) at the same temperature will be (assume both gases to be ideal) **[AIEEE - 2008]**

(1) $460\sqrt{\frac{200}{21}}\ ms^{-1}$ (2) $500\sqrt{\frac{200}{21}}\ ms^{-1}$ (3) $650\sqrt{2}\ ms^{-1}$ (4) $330\sqrt{2}\ ms^{-1}$

**10.** One kg of a diatomic gas is at a pressure of $8 \times 10^4$ N/m$^2$. The density of the gas is 4 kg/m$^3$. What is the energy of the gas due to its thermal motion ? **[AIEEE - 2009]**

**(1)** $6 \times 10^4$ J **(2)** $7 \times 10^4$ J **(3)** $3 \times 10^4$ J **(4)** $5 \times 10^4$ J

**11.** 100 g of water is heated from 30°C to 50°C Ignoring the slight expansion of the water, the change in its internal energy is (specific heat of water is 4184 J/kg/K) :- **[AIEEE - 2011]**

**(1)** 84 kJ **(2)** 2.1 kJ **(3)** 4.2 kJ **(4)** 8.4 kJ

**12.** Three perfect gases at absolute temperatures $T_1$, $T_2$ and $T_3$ are mixed. The masses of molecules are $m_1$, $m_2$, and $m_3$ and the number of molecules are $n_1$, $n_2$ and $n_3$ respectively. Assuming no loss of energy, then final temperature of the mixture is :- **[AIEEE - 2011]**

**(1)** $\frac{n_1T_1^2 + n_2T_2^2 + n_3T_3^2}{n_1T_1 + n_2T_2 + n_3T_3}$ **(2)** $\frac{n_1^2T_1^2 + n_2^2T_2^2 + n_3^2T_3^2}{n_1T_1 + n_2T_2 + n_3T_3}$ **(3)** $\frac{T_1 + T_2 + T_3}{3}$ **(4)** $\frac{n_1T_1 + n_2T_2 + n_3T_3}{n_1 + n_2 + n_3}$

**13.** The specific heat capacity of a metal at low temperautre **(T)** is given as $C_p(\text{kJK}^{-1}\text{kg}^{-1}) = 32\left(\frac{T}{400}\right)^3$ .A 100 gram vessel of this metal is to be cooled from 20°K to 4°K by a special refrigerator operating at room temperature (27°C). The amount of work required to cool the vessel is:- **[AIEEE - 2011]**

**(1)** equal to 0.002 kJ **(2)** greater than 0.148 kJ
**(3)** between 0.148 kJ and 0.028 kJ **(4)** less than 0.028 kJ

**14.** A container with insulating walls is divided into two equal parts by a partition fitted with a valve. One part is filled with an ideal gas at a pressure P and temperature T, whereas the other part is completely evacuated. If the valve is suddenly opened, the pressure and temperature of the gas will be :- **[AIEEE - 2011]**

**(1)** $\frac{P}{2}, T$ **(2)** $\frac{P}{2}, \frac{T}{2}$ **(3)** P, T **(4)** $P, \frac{T}{2}$

## THERMODYNAMICS

**15.** Which statement is incorrect ? **[AIEEE - 2002]**

**(1)** All reversible cycles have same efficiency
**(2)** Reversible cycle has more efficiency than an irreversible one
**(3)** Carnot cycle is a reversible one
**(4)** Carnot cycle has the maximum efficiency in all cycles

**16.** If mass-energy equivalence is taken into account, when water is cooled to form ice, the mass of water should- **[AIEEE - 2002]**

**(1)** increase **(2)** remain unchanged **(3)** decrease **(4)** first increase then decrease

**17.** Even carnot engine cannot give 100% efficiency because we cannot- **[AIEEE - 2002]**

**(1)** prevent radiation **(2)** find ideal sources
**(3)** reach absolute zero temperature **(4)** eliminate friction

**18.** "Heat cannot be itself flow from a body at lower temperature to a body at higher temperature" is a statement or consequence of- **[AIEEE - 2003]**

**(1)** second law of thermodynamics **(2)** conservation of momentum
**(3)** conservation of mass **(4)** first law of thermodynamics

**19.** Which of the following parameters does not characterise the thermodynamic state of matter ? **[AIEEE - 2003]**

**(1)** Temperature **(2)** Pressure **(3)** Work **(4)** Volume

**20.** A carnot engine takes $3 \times 10^6$ cal of heat from a reservoir at 627 °C and gives it to a sink at 27 °C. The work done by the engine is- **[AIEEE - 2003]**

**(1)** $4.2 \times 10^6$ J **(2)** $8.4 \times 10^6$ J **(3)** $16.8 \times 10^6$ J **(4)** zero

**21.** Which of the following statements is correct for any thermodynamic system ? **[AIEEE - 2004]**

**(1)** The internal energy changes in all processes
**(2)** Internal energy and entropy are state functions
**(3)** The change in entropy can never be zero
**(4)** The work done in an adiabatic process is always zero

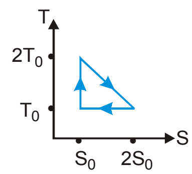
**22.** Two thermally insulated vessels 1 and 2 are filled with air at temperatures ($T_1$, $T_2$), volume ($V_1$, $V_2$) and pressure ($P_1$, $P_2$) respectively. If the valve joining the two vessels is opened, the temperature inside the vessel at equilibrium will be- **[AIEEE-2004]**

**(1)** $T_1 + T_2$ **(2)** $\frac{(T_1 + T_2)}{2}$ **(3)** $\frac{T_1 T_2 (P_1V_1 + P_2V_2)}{P_1V_1T_2 + P_2V_2T_1}$ **(4)** $\frac{T_1 T_2 (P_1V_1 + P_2V_2)}{P_1V_1T_1 + P_2V_2T_2}$

**23.** Which of the following is incorrect regarding the first law of thermodynamics ? **[AIEEE - 2005]**

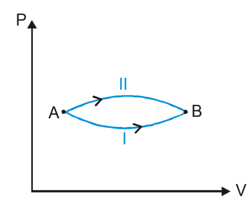
**(1)** It is applicable to any cyclic process
**(2)** It is a restatement of the principle of conservation of energy
**(3)** It introduces the concept of the internal energy
**(4)** It introduced the concept of the entropy

**24.** The temperature-entropy diagram of a reversible engine cycle is given in thefigure. Its efficiency is- **[AIEEE - 2005]**




**(1)** 1/2 **(2)** 1/4
**(3)** 1/3 **(4)** 2/3

**25.** A system goes from A to B via two processes I and II as shown in figure. If $\Delta U_1$ and $\Delta U_2$ are the changes in internal energies in the processes I and II respectively then- **[AIEEE - 2005]**




**(1)** $\Delta U_1 = \Delta U_2$ **(2)** relation between $\Delta U_1$ and $\Delta U_2$ cannot be determined
**(3)** $\Delta U_2 > \Delta U_1$ **(4)** $\Delta U_2 < \Delta U_1$

**26.** Two rigid boxes containing different ideal gases are placed on a table. Box A contains one mole of nitrogen at temperature $T_0$, while box B contains one mole of helium at temperature (7/3) $T_0$. The boxes are then put into thermal contact with each other, and heat flows between them until the gases reach a common final temperature (Ignore the heat capacity of boxes). Then, the final temperature of gases, $T_f$, in terms of $T_0$ is- **[AIEEE - 2006]**

**(1)** $T_f = \frac{3}{7} T_0$ **(2)** $T_f = \frac{7}{3} T_0$ **(3)** $T_f = \frac{3}{2} T_0$ **(4)** $T_f = \frac{5}{2} T_0$

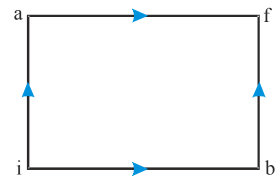
**27.** The work of 146 kJ is performed in order to compress one kilo mole of a gas adiabatically and in this process the temperature of the gas increases by 7°C. The gas is- (R = 8.3 J $mol^{-1}$ $K^{-1}$) **[AIEEE - 2006]**

**(1)** diatomic **(2)** triatomic
**(3)** a mixture of monoatomic and diatomic **(4)** monoatomic

**28.** A carnot engine, having an efficiency of $\eta = 1/10$ as heat engine, is used as a refrigetator. If the work done on the system is 10 J, the amount of energy absorbed from the reservoir at lower temperature is- **[AIEEE - 2007]**

**(1)** 99 J **(2)** 90 J **(3)** 1 J **(4)** 100 J

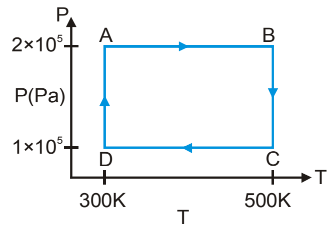
**29.** When a system is taken from state i to state f along the path iaf, it is found that Q = 50 cal and W = 20 cal. Along the path ibf Q = 36 cal. W along the path ibf is- **[AIEEE - 2007]**




**(1)** 6 cal **(2)** 16 cal **(3)** 66 cal **(4)** 14 cal

**Directions :** Question number 30, 31 and 32 are based on the following paragraph.

Two moles of helium gas are taken over the cycle ABCDA, as shown in the P–T diagram.




**30.** Assuming the gas to be ideal the work done on the gas in taking it from A to B is :- **[AIEEE - 2009]**

**(1)** 400 R **(2)** 500 R **(3)** 200 R **(4)** 300 R

**31.** The work done on the gas in taking it from D to A is :- **[AIEEE - 2009]**

**(1)** –690 R **(2)** +690 R **(3)** –414 R **(4)** +414 R

**32.** The net work done on the gas in the cycle ABCDA is :- **[AIEEE-2009]**

**(1)** 1076 R **(2)** 1904 R **(3)** Zero **(4)** 276 R

**33.** A diatomic ideal gas is used in a carnot engine as the working substance. If during the adiabatic expansion part of the cycle the volume of the gas increases from V to 32 V, the efficiency of the engine is :- **[AIEEE - 2010]**

**(1)** 0.25 **(2)** 0.5 **(3)** 0.75 **(4)** 0.99

**34.** A thermally insulated vessel contains an ideal gas of molecular mass M and ratio of specific heats $\gamma$. It is moving with speed v and is suddenly broght to rest. Assuming no heat is lost to the surroundings, its temperature increases by:- **[AIEEE - 2011]**

**(1)** $\frac{\gamma M v^2}{2R}K$ **(2)** $\frac{(\gamma-1)}{2R}Mv^2K$ **(3)** $\frac{(\gamma-1)}{2(\gamma+1)R}Mv^2K$ **(4)** $\frac{(\gamma-1)}{2\gamma R}Mv^2K$

**35.** A Carnot engine operating between temperatures $T_1$ and $T_2$ has efficientcy $\frac{1}{6}$. When $T_2$ is lowered by 62 K, its efficiency increases to $\frac{1}{3}$. Then $T_1$ and $T_2$ are, respectively:- **[AIEEE - 2011]**

**(1)** 330 K and 268 K **(2)** 310 K and 248 K **(3)** 372 K and 310 K **(4)** 372 K and 330 K

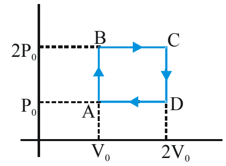
**36.** An aluminium sphere of 20 cm diameter is heated from 0°C to 100°C. Its volume changes by (given that coefficient of linear expansion for aluminium $\alpha_{Al} = 23 \times 10^{-6}/°C$ :- **[AIEEE - 2011]**

**(1)** 28.9 cc **(2)** 2.89 cc **(3)** 9.28 cc **(4)** 49.8 cc

**37.** A metal rod of Young's modulus Y and coefficient of thermal expansion α is held at its two ends such that its length remains invariant. If its temperature is raised by t°C, the linear stress developed in it is:- **[AIEEE - 2011]**

**(1)** $\frac{\alpha t}{Y}$ **(2)** $\frac{Y}{\alpha t}$ **(3)** $Y\alpha t$ **(4)** $\frac{1}{(Y\alpha t)}$

**38.** Helium gas goes through a cycle ABCDA (consisting of two isochoric and two isobaric lines) as shown in figure. Efficiency of this cycle is nearly (Assume the gas to be close to ideal gas) :- **[AIEEE - 2012]**

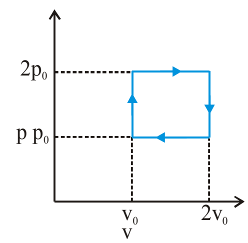



**(1)** 12.5% **(2)** 15.4% **(3)** 9.1% **(4)** 10.5%

**39.** A Carnot engine, whose efficiency is 40% takes in heat from a source maintained at a temperature of 500 K. It is desired to have an engine of efficiency 60%. Then, the intake temperature for the same exhaust (sink) temperature must be :- **[AIEEE - 2012]**

**(1)** 600 K **(2)** efficiency of Carnot engine cannot be made larger than 50%
**(3)** 1200 K **(4)** 750 K

**40.** The above p-v diagram represents the thermodynamic cycle of an engine, operating with an ideal monoatomic gas. The amount of heat, extracted from the source in a single cycle is : **[AIEEE - 2013]**




**(1)** $p_0v_0$ **(2)** $\left(\frac{13}{2}\right)p_0v_0$ **(3)** $\left(\frac{11}{2}\right)p_0v_0$ **(4)** $4p_0v_0$

## MODE OF HEAT TRANSFER

**41.** Heat given to a body which raises its temperature by 1°C is- **[AIEEE - 2002]**

**(1)** water equivalent **(2)** thermal capacity **(3)** specific heat **(4)** temperature gradient

**42.** Which of the following is more close to a black body- **[AIEEE - 2002]**

**(1)** Black board paint **(2)** Green leaves **(3)** Black holes **(4)** Red roses

**43.** Infrared radiations are detected by- **[AIEEE - 2002]**

**(1)** spectrometer **(2)** pyrometer **(3)** nanometer **(4)** photometer

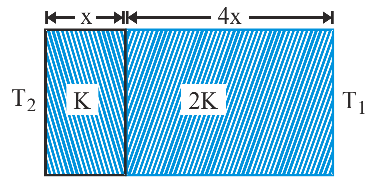
**44.** Two spheres of the same material have radii 1 m and 4 m and temperatures 4000 K and 2000 K respectively. The ratio of the energy radiated per second by the first sphere to that by the second is- **[AIEEE - 2002]**

**(1)** 1 : 1 **(2)** 16 : 1 **(3)** 4 : 1 **(4)** 1 : 9

**45.** If the temperature of the sun were to increase from T to 2T and its radius from R to 2R, then the ratio of the radiant energy received on earth to what it was previously, will be- **[AIEEE - 2004]**

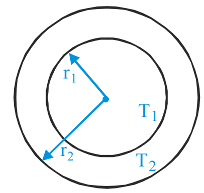
**(1)** 4 **(2)** 16 **(3)** 32 **(4)** 64

**46.** The temperature of the two outer surfaces of a composite slab, consisting of two materials having coefficients of thermal conductivity K and 2K and thickness x and 4x, respectively are $T_2$ and $T_1(T_2 > T_1)$. The rate of heat transfer through the slab, in a steady state is $\left(\frac{A(T_2 - T_1)K}{x}\right)f$, with f equals to- **[AIEEE - 2004]**




**(1)** 1 **(2)** 1/2 **(3)** 2/3 **(4)** 1/3

**47.** The figure shows a system of two concentric spheres of radii $r_1$ and $r_2$ and kept at temperatures $T_1$ and $T_2$, respectively. The radial rate of flow of heat in a substance between the two concentric spheres, is proportional to- **[AIEEE - 2005]**

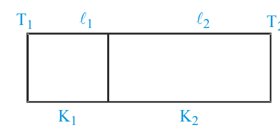



**(1)** $\frac{(r_2 - r_1)}{(r_1 r_2)}$ **(2)** $\ell n\left(\frac{r_2}{r_1}\right)$ **(3)** $\frac{r_1 r_2}{(r_2 - r_1)}$ **(4)** $(r_2 - r_1)$

**48.** Assuming the sun to be a spherical body of radius R at a temperature of T K, evaluate the total radiant power, incident on earth, at a distance r from the sun- (when radius of earth is $r_0$) **[AIEEE - 2006]**

**(1)** $4\pi r_0^2 R^2 \sigma T^4/r^2$ **(2)** $\pi r_0^2 R^2 \sigma T^4/r^2$ **(3)** $r_0^2 R^2 \sigma T^4 / 4\pi R^2$ **(4)** $R^2 \sigma T^4/r^2$

**49.** One end of a thermally insulated rod is kept at a temperature $T_1$ and the other at $T_2$. The rod is composed of two sections of lengths $\ell_1$ and $\ell_2$ and thermal conductivities $K_1$ and $K_2$ respectively. The temperature at the interface of the two sections is- **[AIEEE - 2007]**



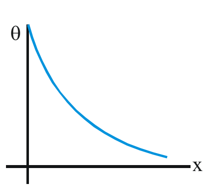

**(1)** $(K_2\ell_2T_1 + K_1\ell_1T_2)/(K_1\ell_1 + K_2\ell_2)$

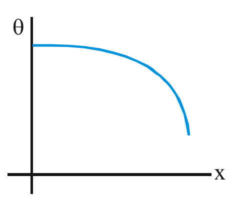
**(2)** $(K_2\ell_1T_1 + K_1\ell_2T_2)/(K_2\ell_1 + K_1\ell_2)$

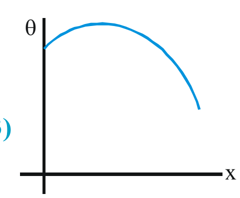
**(3)** $(K_1\ell_2T_1 + K_2\ell_1T_2)/(K_1\ell_2 + K_2\ell_1)$

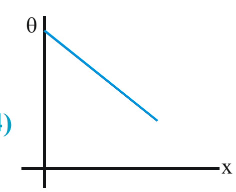
**(4)** $(K_1\ell_1T_1 + K_2\ell_2T_2)/(K_1\ell_1 + K_2\ell_2)$

**50.** A long metallic bar is carrying heat from one of its ends to the other end under steady-state. The variation of temperature θ along the length x of the bar from its hot end is best described by which of the following figures? **[AIEEE - 2009]**

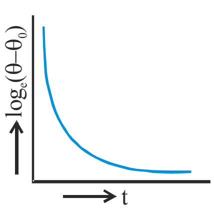
**(1)**


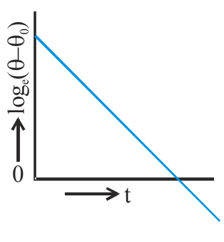

**(2)**


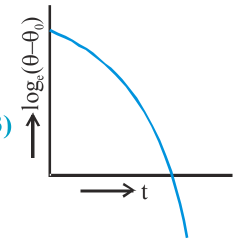

**(3)**


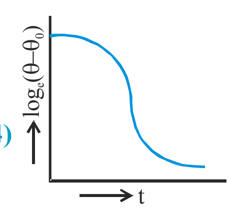

**(4)**



**51.** A liquid in a beaker has temperature θ(t) at time t and $\theta_0$ is temperature of surroundings, then according to Newton's law of cooling the correct graph between $\log_e(\theta - \theta_0)$ and t is :- **[AIEEE - 2012]**

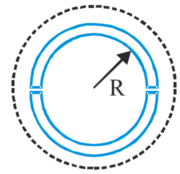
**(1)**



**(2)**



**(3)**


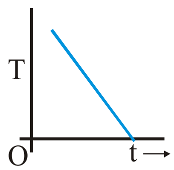

**(4)**


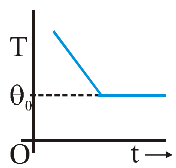
**52.** A wooden wheel of radius R is made of two semicircular parts (see figure). The two parts are held together by a ring made of a metal strip of cross sectional area S and Length L. L is slightly less than $2\pi R$. To fit the ring on the wheel, it is heated so that its temperature rises by $\Delta T$ and it just steps over the wheel. As it cools down to surrounding temperature, it presses the semicircular parts together. If the coefficient of linear expansion of the metal is $\alpha$, and its Young's modulus is Y, the force that one part of the wheel applies on the other part is : **[AIEEE - 2012]**

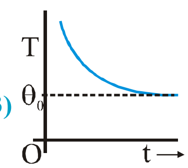


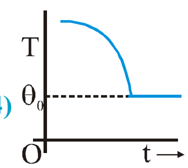

**(1)** $2SY\alpha\Delta T$ **(2)** $2\pi SY\alpha\Delta T$ **(3)** $SY\alpha\Delta T$ **(4)** $\pi SY\alpha\Delta T$

**53.** If a piece of metal is heated to temperature $\theta$ and then allowed to cool in a room which is at temperature $\theta_0$ the graph between the temperature T of the metal and time t will be closed to : **[AIEEE - 2013]**

**(1)** 


**(2)** 


**(3)** 

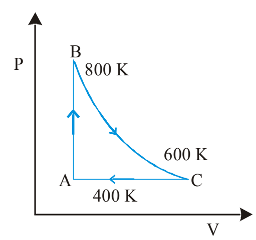

**(4)** 


**54** The pressure that has to be applied to the ends of a steel wire of length 10 cm to keep its length constant when its temperature is raised by 100°C is : **[JEE (Main) - 2014]**

(For steel Young's modulus is $2\times10^{11}$ N $m^{-2}$ and coefficient of thermal expansion is $1.1\times10^{-5}$ $K^{-1}$)

**(1)** $2.2\times10^7$ Pa **(2)** $2.2\times10^6$ P **(3)** $2.2\times10^8$ Pa **(4)** $2.2\times10^9$ Pa

**55.** One mole of diatomic ideal gas undergoes a cyclic process ABC as shown in figure. The process BC is adiabatic. The temperatures at A, B and C are 400 K, 800 K and 600 K respectively. Choose the correct statement: **[JEE (Main) - 2014]**




**(1)** The change in internal energy in the process AB is – 350 R.

**(2)** The change in internal energy in the process BC is – 500 R.

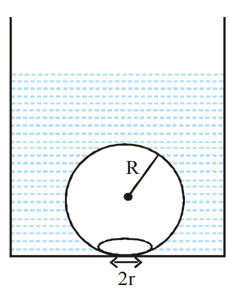
**(3)** The change in internal energy in whole cyclic process is 250 R.

**(4)** The change in internal energy in the process CA is 700 R.

**56** Three rods of Copper, Brass and Steel are welded together to from a Y –shaped structure. Area of cross – section of each rod = 4 $cm^2$ . End of copper rod is maintained at 100°C where as ends of brass and steel are kept at 0°C. Lengths of the copper, brass and steel rods are 46, 13 and 12 cms respectively. The rods are thermally insulated from surroundings except at ends. Thermal conductivities of copper, brass and steel are 0.92, 0.26 and 0.12 CGS units respectively. Rate of heat flow through copper rod is : **[JEE (Main) - 2014]**

**(1)** 4.8 cal/s **(2)** 6.0 cal/s **(3)** 1.2 cal/s **(4)** 2.4 cal/s

**57** On heating water, bubbles being formed at the bottom of the vessel detach and rise. Take the bubbles to be spheres of radius R and making a circular contact of radius r with the bottom of the vessel. If r < < R, and the surface tension of water is T, value of r just before bubbles detach is : (density of water is $\rho_w$) **[JEE (Main) - 2014]**




**(1)** $R^2\sqrt{\frac{\rho_w g}{T}}$ **(2)** $R^2\sqrt{\frac{3\rho_w g}{T}}$ **(3)** $R^2\sqrt{\frac{\rho_w g}{3T}}$ **(4)** $R^2\sqrt{\frac{\rho_w g}{6T}}$

**58.** A solid body of constant heat capacity 1 J/°C is being heated by keeping it in contact with reservoirs in two ways:

(i) Sequentially keeping in contact with 2 reservoirs such that each reservoir supplies same amount of heat.

(ii) Sequentially keeping in contact with 8 reservoirs such that each reservoirs supplies same amount of heat.

In both the cases body is brought from initial temperature 100°C to final temperature 200°C. Entropy change of the body in the two cases respectively is : **[JEE (Main) - 2015]**

**(1)** ln2, 2ln2 **(2)**2ln2, 8ln2 **(3)** ln2, 4ln2 **(4)** ln2, ln2

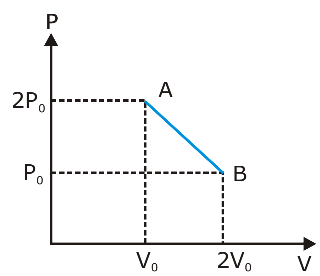
**59.** Consider a spherical shell of radius R at temperature T. The black body radiation inside it can be considered as an ideal gas of photons with internal energy per unit volume $u = \frac{U}{V} \propto T^4$ and pressure $p = \frac{1}{3}\left(\frac{U}{V}\right)$. If the shell now undergoes an adiabatic expansion the relation between T and R is : **[JEE (Main) - 2015]**

**(1)** $T \propto \frac{1}{R}$ **(2)** $T \propto \frac{1}{R^3}$ **(3)** $T \propto e^{-R}$ **(4)** $T \propto e^{-3R}$

**60.** Consider an ideal gas confined in an isolated closed chamber. As the gas undergoes an adiabatic expansion, the average time of collision between molecules increases as $V^q$, when V is the volume of the gas. The value of q is :
$\left(\gamma = \frac{C_P}{C_V}\right)$ **[JEE (Main) - 2015]**

**(1)** $\frac{\gamma+1}{2}$ **(2)** $\frac{\gamma-1}{2}$ **(3)** $\frac{3\gamma+5}{6}$ **(4)** $\frac{3\gamma-5}{6}$

**61.** 'n' moles of an ideal gas undergoes a process $A \rightarrow B$ as shown in the figure. The maximum temperature of the gas during the process will be : **[JEE (Main) - 2016]**




**(1)** $\frac{3p_0V_0}{2nR}$ **(2)** $\frac{9P_0V_0}{2nR}$ **(3)** $\frac{9P_0V_0}{nR}$ **(4)** $\frac{9P_0V_0}{4nR}$

**62.** A pendulum clock loses 12 s a day if the temperature is 40°C and gains 4s a day if the temperature is 20°C. The temperature at which the clock will show correct time, and the co-efficient of linear expansion (α) of the metal of the pendulum shaft are respectively: **[JEE (Main) - 2016]**

**(1)** 60°C; $\alpha = 1.85 \times 10^{-4}$/°C **(2)** 30°C; $\alpha = 1.85 \times 10^{-3}$/°C
**(3)** 55°C; $\alpha = 1.85 \times 10^{-2}$/°C **(4)** 25°C; $\alpha = 1.85 \times 10^{-5}$/°C

**63.** An ideal gas undergoes a quasi static, reversible process in which its molar heat capacity C remains constant. If during this process the relation of pressure P and volume V is given by $PV^n$ = constant, then n is given by (Here $C_p$ and $C_v$ are molar specific heat at constant pressure and constant volume, respectively) : **[JEE (Main) - 2016]**

**(1)** $n = \frac{C - C_p}{C - C_v}$ **(2)** $n = \frac{C_p - C}{C - C_v}$ **(3)** $n = \frac{C - C_v}{C - C_p}$ **(4)** $n = \frac{C_p}{C_v}$

## Part # II [Previous Year Questions][IIT-JEE ADVANCED]

### MCQ's with one correct answer

1. A vessel contains a mixture of one mole of oxygen and two moles of nitrogen at 300 K. The ratio of the average rotational kinetic energy per $O_2$ molecule to per $N_2$ molecule is :– **[IIT-JEE 1998]**
**(A)** 1 : 1 **(B)** 1 : 2
**(C)** 2 : 1 **(D)** depends on the moment of inertia of the two molecules

2. Two identical containers A and B with frictionless pistons contain the same ideal gas at the same temperature and the same volume V. The mass of the gas in A is $m_A$ and that in B is $m_B$. The gas in each cylinder is now allowed to expand isothermally to the same final volume 2V. The changes in the pressure in A and B are found to be ΔP and 1.5 ΔP respectively. Then :– **[IIT-JEE 1998]**
**(A)** $4m_A = 9m_B$ **(B)** $2m_A = 3m_B$ **(C)** $3m_A = 2m_B$ **(D)** $9m_A = 4m_B$

3. Two cylinders A and B fitted with pistons contain equal amounts of an ideal diatomic gas at 300 K. The piston of A is free to move, while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of the gas in A is 30 K, then the rise in temp. of the gas in B is:– **[IIT-JEE 1998]**
**(A)** 30 K **(B)** 18 K **(C)** 50 K **(D)** 42 K

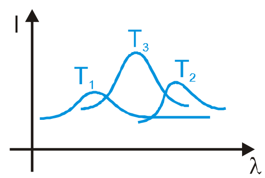
4. A black body is at a temperature of 2880 K. The energy of radiation emitted by this object with wavelength between 499 nm and 500 nm is $U_1$, between 999 nm and 1000 nm is $U_2$ and between 1499 nm and 1500 nm is $U_3$. The Wien constant, b = 2.88 × $10^6$ nm–K. Then :– **[IIT-JEE 1998]**
**(A)** $U_1 = 0$ **(B)** $U_3 = 0$ **(C)** $U_1 > U_2$ **(D)** $U_2 > U_1$

5. The ratio of the speed of sound in nitrogen gas to that in helium gas, at 300 K is :– **[IIT-JEE 1999]**
**(A)** $\sqrt{\left(\frac{2}{7}\right)}$ **(B)** $\sqrt{\left(\frac{1}{7}\right)}$ **(C)** $\frac{\sqrt{3}}{5}$ **(D)** $\frac{\sqrt{6}}{5}$

6. A gas mixture consists of 2 moles of oxygen and 4 moles of argon at temperature T. Neglecting all vibrational modes, the total internal energy of the system is :– **[IIT-JEE 1999]**
**(A)** 4RT **(B)** 15RT **(C)** 9RT **(D)** 11RT

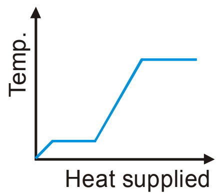
7. A monoatomic ideal gas, initially at temperature $T_1$, is enclosed in a cylinder fitted with a frictionless piston. The gas is allowed to expand adiabatically to a temperature $T_2$ by releasing the piston suddenly. If $L_1$ and $L_2$ are the lengths of the gas column before and after expansion respectively, then $\frac{T_1}{T_2}$ is given by **[IIT-JEE 2000]**
**(A)** $\left(\frac{L_1}{L_2}\right)^{2/3}$ **(B)** $\left(\frac{L_1}{L_2}\right)$ **(C)** $\left(\frac{L_2}{L_1}\right)$ **(D)** $\left(\frac{L_2}{L_1}\right)^{2/3}$

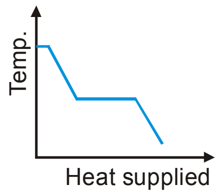
8. The plots of intensity versus wavelength for three black bodies at temperature $T_1$, $T_2$ and $T_3$ respectively are as shown. Their temperatures are such that:– **[IIT-JEE 2000]**

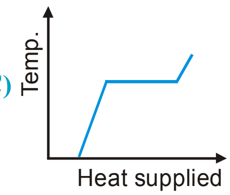


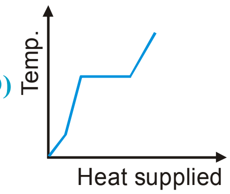

**(A)** $T_1 > T_2 > T_3$ **(B)** $T_1 > T_3 > T_2$ **(C)** $T_2 > T_3 > T_1$ **(D)** $T_3 > T_2 > T_1$

**9.** A block of ice at –10°C is slowly heated and converted to steam at 100°C. Which of the following curves represents the phenomena qualitatively:– **[IIT-JEE 2000]**

**(A)** 

**(B)** 

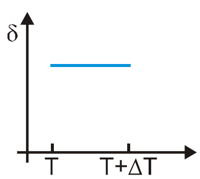
**(C)** 

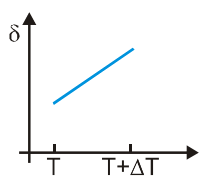
**(D)** 

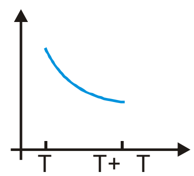

**10.** Starting with the same initial conditions, an ideal gas expands from volume $V_1$ to $V_2$ in three different ways, the work done by the gas $W_1$ if the process is purely isothermal, $W_2$ if purely isobaric and $W_3$ if purely adiabatic, then :– **[IIT-JEE 2000]**

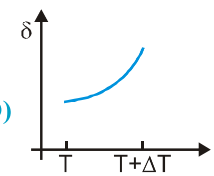
**(A)** $W_2 > W_1 > W_3$ **(B)** $W_2 > W_3 > W_1$ **(C)** $W_1 > W_2 > W_3$ **(D)** $W_1 > W_3 > W_2$

**11.** An ideal gas is initially at temperature T and volume V. Its volume is increased by ΔV due to an increase in temperature ΔT, pressure remaining constant. The quantity $\delta = \dfrac{\Delta V}{V\Delta T}$ varies with temperature as:– **[IIT-JEE 2000]**

**(A)** 

**(B)** 

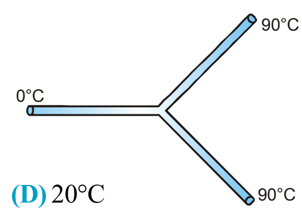
**(C)** 

**(D)** 


**12.** Two monoatomic ideal gases 1 and 2 of molecular masses $m_1$ and $m_2$ respectively are enclosed in separate containers kept at the same temperature. The ratio of the speed of sound in gas 1 to the gas 2 is given by :– **[IIT-JEE 2000]**

**(A)** $\sqrt{\dfrac{m_1}{m_2}}$ **(B)** $\sqrt{\dfrac{m_2}{m_1}}$ **(C)** $\dfrac{m_1}{m_2}$ **(D)** $\dfrac{m_2}{m_1}$

**13.** Three rods made of the same material and having the same cross–section have been joined as shown in the figure. Each rod is of the same length. The left and right ends are kept at 0°C and 90°C respectively. The temperature of junction of the three rods will be : **[IIT-JEE 2001]**

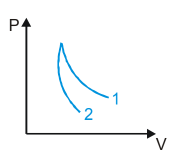



**(A)** 45°C **(B)** 60°C **(C)** 30°C **(D)** 20°C

**14.** In a given process of an ideal gas, dW = 0 and dQ < 0. Then for the gas :– **[IIT-JEE 2001]**

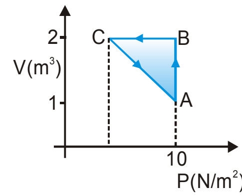
**(A)** the temperature will decrease **(B)** the volume will increase
**(C)** the pressure will remain constant **(D)** the temperature will increase

**15.** P–V plots for two gases during adiabatic processes are shown in the figure. Plots 1 and 2 should correspond respectively to : **[IIT-JEE 2001]**



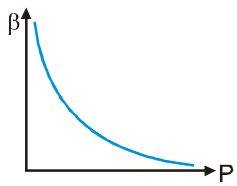

**(A)** He and $O_2$ **(B)** $O_2$ and He **(C)** He and Ar **(D)** $O_2$ and $N_2$

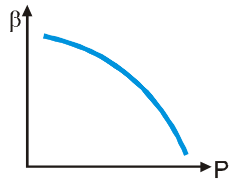
**16.** An ideal gas is taken through the cycle A → B → C → A, as shown in the figure. If the net heat supplied to the gas in the cycle is 5 J, the work done by the gas in the process C → A is :– **[IIT-JEE 2002]**

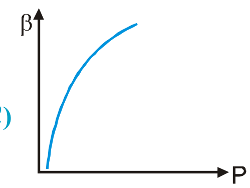


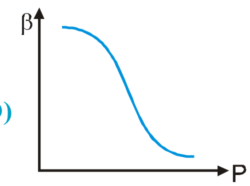

**(A)** –5J **(B)** –10J **(C)** –15J **(D)** –20J

**17.** Which of the following graphs correctly represent the variation of $\beta = -\frac{dV/dP}{V}$ with P for an ideal gas at constant temperature ? **[IIT-JEE 2002]**

**(A)** 

**(B)** 

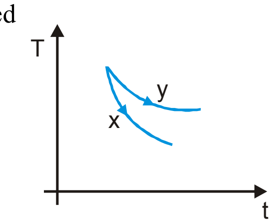
**(C)** 

**(D)** 


**18.** An ideal black–body at room temperature is thrown into a furnance. It is observed that **[IIT-JEE 2003]**

**(A)** initially it is the darkest body and at later times the brightest
**(B)** it is the darkest body at all times
**(C)** it cannot be distinguished at all times
**(D)** initially it is the darkest body and at later times it cannot be distinguished

**19.** The graph, shown in the diagram, represents the variation of temperature (T) of the bodies, x and y having same surface area, with time (T) due to the emission of radiation. Find the correct relation between the emissivity and absorptivity power of the two bodies :– **[IIT-JEE 2003]**

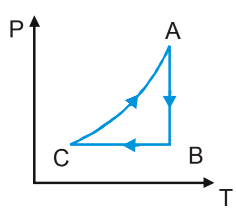


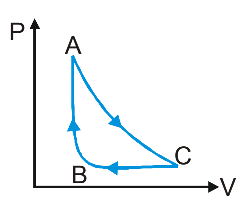

**(A)** $e_x > e_y$ and $a_x < a_y$ **(B)** $e_x < e_y$ and $a_x > a_y$ **(C)** $e_x > e_y$ and $a_x > a_y$ **(D)** $e_x < e_y$ and $a_x < a_y$

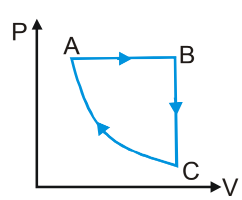
**20.** Two rods, one of aluminium and the other made of steel, having initial length $\ell_1$ and $\ell_2$ are connected together to form a single rod of length $\ell_1 + \ell_2$. The coefficient of linear expansion for aluminium and steel area $\alpha_a$ and $\alpha_s$ respectively. If the length of each rod increases by the same amount when their temperature are raised by t°C, then find the ratio $\frac{\ell_1}{\ell_1 + \ell_2}$ :– **[IIT-JEE 2003]**

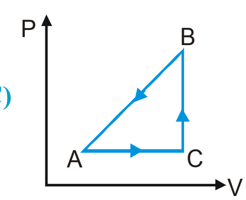
**(A)** $\frac{\alpha_s}{\alpha_a}$ **(B)** $\frac{\alpha_a}{\alpha_s}$ **(C)** $\frac{\alpha_s}{(\alpha_a + \alpha_s)}$ **(D)** $\frac{\alpha_a}{(\alpha_a + \alpha_s)}$

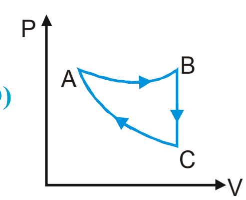
**21.** The P–T diagram for an ideal gas is shown in the figure, where AC is anadiabatic process, find the corresponding P–V diagram :– **[IIT-JEE 2003]**




**(A)** 

**(B)** 

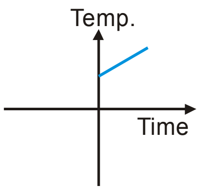
**(C)** 

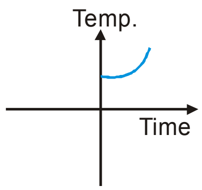
**(D)** 

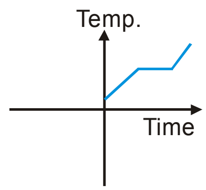
**22.** 2 kg of ice at –20°C is mixed with 5 kg of water at 20°C in an insulating vessel having a negligible heat capacity. Calculate the final mass of water remaining in the container. It is given that the specific heats of water and ice are 1 kcal/kg/°C while the latent heat of fusion of ice is 80 kcal/kg :– **[IIT-JEE 2003]**

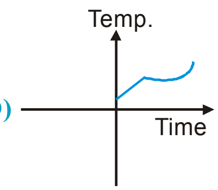
**(A)** 7 kg **(B)** 6 kg **(C)** 4 kg **(D)** 2 kg

**23.** Liquid oxygen at 50 K is heated to 300 K at constant pressure of 1 atm. The rate of heating is constant. Which of the following graphs represent the variation of temperature with time :– **[IIT-JEE 2004]**

**(A)** 


**(B)** 


**(C)** 


**(D)** 


**24.** An ideal gas expands isothermally from a volume $V_1$ and $V_2$ and then compressed to original volume $V_1$ adiabatically. Initial pressure is $P_1$ and final pressure is $P_3$. The total work done is W. Then :– **[IIT-JEE 2004]**

**(A)** $P_3 > P_1$, $W > 0$ **(B)** $P_3 < P_1$, $W < 0$ **(C)** $P_3 > P_1$, $W < 0$ **(D)** $P_3 = P_1$, $W = 0$

**25.** Two identical conducting rods are first connected independently to two vessels, one containing water at 100°C and the other containing ice at 0°C. In the second case, the rods are joined end to end and connected to the same vessels. Let $q_1$ and $q_2$ g/s be the rate of melting of ice in the two cases respectively. The ratio $\frac{q_1}{q_2}$ is :– **[IIT-JEE 2004]**

**(A)** $\frac{1}{2}$ **(B)** $\frac{2}{1}$ **(C)** $\frac{4}{1}$ **(D)** $\frac{1}{4}$

**26.** Three discs, A, B and C having radii 2m, 4m and 6m respectively are coated with carbon black on their outer surfaces. The wavelengths corresponding to maximum intensity are 300 nm, 400 nm and 500 nm respectively. The power radiated by them are $Q_A$, $Q_B$ and $Q_C$ respectively :– **[IIT-JEE 2004]**

**(A)** $Q_A$ is maximum **(B)** $Q_B$ is maximum **(C)** $Q_C$ is maximum **(D)** $Q_A = Q_B = Q_C$

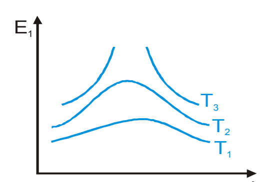
**27.** Water of volume 2L in a container is heated with a coil of 1 kW at 27°C. The lid of the container is open and energy dissipates at rate of 160 J/s. In how much time temperature will rise from 27°C to 77°C ? (Give specific heat of water is 4.2 kJ/kg) :– **[IIT-JEE 2005]**

**(A)** 8 min 20 s **(B)** 6 min 2 s **(C)** 7 min **(D)** 14 min

**28.** In which of the following process, convection does not take place primarily :– **[IIT-JEE 2005]**

**(A)** Sea and land breeze **(B)** Boiling of water
**(C)** Warming of glass of bulb due to filament **(D)** Heating air around a furnace

**29.** Variation of radiant energy emitted by sun, filament of tungsten lamp and welding arc as a function of its wavelength is shown in figure. Which of the following option is the correct match :– **[IIT-JEE 2005]**




**(A)** Sun–$T_1$, tungsten filament–$T_2$, welding arc–$T_3$
**(B)** Sun–$T_2$, tungsten filament–$T_1$, welding arc–$T_3$
**(C)** Sun–$T_3$, tungsten filament–$T_2$, welding arc–$T_1$
**(D)** Sun–$T_3$, tungsten filament–$T_1$, welding arc–$T_2$

**30.** Calorie is defined as the amount of heat required to raise temperature of 1 g of water by 1°C and it is defined under which of the following conditions :– **[IIT-JEE 2005]**

**(A)** From 14.5°C to 15.5°C at 760 mm of Hg **(B)** From 98.5°C to 99.5°C at 760 mm of Hg
**(C)** From 13.5°C to 14.5°C at 76 mm of Hg **(D)** From 3.5°C to 4.5°C at 76 mm of Hg

**31.** A body with area A and temperature T and emissivity e = 0.6 is kept inside a spherical black body. What will be the maximum energy radiated :– **[IIT-JEE 2005]**

**(A)** $0.60\ eAT^4$ **(B)** $0.80\ eAT^4$ **(C)** $1.00\ eAT^4$ **(D)** $0.40\ eAT^4$

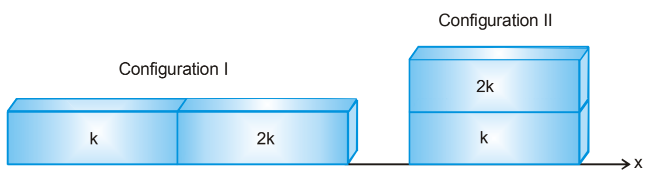
**32.** An ideal gas is expanding such that $PT^2$ = constant. The coefficient of volume expansion of the gas is:–

**(A)** $\frac{1}{T}$ **(B)** $\frac{2}{T}$ **(C)** $\frac{3}{T}$ **(D)** $\frac{4}{T}$ **[IIT-JEE 2008]**

**33.** Two non-reactive monoatomic ideal gases have their atomic masses in the ratio 2 : 3. The ratio of their partial pressures, when enclosed in a vessel kept at a constant temperature, is 4 : 3. The ratio of their densities is :- **[IIT-JEE 2013]**

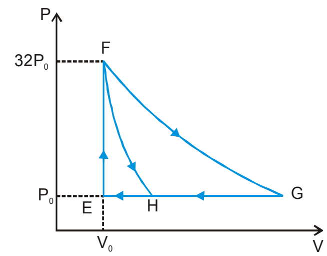
**(A)** 1 : 4 **(B)** 1 : 2 **(C)** 6 : 9 **(D)** 8 : 9

**34.** Two rectangular blocks, having identical dimensions, can be arranged either in configuration I or in configuration II as shown in the figure. One of the blocks has thermal conductivity k and the other 2k. The temperature difference between the ends along the x-axis is the same in both the configurations. It takes 9s to transport a certain amount of heat from the hot end to the cold end in the configuration I. The time to transport the same amount of heat in the configuration II is :- **[IIT-JEE 2013]**




**(A)** 2.0 s **(B)** 3.0 s **(C)** 4.5 s **(D)** 6.0 s

**35.** One mole of a monatomic ideal gas is taken along two cyclic processes E→F→G→E and E→F→H→E as shown in the PV diagram. The processes involved are purely isochoric, isobaric, isothermal or adiabatic.




Match the paths in List I with the magnitudes of the work done in the List II and select the correct answer using the codes given blow the lists. **[IIT-JEE 2013]**

| | **List I** | | **List II** |
|---|---|---|---|
| P. | G → E | 1. | $160\ P_0V_0\ ln2$ |
| Q. | G → H | 2. | $36\ P_0V_0$ |
| R. | F → H | 3. | $24\ P_0V_0$ |
| S. | F → G | 4. | $31\ P_0V_0$ |

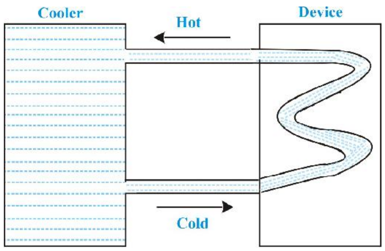
**Codes :**

| | **P** | **Q** | **R** | **S** |
|---|---|---|---|---|
| **(A)** | 4 | 3 | 2 | 1 |
| **(B)** | 4 | 3 | 1 | 2 |
| **(C)** | 3 | 1 | 2 | 4 |
| **(D)** | 1 | 3 | 2 | 4 |

**36.** Parallel rays of light of intensity $I = 912\ Wm^{-2}$ are incident on a spherical black body kept in surroundings of temperature 300 K. Take Stefan-Boltzmann constant $\sigma = 5.7\times10^{-8}\ Wm^{-2}\ K^{-4}$ and assume that the energy exchange with the surroundings is only through radiation. The final steady state temperature of the black body is close to **[IIT-JEE 2014]**

**(A)** 330 K  **(B)** 660 K  **(C)** 990 K  **(D)** 1550 K

**37.** A water cooler of storage capacity 120 litres can cool water at a constant rate of *P* watts. In a closed circulation system (as shown schematically in the figure), the water from the cooler is used to cool an external device that generates constantly 3 kW of heat (thermal load). The temperature of water fed into the device cannot exceed 30°C and the entire stored 120 litres of water is initially cooled to 10°C. The entire system is thermally insulated. The minimum value of *P* (in watts) for which the device can be operated for 3 hours is **[IIT-JEE 2016]**




(A) 1600  (B) 2067  (C) 2533  (D) 3933

## MCQs with one or more than one correct answer

**1.** Let $\bar{v}$, $v_{rms}$ and $v_p$ respectively denote the mean speed, root mean square speed and most probable speed of the molecules in an ideal monoatomic gas at absolute temperature T. The mass of a molecule is m. Then:–

**(A)** No molecule can have energy greater than $\sqrt{2}\ v_{rms}$ **[IIT-JEE 1998]**

**(B)** No molecule can have speed less than $\frac{v_p}{\sqrt{2}}$

**(C)** $v_p < \bar{v} < v_{rms}$

**(D)** The average kinetic energy of a molecule is $\frac{3}{4}mv_p^2$

**2.** During the melting of a slab of ice at 273 K at atmospheric pressure :– **[IIT-JEE 1998]**

**(A)** Positive work is done by the ice–water system on the atmosphere

**(B)** Positive work is done on the ice–water system by the atmosphere

**(C)** the internal energy of the ice–water increases

**(D)** The internal energy of the ice–water system decreases

**3.** A bimetallic strip is formed out of two identical strips one of copper and the other of brass. The coefficients of linear expansion of the two metals are $\alpha_C$ and $\alpha_B$. On heating, the temperature of the strip goes up by $\Delta T$ and the strip bends to form an arc of radius of curvature R. Then R is :– **[IIT-JEE 1999]**

**(A)** Proportional to $\Delta T$  **(B)** Inversely proportional to $\Delta T$

**(C)** Proportional to $|\alpha_B - \alpha_C|$  **(D)** Inversely proportional to $|\alpha_B - \alpha_C|$

**4.** $C_V$ and $C_P$ denote the molar specific heat capacities of a gas at constant volume and constant pressure, respectively. Then **[IIT-JEE 2009]**

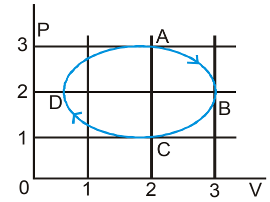
**(A)** $C_P - C_V$ is larger for a diatomic ideal gas than for a monoatomic ideal gas

**(B)** $C_P + C_V$ is larger for a diatomic ideal gas than for a monoatomic ideal gas

**(C)** $C_P/C_V$ is larger for a diatomic ideal gas than for a monatomic ideal gas

**(D)** $C_P \cdot C_V$ is larger for a diatomic ideal gas than for a monoatomic ideal gas

**5.** The figure shows the P-V plot of an ideal gas taken through a cycle ABCDA. The part ABC is a semi-circle and CDA is half of an ellipse. Then, **[IIT-JEE 2009]**



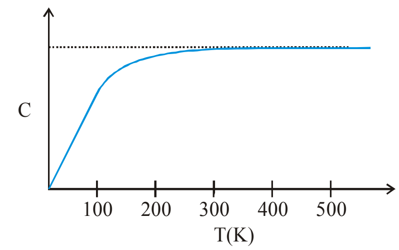

**(A)** the process during the path $A \rightarrow B$ is isothermal

**(B)** heat flows out of the gas during the path $B \rightarrow C \rightarrow D$

**(C)** work done during the path $A \rightarrow B \rightarrow C$ is zero

**(D)** positive work is done by the gas in the cycle ABCDA

**6.** The figure below shows the variation of specific heat capacity (C) of a solid as a function of temperature (T). The temperature is increased continuously from 0 to 500 K at a constant rate. Ignoring any volume change, the following statement(S) is (are) correct to a reasonable approximation :- **[IIT-JEE 2013]**




**(A)** The rate at which heat is absorbed in the range 0–100 K varies linearly with temperature T.

**(B)** Heat absorbed in increasing the temperature from 0–100 K is less than the heat required for increasing the temperature from 400–500 K.

**(C)** There is no change in the rate of heat absorption in the range 400–500 K

**(D)** The rate of heat absorption increases in the range 200–300 K

**7.** Heater of an electric kettle is made of a wire of length L and diameter d. It takes 4 minutes to raise the temperature of 0.5 kg water by 40 K. This heater is replaced by a new heater having two wires of the same material, each of length L and diameter 2d. The way these wires are connected is given in the options. How much time in minutes will it take to raise the temperature of the same amount of water by 40K? **[IIT-JEE 2014]**

**(A)** 4 if wires are in parallel **(B)** 2 if wires are in series

**(C)** 1 if wires are in series **(D)** 0.5 if wires are in parallel.

**8.** A container of fixed volume has a mixture of one mole of hydrogen and one mole of helium in equilibrium at temperature T. Assuming the gases are ideal, the correct statement**(s)** is (are) **[IIT-JEE 2015]**

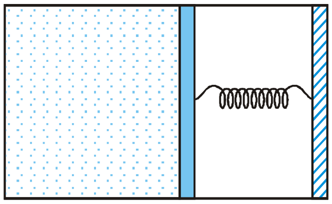
**(A)** The average energy per mole of the gas mixture is 2RT.

**(B)** The ratio of speed of sound in the gas mixture to that in helium gas is $\sqrt{6/5}$.

**(C)** The ratio of the rms speed of helium atoms to that of hydrogen molecules is 1/2.

**(D)** The ratio of the rms speed of helium atoms to that of hydrogen moleucles is $1/\sqrt{2}$.

**9.** An ideal monoatomic gas is confined in a horizontal cylider by a spring loaded piston (as shown in the figure). Initially the gas is at temperature $T_1$, pressure $P_1$ and volume $V_1$ and the spring is in its relaxed state. The gas is then heated very slowly to temperature $T_2$, pressure $P_2$ and volume $V_2$. During this process the piston moves out by a distance x. Ignoring the friction between the piston and the cylider, the correct statement(s) is (are). **[IIT-JEE 2015]**



**(A)** If $V_2$ - $2V_1$ and $T_2 = 3T_1$, then the energy stored in the spring is $\frac{1}{4}$ $P_1V_1$

**(B)** If $V_2 = 2V_1$ and $T_2 = 3T$, then the change in internal energy is $3P_1V_1$

**(C)** If $V_2 = 3V_1$ and $T_2 = 4T$, then the work done by the gas is $\frac{7}{3}$ $P_1V_1$

**(D)** If $V_2 = 3V_1$ and $T_2 = 4T_1$, the heat supplied to the gas is $\frac{17}{6}$ $P_1V_1$

**10.** A gas is enclosed ina cylinder with a movable frictionless piston. Its initial thermodynam state at pressure $P_i = 10^5$ Pa and volume $V_i = 10^{-3}$ m$^3$ changes to a final state at $P_f = (1/32) \times 10^5$ Pa and $V_f = 8 \times 10^{-3}$ m$^3$ in an adiabatic quasi-static process, such that $P^3V^5$ = constant. Consider another thermodynamic process that brings the system from the same initial state to the same final state in two steps : an isobaric expansion at $P_i$ folowed by an isochoric (isovolumetric) process at volume $V_f$. The amount of heat supplied to the system in the two-step process is approximately

**(A)** 112 J **(B)** 294 J **(C)** 588 J **(D)** 813 J **[IIT-JEE 2016]**

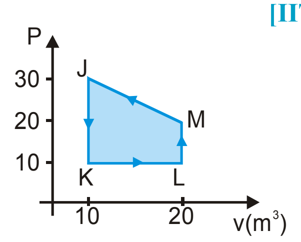
**11.** The ends Q and R of two thin wires, PQ and Rs, are soldered (joined) together. Initially each of the wires has a length of 1 m at 10°C . Now the end P is maintained at 10 °C, while the end S is heated and maintained at 400 °C. The system is thermally insulated from its surroundings. If the thermal conductivity of wire PQ is twic that of the wire RS and the coefficienf of linear thermal expansion of PQ is $1.2 \times 10^{-5}$ K$^{-1}$, the change in length of the wire PQ is **[IIT-JEE 2016]**

**(A)** 0.78 mm **(B)** 0.90 mm **(C)** 1.56 mm **(D)** 2.34 mm

## Match the Column

**1.** For the given process :– **[IIT-JEE 2006]**

| | Column I | | Column II |
|---|---|---|---|
| **(A)** | Process J → K | **(P)** | W > 0 |
| **(B)** | Process K → L | **(Q)** | W < 0 |
| **(C)** | Process L → M | **(R)** | Q > 0 |
| **(D)** | Process M → J | **(S)** | Q < 0 |

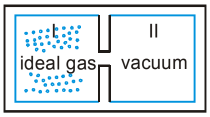



**2.** Column–I gives some devices and Column–II gives some processes on which the functioning of these devices depend. Match the devices in Column–I with the process in Column–II. **[IIT-JEE 2007]**

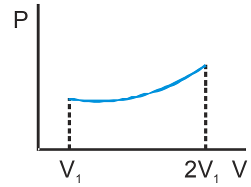
| | Column I | | Column II |
|---|---|---|---|
| **(A)** | Bimetallic strip | **(P)** | Radiation from a hot body |
| **(B)** | Stem engine | **(Q)** | Energy conversion |
| **(C)** | Incandescent lamp | **(R)** | Melting |
| **(D)** | Electric fuse | **(S)** | Thermal expansion of solids |

**3.** **Column I** contains a list of processes involving expansion of an ideal gas. Match this with **Column II** describing the thermodynamic change during this process. Indicate your answer by darkening the appropriate bubbles of the 4 × 4 matrix given in the ORS. **[IIT-JEE 2008]**

| | Column I | | Column II |
|---|---|---|---|
| **(A)** | An insulated container has two chambers separated by a valve. Chamber I contains an ideal gas and the Chamber II has vacuum. The valve is opened. | **(P)** | The temperature of the gas decreases |



| | | | |
|---|---|---|---|
| **(B)** | An ideal monoatomic gas expands to twice its original volume such that its pressure $P \propto \frac{1}{V^2}$, where V is the volume of the gas. | **(Q)** | The temperature of the gas increases or remains constant |
| **(C)** | An ideal monoatomic gas expands to twice its original volume such that its pressure $P \propto \frac{1}{V^{4/3}}$, where V is its volume | **(R)** | The gas loses heat |
| **(D)** | An ideal monoatomic gas expands such that its pressure P and volume V follows the behaviour shown in the graph | **(S)** | The gas gains heat |




## Assertion & Reason

**1.** **Statement–I :** The total translation kinetic energy of all the molecules of a given mass of an ideal gas is 1.5 times the product of its pressure and its volume. **[IIT-JEE 2007]**

**Statement–II :** The molecules of a gas collide with each other and the velocities of the molecules change due to the collision.

**(A)** statement–I is true, statement–II is true; statement–II is a correct explanation for statement–I

**(B)** statement–I is true, statement–II is true, statement–II is NOT a correct explanation for statement–I

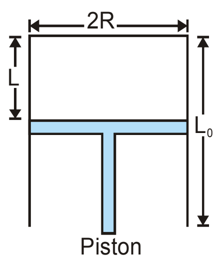
**(C)** statement–I is true, statement–II is false

**(D)** statement–I is false, statement–II is true

## Comprehension Type Questions

### Comprehension# 1

A fixed thermally conducting cylinder has a radius R and height $L_0$. The cylinder is open at its bottom and has a small hole at its top. A piston of mass M is held at a distance L from the top surface, as shown in the figure. The atmospheric pressure is $P_0$. **[IIT-JEE 2007]**



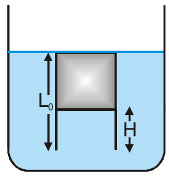

**1.** The piston is now pulled out slowly and held at a distance 2L from the top. The pressure in the cylinder between its top and the piston will then be :–

**(A)** $P_0$ **(B)** $\frac{P_0}{2}$ **(C)** $\frac{P_0}{2}+\frac{Mg}{\pi R^2}$ **(D)** $\frac{P_0}{2}-\frac{Mg}{\pi R^2}$

**2.** While the piston is at a distance 2L from the top, the hole at the top is sealed. The piston is then released, to a position where it can stay in equilibrium. In this condition, the distance of the piston from the top is :–

**(A)** $\left(\frac{2P_0\pi R^2}{\pi R^2 P_0 + Mg}\right)(2L)$ **(B)** $\left(\frac{2P_0\pi R^2 - Mg}{\pi R^2 P_0}\right)(2L)$ **(C)** $\left(\frac{P_0\pi R^2 + Mg}{\pi R^2 P_0}\right)(2L)$ **(D)** $\left(\frac{P_0\pi R^2}{\pi R^2 P_0 - Mg}\right)(2L)$

**3.** The piston is taken completely out of the cylinder. The hole at the top is sealed. A water tank is brought below the cylinder and put in a position so that the water surface in the tank is at the same level as the top of the cylinder as shown in the figure. The density of the water is ρ. In equilibrium, the height H of the water column in the cylinder satisfies :–




**(A)** $\rho g(L_0 - H)^2 + P_0(L_0 - H) + L_0P_0 = 0$

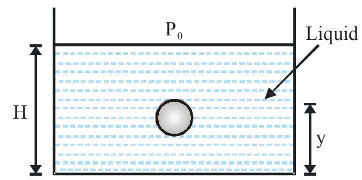
**(B)** $\rho g(L_0 - H)^2 - P_0(L_0 - H) - L_0P_0 = 0$

**(C)** $\rho g(L_0 - H)^2 + P_0(L_0 - H) - L_0P_0 = 0$

**(D)** $\rho g(L_0 - H)^2 - P_0(L_0 - H) + L_0P_0 = 0$

**Comprehension# 2**

A small spherical monoatomic ideal gas bubble $\left(\gamma = \frac{5}{3}\right)$ is trapped inside a liquid of density $\rho_\ell$ (see figure). Assume that the bubble does not exchange any heat with the liquid. The bubble contains n moles of gas. The temperature of the gas when the bubble is at the bottom is $T_0$, the height of the liquid is H and the atmospheric pressure is $P_0$ (Neglect surface tension). **[IIT-JEE 2008]**




**1.** As the bubble moves upwards, besides the buoyancy force the following forces are acting on it.

**(A)** Only the force of gravity

**(B)** The force due to gravity and the force due to the pressure of the liquid

**(C)** The force due to gravity, the force due to the pressure of the liquid and the force due to viscosity of the liquid

**(D)** The force due to gravity and the force due to viscosity of the liquid.

**2.** When the gas bubble is at a height y from the bottom, its temperature is :–

**(A)** $T_0\left(\frac{P_0 + \rho_\ell gH}{P_0 + \rho_\ell gy}\right)^{2/5}$ **(B)** $T_0\left(\frac{P_0 + \rho_\ell g(H-y)}{P_0 + \rho_\ell gH}\right)^{2/5}$ **(C)** $T_0\left(\frac{P_0 + \rho_\ell gH}{P_0 + \rho_\ell gy}\right)^{3/5}$ **(D)** $T_0\left(\frac{P_0 + \rho_\ell g(H-y)}{P_0 + \rho_\ell gH}\right)^{3/5}$

**3.** The buoyancy force acting on the gas bubble is (Assume R is the universal gas constant)

**(A)** $\rho_\ell nRgT_0 \frac{(P_0 + \rho_\ell gH)^{2/5}}{(P_0 + \rho_\ell gy)^{7/5}}$

**(B)** $\frac{\rho_\ell nRgT_0}{(P_0 + \rho_\ell gH)^{2/5}[P_0 + \rho_\ell g(H-y)]^{3/5}}$

**(C)** $\rho_\ell nRgT_0 \frac{(P_0 + \rho_\ell gH)^{3/5}}{(P_0 + \rho_\ell gy)^{8/5}}$

**(D)** $\frac{\rho_\ell nRgT_0}{(P_0 + \rho_\ell gH)^{3/5}[P_0 + \rho_\ell g(H-y)]^{2/5}}$

**Comprehension# 3**

In the figure a container is shown to have a movable (without friction) piston on top. The container and the piston are all made of perfectly insulating material allowing no heat transfer between outside and inside the container. The container is divided into two compartments by a rigid partition made of a thermally conducting material that allows slow transfer of heat. The lower compartment of the container is filled with 2 moles of an ideal monatomic gas at 700 K and the upper compartment is filled with 2 moles of an ideal diatomic gas at 400 K. The

heat capacities per mole of an ideal monatomic gas are $C_V = \frac{3}{2}R$, $C_P = \frac{5}{2}R$, and those for an ideal diatomic gas are $C_V = \frac{5}{2}R$, $C_P = \frac{7}{2}R$. **IIT-JEE 2014]**

**1.** Consider the partition to be rigidly fixed so that it does not move. When equilibrium is achieved, the final temperature of the gases will be

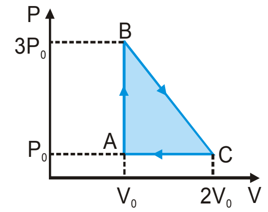
**(A)** 550 K **(B)** 525 K **(C)** 513K **(D)** 490 K

**2.** Now consider the partition to be free to move without friction so that the pressure of gases in both compart ments is the same. Then total work done by the gases till the time they achieve equilibrium will be

**(A)** 250 R **(B)** 200 R **(C)** 100 R **(D)** –100 R

## Subjective Questions

**1.** One mole of an ideal monoatomic gas is taken round the cyclic process ABCA as shown in figure. Calculate:




**[IIT-JEE 1998]**

**(i)** The work done by the gas.

**(ii)** The heat rejected by the gas in the path CA and the heat absorbed by the gas in the path AB.

**(iii)** The net heat absorbed by the gas in the path BC.

**(iv)** The maximum temperature attained by the gas during the cycle.

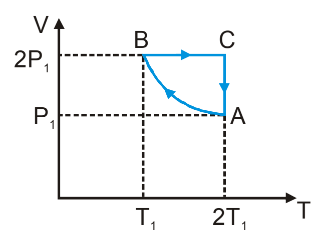
**2.** A solid body X of heat capacity C is kept in an atmosphere whose temperature is $T_A$ = 300 K. At time t = 0, the temperature of X is $T_0$ = 400 K. It cools according to Newton's law of cooling. At time $t_1$ its temperature is found to be 350 K. At this time ($t_1$) the body X is connected to a large body Y at atmospheric temperature $T_A$ through a conducting rod of length L, cross–section area A and thermal conductivity K. The heat capacity of Y is so large that any variation in its temperature may be neglected. The cross–section area A of the connecting rod is small compared to the surface area of X. Find the temperature of X at time t = $3t_1$. **[IIT-JEE 1998]**

**3.** Two moles of an ideal monoatomic gas initially at pressure $P_1$ and volume $V_1$ undergo an adiabatic compression until its volume is $V_2$. Then the gas is given heat Q at constant volume $V_2$. **[IIT-JEE 1999]**

(i) Sketch the complete process on a P–V diagram.

(ii) Find the total work done by the gas, the total change in internal energy and the final temperature of the gas. (Give your answer in terms of $P_1$, $V_1$, $V_2$, Q and R)

**4.** Two moles of an ideal monoatomic gas is taken through a cycle ABCA as shown in the P–V diagram. During the process AB, pressure and temperature of the gas very such that PT = constant. If $T_1$ = 300K, calculate



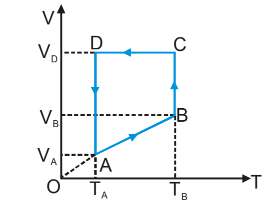

**(i)** The work done on the gas in the process AB and

**(ii)** The heat absorbed or released by the gas in each of the processes.

Give answers in terms of the gas constant P. **[IIT-JEE 2000]**

**5.** An ice cube of mass 0.1 kg at 0°C is placed in an isolated container which is at 227°C. The specific heat S of the container varies with temperature T according to the empirical relation S = A + BT, where A = 100 cal/kg–K and B = $2 \times 10^{-2}$ cal/kg–$K^2$. If the final temperature of the container is 27°C, determine the mass of the container (Latent heat of fusion for water = $8 \times 10^4$ cal/kg, specific heat of water = $10^3$ cal/kg–K). **[IIT-JEE 2001]**

**6.** A monoatomic ideal gas of two moles is taken through a cyclic process starting from A as shown in the figure. The volume ratio are $\frac{V_B}{V_A}=2$ and $\frac{V_D}{V_A}=4$. If the temperature $T_A$ at A is 27°C. Calculate :



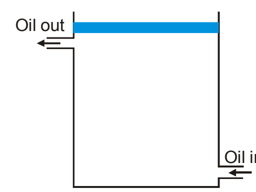

**(i)** The temperature of the gas at point B. **[IIT-JEE 2001]**
**(ii)** Heat absorbed or released by the gas in each process.
**(iii)** The total work done by the gas during the complete cycle.
Express your answer in terms of the gas constant R.

**7.** A 5m long cylindrical steel wire with radius $2 \times 10^{-3}$ m is suspended vertically from a rigid support and carries a bob of mass 100 kg at the other end. If the bob gets snapped, calculate the change in temperature of the wire ignoring losses. (For the steel wire : Young's modulus = $2.1 \times 10^{11}$ Pa; Density = 7860 Kg/m$^3$ ; Specific heat = 420 J/kg–K). **[IIT-JEE 2001]**

**8.** A cubical box of side 1m contains helium gas (atomic weight 4) at a pressure of 100 N/m$^2$. During an observation time of 1s, an atom travelling with the root mean square speed parallel to one of the edges of the cube, was found to make 5000 hits with a particular wall, without any collision with other atoms.
Take : R = 25/3 J/mol–K and k = $1.38 \times 10^{-23}$ J/K. **[IIT-JEE 2002]**
**(i)** Evaluate the temperature of the gas.
**(ii)** Evaluate the average kinetic energy per atom.
**(iii)** Evaluate the total mass of helium gas in the box.

**9.** An insulated box containing a monoatomic gas of molar mass M moving with a speed $v_0$ is suddenly stopped. Find the increment in gas temperature as a result of stopping the box. **[IIT-JEE 2003]**

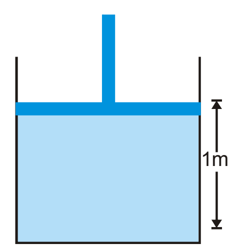
**10.** The top of an insulated cylindrical container is covered by a disc having emissivity 0.6 and conductivity 0.167 W/km and thickness 1 cm. The temperature is maintained by circulating oil as shown : **[IIT-JEE 2003]**




**(i)** Find the radiation loss to the surroundings in J/m$^2$ s if temperature of the upper surface of disc is 127°C and temperature of surroundings is 27°C.
**(ii)**Also find the temperature of the circulating oil. Neglect the heat loss due to convection.

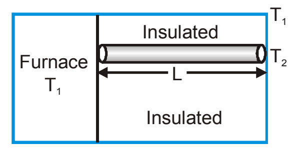
(Give : $\sigma = \frac{17}{3} \times 10^{-8}$ W$^{-2}$K$^{-4}$]

**11.** The piston cylinder arrangement shown contains a diatomic gas at temperature 300 K. The cross–sectional area of the cylinder is 1m$^2$. Initially the height of the piston above the base of the cylinder is 1m. The temperature is now raised to 400 K at constant pressure. Find the new height of the piston above the base of the cylinder. If the piston is now brought back to its original height without any heat loss, find the new equilibrium temperature of the gas. You can leave the answer in fraction. **[IIT-JEE 2004]**




**12.** A cube of coefficient of linear expansions $\alpha_s$ is floating in a bath containing a liquid of coefficient of volume expansion $\gamma_l$. When the temperature is raised by $\Delta T$, the depth upto which the cube is submerged in the liquid remains the same. Find the relation between $\alpha_s$ and $\gamma_l$ showing all the steps. **[IIT-JEE 2004]**

**13.** One end of a rod of length L and cross–sectional area A is kept in a furnace of temperature $T_1$. The other end of the rod is kept at a temperature $T_2$. The thermal conductivity of the material of the rod is K and emissivity of the rod is e. it is given that $T_2 = T_s + \Delta T$, where $\Delta T << T_s$, Ts being the temperature of the surroundings. If $\Delta T \propto (T_1 - T_s)$, find the proportionality constant that heat is lost only by radiation at the end where the temp, of the rod is $T_2$. **[IIT-JEE 2004]**




**14.** A metal of mass 1 kg at constant atmospheric pressure and at initial temperature 20°C is given a heat of 200000 J. Find the following : **IIT-JEE 2005]**

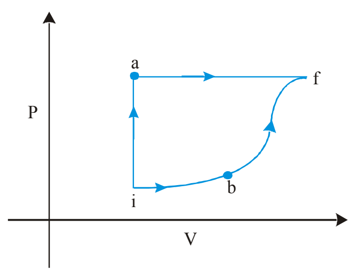
**(i)** change in temperature **(ii)** work done and **(iii)** change in internal energy.

(Given : Specific heat 400 J/kg/°C, coefficient of cubical expansion, $\gamma = 8 \times 10^{-5}$ /°C, density $\rho = 9000$ kg/m$^3$, atmospheric pressure = $10^5$ N/m$^2$.

**15.** In an insulated vessel, 0.05 kg steam at 373 K and 0.45 kg of ice at 253 K are mixed find the final temperature of the mixture (in kelvin). Given : $L_{fusion}$ = 80 cal/g = 336 J/g; $L_{vaporization}$ = 540 cal/g = 2268 J/g; $S_{ice}$ = 2100 J/kg, K = 0.5 cal/gK; and $S_{water}$ = 4200 J/kg, K = 1 cal/gK **[IIT-JEE 2006]**

**16.** A metal rod AB of length 10x has its one end A in ice at 0°C and the other end B in water at 100 °C. It a point P on the rod is maintained at 400 °C, then it is found that equal amounts of water and ice evaporate and melt per unit time. The latent heat of evaporation of water 540 cal/g and latent heat of melting of ice is 80 cal/g. If the point P is at $\lambda$x distance from the ice end then find out the value of $\lambda$. [Neglect any heat loss to the surrounding.] **[IIT-JEE 2009]**

**17.** A thermodynamic system is taken from an initial state *i* with internal energy $U_i$ = 100 J to the final state *f* along two different paths *iaf* and *ibf*, as schematically shown in the figure. The work done by the system along the paths *af*, *ib* and *bf* are $W_{af}$ = 200 J, $W_{ib}$ = 50 J and $W_{bf}$ = 100 J respectively. The heat supplied to the system along the path iaf, ib and bf are $Q_{iaf}$ , $Q_{ib}$ and $Q_{bf}$ respectively. If the internal energy of the system in the state b is $U_b$ = 200 J and $Q_{iaf}$ = 500 J, the ratio $Q_{bf}/Q_{ib}$ is **[IIT-JEE 2014]**




**18.** Two spherical stars A and B emit blackbody radiation. The radius of A is 400 times that of B and A emits $10^4$ times the power emitted from B. The ratio $\left(\frac{\lambda_A}{\lambda_B}\right)$ of their wavelengths $\lambda_A$ and $\lambda_B$ at which the peaks occur in their respective radiation curves is. **[IIT-JEE 2015]**

**19.** A metal is heated in a furnace where a sensor is kept above the metal surface to read the power radiated (*P*) by the metal. The sensor has a scale that displays $\log_2 (P/P_0)$, where $P_0$ is a constant. When the metal surface is at a temperature of 487°C, the sensor shows a value 1. Assume that the emissivity of the metallic surface remains constant. What is the value displayed by the sensor when the temperature of the metal surface is raised to 2767 °C? **[IIT-JEE 2016]**

**20.** Consider two solid spheres P and Q each of density 8 gm cm$^{-3}$ and diameters 1cm and 0.5cm, respectively. Sphere P is dropped into a liquid of density 0.8 gm cm$^{-3}$ and viscosity $\eta$= 3 poiseulles. Sphere Q is dropped into a liquid of density 1.6 gm cm$^{-3}$ and viscosity $\eta$ = 2 poiseulles. The ratio of the terminal velocities of P and Q is **[IIT-JEE 2016]**

## MOCK TEST

### SECTION - I : STRAIGHT OBJECTIVE TYPE

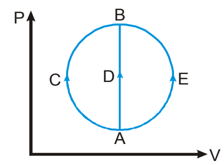
**1.** A diatomic ideal gas is heated at constant volume until the pressure is doubled and again heated at constant pressure until volume is doubled. The average molar heat capacity for whole process is:

**(A)** $\frac{13R}{6}$ **(B)** $\frac{19R}{6}$ **(C)** $\frac{23R}{6}$ **(D)** $\frac{17R}{6}$

**2.** A gas mixture consists of 2 moles of Oxygen and 4 moles of Argon at temperature T. Neglecting all vibrational modes, the total internal energy of the system is :

**(A)** 4 RT **(B)** 5 RT **(C)** 15 RT **(D)** 11 RT

**3.** One mole of an ideal gas is taken from state A to state B by three different processes, **(a)** ACB (b) ADB (c) AEB as shown in the P − V diagram. The heat absorbed by the gas is :

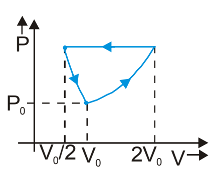


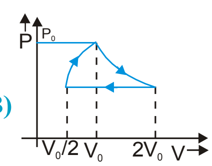

**(A)** greater in process (B) then in (A)
**(B)** the least in process (B)
**(C)** the same in (A) and (C)
**(D)** less in (C) then in (B)

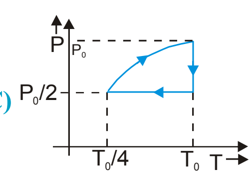
**4.** In an adiabatic expansion the product of pressure and volume :

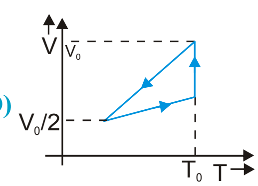
**(A)** decreases **(B)** increases
**(C)** remains constant **(D)** first increases, then decreases.

**5.** One mole of an ideal gas at pressure $P_0$ and temperature $T_0$ is expanded isothermally to twice its volume and then compressed at constant pressure to $(V_0/2)$ and the gas is brought back to original state by a process in which P α V (Pressure is directly proportional to volume). The correct representation of process is

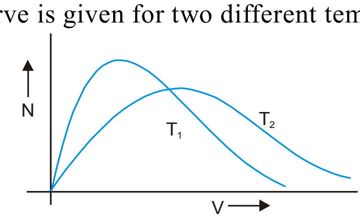
**(A)**



**(B)**



**(C)**



**(D)**



**6.** Maxwell's speed distribution curve is given for two different temperatures. For the given curves.

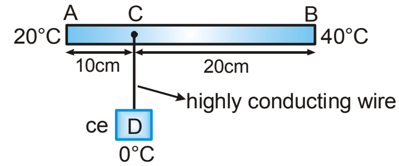



**(A)** $T_1 > T_2$ **(B)** $T_1 < T_2$ **(C)** $T_1 \le T_2$ **(D)** $T_1 = T_2$

**7.** There are two thin spheres A and B of the same material and same thickness. They emit radiation like black bodies. Radius of A is double that of B. A and B have same temperature T. When A and B are kept in a room of temperature $T_0$ (< T), the ratio of their rates of cooling (rate of fall of temperature) is: [ assume negligible heat exchange between A and B ]

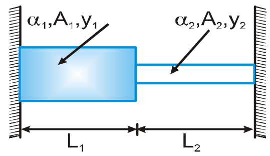
**(A)** 2 : 1 **(B)** 1 : 1 **(C)** 4 : 1 **(D)** 8 : 1

**8.** In the figure shown AB is a rod of length 30 cm and area of cross-section 1.0 $cm^2$ and thermal conductivity 336 S. I. units. The ends A & B are maintained at temperatures 20° C and 40 °C respectively. A point C of this rod is connected to a box D, containing ice at 0° C, through a highly conducting wire of negligible heat capacity. The rate at which ice melts in the box is :[ Assume latent heat of fusion for ice $L_f$ = 80 cal/gm ]




**(A)** 84 mg/s **(B)** 84 g/s **(C)** 20 mg/s **(D)** 40 mg/s

**9.** Two elastic rods are joined between fixed supports as shown in the figure. Condition for no change in the lengths of individual rods with the increase of temperature
( $\alpha_1$, $\alpha_2$ = linear expansion co-efficient
$A_1$, $A_2$ = Area of rods
$y_1$, $y_2$ = Young modulus )




**(A)** $\frac{A_1}{A_2} = \frac{\alpha_1\ y_1}{\alpha_2\ y_2}$ **(B)** $\frac{A_1}{A_2} = \frac{L_1\ \alpha_1\ y_1}{L_2\ \alpha_2\ y_2}$ **(C)** $\frac{A_1}{A_2} = \frac{L_2\ \alpha_2\ y_2}{L_1\ \alpha_1\ y_1}$ **(D)** $\frac{A_1}{A_2} = \frac{\alpha_2\ y_2}{\alpha_1\ y_1}$

**10.** Four particles have speeds 1, 0, 2, 3 m/s. The root mean square speed of the particles is: (in m/s)

**(A)** 3.5 **(B)** $\sqrt{3.5}$ **(C)** 1.5 **(D)** $\sqrt{\frac{14}{3}}$

**11.** In a process the density of a gas remains constant. If the temperature is doubled, then the change in the pressure will be :

**(A)** 100 % increase **(B)** 200 % increase **(C)** 50 % decrease **(D)** 25 % decrease

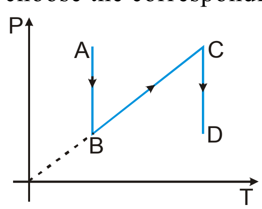
**12.** A steel rod of length 1m is heated from 25ºC to 75ºC keeping its length constant. The longitudinal strain developed in the rod is (Given : Coefficient of linear expansion of steel = $12 \times 10^{-6}$/ºC)

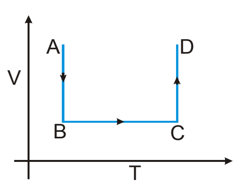
**(A)** $6 \times 10^{-6}$ **(B)** $-6 \times 10^{-5}$ **(C)** $-6 \times 10^{-4}$ **(D)** zero

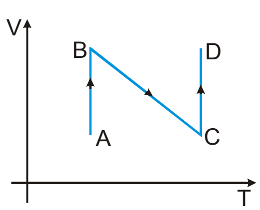
**13.** A rod of length $\ell$ and cross section area A has a variable thermal conductivity given by k = $\alpha$ T, where $\alpha$ is a positive constant and T is temperature in kelvin. Two ends of the rod are maintained at temperatures $T_1$ and $T_2$ ($T_1 > T_2$). Heat current flowing through the rod will be

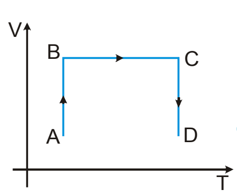
**(A)** $\frac{A\alpha(T_1^2 - T_2^2)}{\ell}$ **(B)** $\frac{A\alpha(T_1^2 + T_2^2)}{\ell}$ **(C)** $\frac{A\alpha(T_1^2 + T_2^2)}{3\ell}$ **(D)** $\frac{A\alpha(T_1^2 - T_2^2)}{2\ell}$

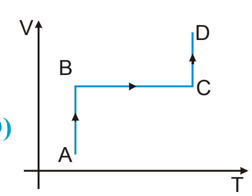
**14.** P-T diagram is shown below then choose the corresponding V-T diagram



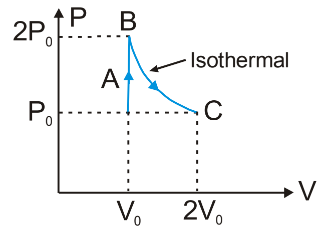

**(A)**



**(B)**



**(C)**



**(D)**


**15.** A diatomic ideal gas undergoes a thermodynamic change according to the P–V diagram shown in the figure. The total heat given to the gas is nearly :




**(A)** $2.5\ P_0V_0$ **(B)** $1.4\ P_0V_0$ **(C)** $3.9\ P_0V_0$ **(D)** $1.1\ P_0V_0$

**16.** On an X temperature scale, water freezes at – 125.0° X and boils at 375.0° X. On a Y temperature scale, water freezes at – 70.0°Y and boils at – 30.0°Y. The value of temperature on X-scale equal to the temperature of 50.0°Y on Y-scale is :

**(A)** 455.0° X **(B)** – 125.0° X **(C)** 1375.0° X **(D)** 1500.0° X

**17.** A solid spherical black body of radius r and uniform mass distribution is in free space. It emits power 'P' and its rate of cooling is R then

**(A)** $R\ P \propto r^2$ **(B)** $R\ P \propto r$ **(C)** $R\ P \propto 1/r^2$ **(D)** $R\ P \propto \frac{1}{r}$

**18.** A black body emits radiation at the rate P when its temperature is T. At this temperature the wavelength at which the radiation has maximum intensity is $\lambda_0$. If at another temperature T′ the power radiated is P′ and wavelength at maximum intensity is $\frac{\lambda_0}{2}$ then

**(A)** $P'\ T' = 32PT$ **(B)** $P'\ T' = 16PT$ **(C)** $P'\ T' = 8PT$ **(D)** $P'\ T' = 4PT$

**19.** The emissive power of a black body at T = 300 K is 100 Watt/m$^2$. Consider a body B of area A = 10 m$^2$ coefficient of reflectivity r = 0.3 and coefficient of transmission t = 0.5. Its temperature is 300 K. Then which of the following is incorrect :

**(A)** The emissive power of B is 20 W/m$^2$
**(B)** The emissive power of B is 200 W/m$^2$
**(C)** The power emitted by B is 200 Watts
**(D)** The emissivity of B is = 0.2

**20.** There are four objects A, B, C and D. It is observed that A and B are in thermal equilibrium and C and D are also in thermal equilibrium. However, A and C are not in thermal equilibrium. We can conclude that :

**(A)** B and D are in thermal equilibrium
**(B)** B and D could be in thermal equilibrium
**(C)** B and D cannot be in thermal equilibrium
**(D)** The zeroth law of thermodynamics does not apply here because there are more than three objects

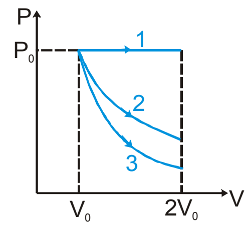
**21.** If $H_C$, $H_K$ and $H_F$ are heat required to raise the temperature of one gram of water by one degree in Celsius, Kelvin and Fahrenheit temperature scales respectively then :

**(A)** $H_K > H_C > H_F$ **(B)** $H_F > H_C > H_K$ **(C)** $H_K = H_C > H_F$ **(D)** $H_K = H_C = H_F$

**22.** Find the amount of work done to increase the temperature of one mole of an ideal gas by 30ºC if it is expanding under the condition $V \propto T^{2/3}$.

**(A)** 166.2 J **(B)** 136.2 **(C)** 126.2 J **(D)** none of these

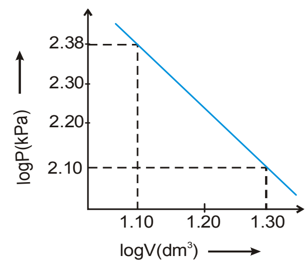
**23.** A gas is expanded from volume $V_0$ to $2V_0$ under three different processes. Process 1 is isobaric process, process 2 is isothermal and process 3 is adiabatic. Let $\Delta U_1, \Delta U_2$ and $\Delta U_3$ be the change in internal energy of the gas in these three processes. Then :




**(A)** $\Delta U_1 > \Delta U_2 > \Delta U_3$ **(B)** $\Delta U_1 < \Delta U_2 < \Delta U_3$

**(C)** $\Delta U_2 < \Delta U_1 < \Delta U_3$ **(D)** $\Delta U_2 < \Delta U_3 < \Delta U_1$

**24.** Logarithms of readings of pressure and volume for an ideal gas were plotted on a graph as shown in Figure. By measurring the gradient, it can be shown that the gas may be




**(A)** monoatomic and undergoing an adiabatic change

**(B)** monoatomic and undergoing an isothermal change

**(C)** diatomic and undergoing an adiabatic change

**(D)** triatomic and undergoing an isothermal change.

**25.** A metallic sphere having radius 0.08 m and mass m = 10kg is heated to a temperature of 227°C and suspended inside a box whose walls are at a temperature of 27°C. The maximum rate at which its temperature will fall is :- (Take e = 1, Stefan's constant $\sigma = 5.8 \times 10^{-8}$ $Wm^{-2} K^{-4}$ and specific heat of the metal s = 90 cal/kg/deg J = 4.2 Joules/Calorie)

**(A)** .055 °C/sec **(B)** .066 °C/sec **(C)** .044 °C/sec **(D)** 0.03 °C/sec

## SECTION - II : MULTIPLE CORRECT ANSWER TYPE

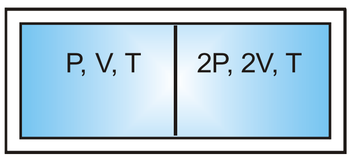
**26.** A partition divides a container having insulated walls into two compartments I and II. The same gas fills the two compartments whose initial parameters are given. The partition is a conducting wall which can move freely without friction. Which of the following statement is/are correct, with reference to the final equilibrium position?

**(A)** The Pressure in the two compartments are equal.

**(B)** Volume of compartment I is $\frac{3V}{5}$

**(C)** Volume of compartment II is $\frac{12V}{5}$

**(D)** Final pressure in compartment I is $\frac{5P}{3}$




**27.** During an experiment, an ideal gas is found to obey a condition $\frac{P^2}{\rho}$ = constant [$\rho$ = density of the gas]. The gas is initially at temperature T, pressure P and density $\rho$. The gas expands such that density changes to $\frac{\rho}{2}$

**(A)** The pressure of the gas changes to $\sqrt{2}$ P.

**(B)** The temperature of the gas changes to $\sqrt{2}$ T.

**(C)** The graph of the above process on the P-T diagram is parabola.

**(D)** The graph of the above process on the P-T diagram is hyperbola.

**28.** Pick the correct statements (s) :

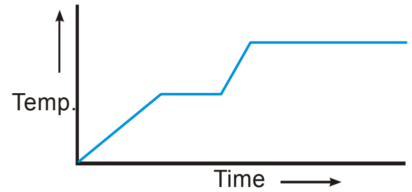
**(A)** The rms translational speed for all ideal-gas molecules at the same temperature is not the same but it depends on the molecular mass.

**(B)** Each particle in a gas has average translational kinetic energy and the equation $\frac{1}{2}mv^2_{rms} = \frac{3}{2}kT$ establishes the relationship between the average translational kinetic energy per particle and temperature of an ideal gas. It can be concluded that single particle has a temperature.

**(C)** Temperature of an ideal gas is doubled from 100°C to 200°C. The average kinetic energy of each particle is also doubled.

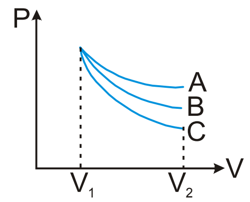
**(D)** It is possible for both the pressure and volume of a monoatomic ideal gas to change simultaneously without causing the internal energy of the gas to change.

**29.** Heat is supplied to a certain homogeneous sample of matter at a uniform rate. Its temperature is plotted against time as shown in the figure. Which of the following conclusions can be drawn?




**(A)** its specific heat capacity is greater in the solid state than in the liquid state.
**(B)** its specific heat capacity is greater in the liquid state than in the solid state.
**(C)** its latent heat of vaporization is greater than its latent heat of fusion.
**(D)** its latent heat of vaporization is smaller than its latent heat of fusion.

**30.** An ideal gas undergoes an expansion from a state with temperature $T_1$ and volume $V_1$ to $V_2$ through three different polytropic processes A, B and C as shown in the P-V diagram. If $|\Delta E_A|$, $|\Delta E_B|$ and $|\Delta E_C|$ be the magnitude of changes in internal energy along the three paths respectively, then :




**(A)** $|\Delta E_A| < |\Delta E_B| < |\Delta E_C|$ if temperature in every process decreases
**(B)** $|\Delta E_A| > |\Delta E_B| > |\Delta E_C|$ if temperature in every process decreases
**(C)** $|\Delta E_A| > |\Delta E_B| > |\Delta E_C|$ if temperature in every process increases
**(D)** $|\Delta E_B| < |\Delta E_A| < |\Delta E_C|$ if temperature in every process increases

**31.** When the temperature of a copper coin is raised by 80 ºC, its diameter increases by 0.2%,
**(A)** percentage rise in the area of a face is 0.4%
**(B)** percentage rise in the thickness is 0.4%
**(C)** percentage rise in the volume is 0.6%
**(D)** coefficient of linear expansion of copper is $0.25 \times 10^{-4}$ / ºC.

**32.** A vessel is partly filled with liquid. When the vessel is cooled to a lower temperature, the space in the vessel, unoccupied by the liquid remains constant. Then the volume of the liquid ($V_L$), volume of the vessel ($V_v$), the coefficients of cubical expansion of the material of the vessel ($\gamma_v$) and of the liquid ($\gamma_L$) are related as

**(A)** $\gamma_L > \gamma_v$ **(B)** $\gamma_L < \gamma_v$ **(C)** $\gamma_v/\gamma_L = V_v/V_L$ **(D)** $\gamma_v/\gamma_L = V_L/V_v$

**33.** Two identical objects A and B are at temperatures $T_A$ and $T_B$ respectively. Both objects are placed in a room with perfectly absorbing walls maintained at a temperature T ($T_A > T > T_B$). The objects A and B attain the temperature T eventually. Select the correct statements from the following. [JEE 1993]

**(A)** A only emits radiation, while B only absorbs it until both attain the temperature T.

**(B)** A loses more heat by radiation than it absorbs, while B absorbs more radiation than it emits, until they attain the temperature T.

**(C)** Both A and B only absorb radiation, but do not emit it, until they attain the temperature T.

**(D)** Each object continues to emit and absorb radiation even after attaining the temperature T.

## SECTION - III : ASSERTION AND REASON TYPE

**34.** **Statement-1 :** Two solid cylindrical rods of identical size and different thermal conductivity $K_1$ and $K_2$ are connected in series. Then the equivalent thermal conductivity of two rod system is less than the value of thermal conductivity of either rod.


**Statement-2 :** For two cylindrical rods of identical size and different thermal conductivity $K_1$ and $K_2$ connected in series, the equivalent thermal conductivity K is given by

$$\frac{2}{K} = \frac{1}{K_1} + \frac{1}{K_2}$$

**(A)** Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1
**(B)** Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1
**(C)** Statement-1 is True, Statement-2 is False
**(D)** Statement-1 is False, Statement-2 is True.

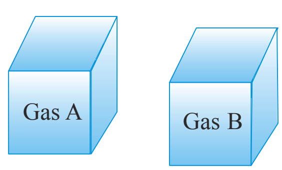
**35.** **Statement-1 :** As the temperature of the blackbody increases, the wavelength at which the spectral intensity ($E_\lambda$) is maximum decreases.
**Statement-2 :** The wavelength at which the spectral intensity will be maximum for a black body is proportional to the fourth power of its absolute temperature.
**(A)** Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1
**(B)** Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1
**(C)** Statement-1 is True, Statement-2 is False
**(D)** Statement-1 is False, Statement-2 is True.

**36.** **Statement-1 :** An ideal gas is enclosed within a container fitted with a piston. When volume of this enclosed gas is increased at constant temperature, the pressure exerted by the gas on the piston decreases.
**Statement-2 :** In the above situation the rate of molecules striking the piston decreases. If the rate at which molecules of a gas having same average speed striking a given area of the wall decreases, the pressure exerted by gas on the wall decreases.
**(A)** Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
**(B)** Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
**(C)** Statement-1 is True, Statement-2 is False
**(D)** Statement-1 is False, Statement-2 is True

## SECTION - IV : COMPREHENSION TYPE

**Comprehension # 1**

Two closed identical conducting containers are found in the laboratory of an old scientist. For the verification of the gas some experiments are performed on the two boxes and the results are noted.




**Experiment 1.** When the two containers are weighed $W_A = 225$ g , $W_B = 160$ g and mass of evacuated container $W_C = 100$ g.

**Experiment 2.** When the two containers are given same amount of heat same temperature rise is recorded. The pressure change found are

$\Delta P_A = 2.5$ atm. $\Delta P_B = 1.5$ atm.

**Required data for unknown gas :**

| | | | | | | |
|---|---|---|---|---|---|---|
| Mono (molar mass) | He 4g | Ne 20g | Ar 40 g | Kr 84 g | Xe 131 g | Rd 222 g |
| Dia (molar mass) | $H_2$ 2g | $F_2$ 19 g | $N_2$ 28g | $O_2$ 32g | $Cl_2$ 71 g | |

**37.** Identify the type of gas filled in container A and B respectively.

**(A)** Mono, Mono **(B)** Dia, Dia **(C)** Mono, Dia **(D)** Dia, Mono.

**38.** Identify the gas filled in the container A and B.

**(A)** $N_2$, Ne **(B)** He, $H_2$ **(C)** $O_2$, Ar **(D)** Ar, $O_2$

**39.** If the gases have initial temperature 300 K and they are mixed in an adiabatic container having the same volume as the previous containers. Now the temperature of the mixture is T and pressure is P. Then

**(A)** $P > P_A$, $T > 300$ K **(B)** $P > P_B$, $T = 300$ K
**(C)** $P < P_A$, $T = 300$ K **(D)** $P > P_A$, $T < 300$ K

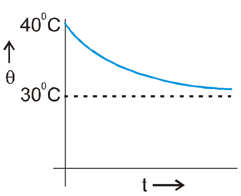
**Comprehension # 2**

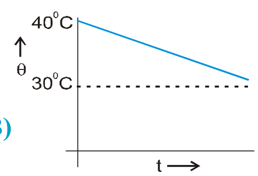
A body cools in a surrounding of constant temperature 30 ºC. Its heat capacity is 2J/ºC. Initial temperature of the body is 40ºC . Assume Newton's law of cooling is valid. The body cools to 38ºC in 10 minutes.

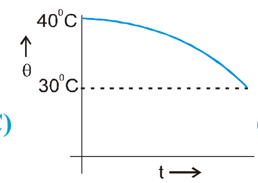
**40.** In further 10 minutes it will cool from 38ºC to ______ :

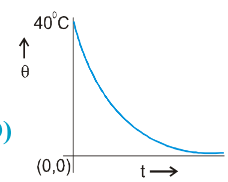
**(A)** 36ºC **(B)** 36.4ºC **(C)** 37ºC **(D)** 37.5ºC

**41.** The temperature of the body in ºC denoted by θ the variation of θ versus time t is best denoted as

**(A)**



**(B)**



**(C)**



**(D)**



**42.** When the body temperature has reached 38 ºC, it is heated again so that it reaches to 40ºC in 10 minutes .The total heat required from a heater by the body is:

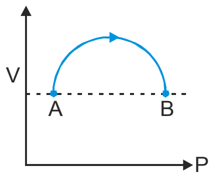
**(A)** 3.6J **(B)** 0.364J **(C)** 8 J **(D)** 4 J

## SECTION - V : MATRIX - MATCH TYPE

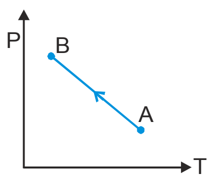
**43.** An ideal monoatomic gas undergoes different types of processes which are described in column-I. Match the corresponding effects in column-II. The letters have usual meaning.

| Column-I | Column-II |
|---|---|
| **(A)** $P = 2V^2$ | **(P)** If volume increases then temperature will also increase. |
| **(B)** $PV^2$ = constant | **(Q)** If volume increases then temperature will decrease. |
| **(C)** $C = C_V + 2R$ | **(R)** For expansion, heat will have to be supplied to the gas. |
| **(D)** $C = C_V - 2R$ | **(S)** If temperature increases then work done by gas is positive. |
| | **(T)** If temperature decreases then work done by gas is positive |

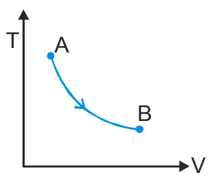
**44.** A sample of gas goes from state A to state B in four different manners, as shown by the graphs. Let W be the work done by the gas and ΔU be change in internal energy along the path AB. Correctly match the graphs with the statements provided.

**(A)** 

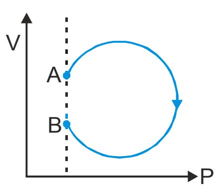

**(P)** Both W and ΔU are positive

**(B)** 


**(Q)** Both W and ΔU are negative

**(C)** 


**(R)** W is positive whereas ΔU is negative

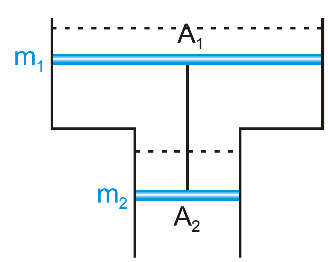
**(D)** 


**(S)** W is negative whereas ΔU is positive

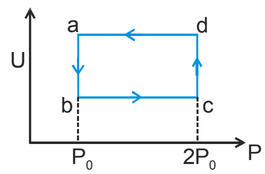
**(T)** Final temperature of an ideal gas is less than its initial temperature.

## SECTION - VI : INTEGER TYPE

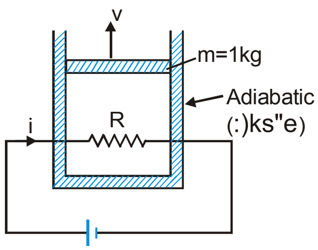
**45.** Consider a vertical tube open at both ends. The tube consists of two parts, each of different cross-sections and each part having a piston which can move smoothly in respective tubes. The two pistons are joined together by an inextensible wire. The combined mass of the two piston is 5 kg and area of cross-section of the upper piston is 10 $cm^2$ greater than that of the lower piston. Amount of gas enclosed by the pistons is one mole. When the gas is heated slowly, pistons move by 50 cm. Find rise in the temperature of the gas, in the form $\frac{X}{R}$K where R is universal gas constant. Use g = 10 $m/s^2$ and outside pressure = $10^5$ $N/m^2$). Fill value of X in the answer sheet.



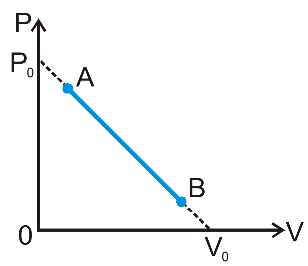
**46.** Figure shows the variation of internal energy (U) with the pressure (P) of 2.0 mole gas in cyclic process abcda. The temperature of gas at c and d are 300 and 500 K. Calculate the heat absorbed by the gas during the process 10xR ln2 then x is .




**47.** Current i = 2A flows through the resistance R = 10Ω. With what constant speed v (in m/s), must the piston move in upward direction so that temperature of ideal gas may remain unchanged. (g = 10 m/s$^2$)




**48.** One mole of an ideal monatomic gas undergoes a linear process from A to B, in which is pressure P and its volume V change as shown in figure,where $V_o$ = 8 litres. As the volume of the gas is increased, in some range of volume the gas expands with absorbing the heat (the endothermic process) ; in the other range the gas emits the heat (the exothermic process). Then find the volume ( in litres) after which if the volume of gas is further increased the given process switches from endothermic to exothermic.



# ANSWER KEY

## EXERCISE - 1

**1.** C **2.** C **3.** B **4.** B **5.** A **6.** B **7.** D **8.** C **9.** A **10.** D **11.** A **12.** C **13.** C
**14.** B **15.** A **16.** B **17.** B **18.** A **19.** A **20.** D **21.** D **22.** D **23.** B **24.** D **25.** D **26.** B
**27.** B **28.** B **29.** C **30.** C **31.** D **32.** C **33.** B **34.** C **35.** A **36.** B **37.** D **38.** A **39.** C
**40.** D **41.** B **42.** C **43.** A **44.** B **45.** D **46.** D **47.** D **48.** C **49.** A **50.** C **51.** A **52.** A
**53.** A **54.** C **55.** D **56.** B **57.** B **58.** D **59.** B **60.** B

## EXERCISE - 2 : PART # I

1. C 2. B,D 3. C 4. B,C 5. B 6. B 7. A,B 8. B,C,D 9. B,C
10. A,B,C,D 11. C **12.** B **13.** A,C **14.** B,D **15.** B **16.** B **17.** D
**18.** A,B,C,D **19.** D **20.** C, D **21.** D 22. A,B,D 23. A,B,C 24. A,B,C,D 25. A,B
26. C,D 27. C 28. C 29. A,B,C,D 30. D 31. D 32. A,C **33.** A,C
**34.** A **35.** D **36.** B **37.** B, D **38.** B **39.** B **40.** B **41.** A
**42.** B,D **43.** B **44.** B **45.** D **46.** A **47.** C **48.** B **49.** A
**50.** B **51.** B 52. D 53. A 54. A 55. C 56. D 57. A,C
58. A 59. D 60. A 61. B 62. A 63. C 64. D 65. A
66. A 67. C,D 68. C 69. A,B,C,D 70. B 71. C **72.** A,C,D **73.** A
**74.** B **75.** D **76.** B,C,D **77.** A **78.** A,B,C **79.** D

### PART # II

1. C 2. B 3. D 4. A 5. A 6. A 7. A 8. C 9. D 10. A 11. D **12.** A **13.** A
**14.** A **15.** D **16.** D **17.** D **18.** A **19.** A **20.** A **21.** C 22. A 23. A 24. A 25. A 26. A
27. C 28. A 29. A 30. A 31. A 32. B

## EXERCISE - 3 : PART # I

**1.** $A \to Q$ ; $B \to R$; $C \to P$ ; $D \to S$
**2.** $A \to T$ ; $B \to R$ ; $C \to Q$ ; $D \to T$
**3.** $A \to P$ ; $B \to R$ ; $C \to T$
**4.** $A \to T$ ; $B \to T$ ; $C \to T$
**5.** $A \to Q$ ; $B \to T$ ; $C \to S$; $D \to T$
**6.** $A \to Q$ ; $B \to R$ ; $C \to P$ ; $D \to Q$
**7.** $A \to P,R$ ; $B \to S$ ; $C \to Q$ ; $D \to S$
**8.** $A \to T$ ; $B \to T$ ; $C \to P$; $D \to Q$
**9.** $A \to S$ ; $B \to R$ ; $C \to Q$ ; $D \to P$
**10.** $A \to R$ ; $B \to S$; $C \to Q$ ; $D \to P$
**11.** $A \to Q$ ; $B \to R$ ; $C \to S$ ; $D \to P$

### PART # II

**Comp. #1 :** **1.** A **2.** C
**Comp. #2 :** **1.** D **2.** D
**Comp. #3:** **1.** D **2.** A
**Comp. #4 :** **1.** C **2.** B **3.** C
**Comp. #5 :** **1.** B **2.** D **3.** A **4.** A **5.** A
**Comp. #6 :** **1.** A **2.** B **3.** D **4.** C
**Comp. #7:** **1.** C **2.** D **3.** B **4.** C **5.** B
**Comp. #8 :** **1.** B **2.** B **3.** B
**Comp. #9:** **1.** D **2.** A **3.** C **4.** D
**Comp. #10:** **1.** B **2.** A **3.** B
**Comp #11** **1.** B **2.** B **3.** B
**Comp. #12:** **1.** C **2.** A **3.** B
**Comp. #13:** **1.** A **2.** B **3.** C
**Comp. #14:** **1.** B **2.** A **3.** C
**Comp. #15:** **1.** B **2.** A **3.** A

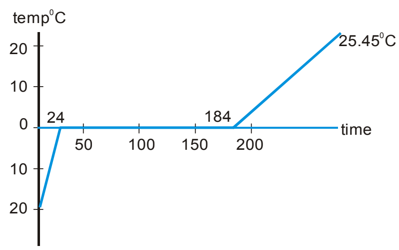
## EXERCISE - 4

**1.** $\frac{d}{(\alpha_1-\alpha_2)(t_2-t_1)}$ **2.** $4L_2^2\alpha_2 = L_1^2\alpha_1$ **3.** **(i)** 240W **(ii)** 1.5 **4.** 3.739 kg

**5.** $\theta_1 = 116^0C$, $\theta_2 = 74^0C$ **6.** **(i)** –100 $^0$C/m, **(ii)** 1000J **7.** 5$^0$C **8.** 9000 W **9.** 1927 K

**10.** 1 kg **11.** **(i)** 1934 K **(ii)** 1.5 μm

**13.** 20.3 $^0$C **14.**




**15.** 12 g **16.** 12. 96 ms$^{-1}$

**17.** **(i)** –56.6$^0$C, 5.11 atm **(ii)** both decrease **(iii)** 31.1$^0$C, 73 atm **(iv)** **(A)** vapour **(B)** solid **(C)** liquid

**18.** 75.4 cm of Hg **19.** 83.83 cm of Hg **20.** 0.139 kg **21.** $M_{neon}$ = 4.074 g $M_{orgon}$ = 23.926 g

**22.** **(i)** mono atomic, 3 **(ii)** $\frac{3}{2}$R, $\frac{5}{3}$ **(iii)** 450 R **23.** **(i)** ideal gas behaviour **(ii)** $T_1 > T_2$ **(iii)** 0.26 JK$^{-1}$

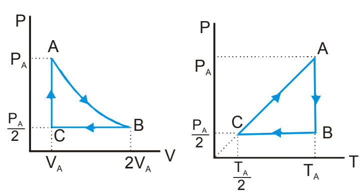
**24.** 37.2 cm, 34.7 cm **25.** **(i)** 1.96 × 10$^{27}$ **(ii)** 36 m/s **26.** **(i)** 1152 J **(ii)** 1152 J **(iii)** zero

**27.** **(i)** $T_A$ = 120.34 K, $T_B$ =240.68 K, $T_C$ =481.36 K, $T_D$ =240.68 K **(ii)** No **(iii)** $Q_{ABC}$=3.25×10$^6$ J, $Q_{ADC}$ = 2.75 × 10$^6$ J

**28.** **(i)** $P_1<P_2$, $T_1<T_2$ **(ii)** $T_1=T_2<T_3$ **(iii)** $V_1<V_2$ **(iv)** $P_1>P_2$

**29.** **(i)** 1.8 × 10$^5$ J **(ii)** 4.8 × 10$^5$ J **(iii)** 6.6 × 10$^5$ J **(iv)** 17.1 J/mole–K **30.** AC, 170 J, 10 J

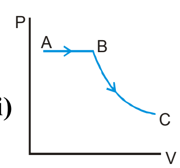
**31.** **(i)**




**(ii)** 0.58 $RT_A$

**32.** **(i)** 1869.75 J **(ii)** – 52.97.6 J **(iii)** 500 K **33.** **(i)** 189 K **(ii)** –2767 J **(iii)** 2767 J

**34.** **(i)**



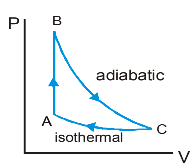

**(ii)** 113 L, 0.44 × 10$^5$ N/m$^2$, **(iii)** 12459 J **35.** **(i)** f = 5 **(ii)** W=12.3 PV

**36.** –972 J **37.** 675 K, 3.6 × 10$^6$ N/m$^2$ **38.** **(i)** 765 J **(ii)** 10.82 % **39.** 2 mole **40.** x = 8 **41.** 5 **42.** 1.5

**43.** **(i)** For process A → W = 0, Q = 148.5 J, U=148.5 J

For process B → W = 148.5 J, Q = 0, U=148.5 J

For process C → W = 6.9 J, Q = –6.9 J, U=0




**(ii)** η =0.954

**44.** 1660 N **45.** 830 J, 170 J **46.** 1.6 m, 365 K **47.** 8.08 × 10$^5$ Pa **48.** 800 K, 720 K

**49.** **(i)** $T_1$ = 12.94 $T_0$ $T_2$ = 2.25 $T_0$ **(ii)** –1.875 $RT_0$ **50.** $T_B$ = 909K, $T_D$ = 791.4 K, 61.4% **51.** 166. 32 S

**52.** 41.6 W, 26.48$^0$C, 0.52$^0$C **53.** 6.7 × 10$^5$ /$^0$C **54.** $31P_0V_0$, $-5P_0V_0$ **55.** 0.259 **56.** 400 J, $2T_0$

**57**. 2000 N/m, 1295 J **58**. 74 cm, 73.94 cm, 69.52 cm **59**. 30 cm

**60**. $\frac{13}{12}P$, $\ell_1 = 0.6\ \ell$, $\ell_2 = 1.5\ \ell$, $\ell_3 = 0.9\ \ell$ **61**. **(i)** 80J, 180 J **(ii)** 4.5 R

**62**. **(i)** $P_A = P_C = \frac{27}{8}P_0$, $P_B = \frac{21}{4}P_0$ **(ii)** $T_A = T_B = \frac{21}{4}T_0$, $T_C = \frac{3}{2}T_0$ **(iii)** $18\,P_0V_0$

**(iv)** $W_A = P_0V_0$, $W_B = 0$ **(v)** $\frac{17}{2}P_0V_0$

## EXERCISE - 5 : PART # I

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** 3 | **2.** 4 | **3.** 3 | **4.** 4 | **5.** 1 | **6.** 2 | **7.** 1 | **8.** 1 | **9.** 1 | **10.** 3 | **11.** 4 | **12.** 4 | **13.** 3 |
| **14.** 1 | **15.** 1 | **16.** 1 | **17.** 3 | **18.** 1 | **19.** 3 | **20.** 2 | **21.** 2 | **22.** 3 | **23.** 4 | **24.** 3 | **25.** 1 | **26.** 3 |
| **27.** 1 | **28.** 2 | **29.** 1 | **30.** 1 | **31.** 4 | **32.** 4 | **33.** 3 | **34.** 2 | **35.** 3 | **36.** 1 | **37.** 3 | **38.** 2 | **39.** 4 |
| **40.** 2 | **41.** 2 | **42.** 1 | **43.** 2 | **44.** 1 | **45.** 4 | **46.** 4 | **47.** 3 | **48.** 2 | **49.** 3 | **50.** 4 | **51.** 2 | **52.** 1 |
| **53.** 3 | **54.** 3 | **55.** 2 | **56** 1 | **57.** NONE | | **58.** 4 | **59.** 1 | **60.** 1 | **61.** 4 | **62.** 4 | **63.** 1 | |

## PART # II

### MCQ's (Single Correct answers)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** A | **2.** C | **3.** D | **4.** D | **5.** C | **6.** D | **7.** D | **8.** B | **9.** A | **10.** A | **11.** C | **12.** B | **13.** B |
| **14.** A | **15.** B | **16.** A | **17.** A | **18.** D | **19.** D | **20.** C | **21.** A | **22.** B | **23.** C | **24.** C | **25.** D | **26.** B |
| **27.** A | **28.** C | **29.** D | **30.** A | **31.** A | **32.** C | **33.** D | **34.** A | **35.** A | **36.** A | **37.** B | | |

### MCQ's (one or more than one correct)

**1** C,D **2** B,C **3** B,D **4** B,D **5** B,D **6** ABCD **7.** B,D **8.** A,B,D **9.** A,B/B **10.** C **11.** A

### Match the column

**1**. A→ S ; B → P,R ; C → R ; D → Q,S **2**. A → Q,S ; B → Q ; C → P ;Q ;D → Q,R **3**. A→ Q ; B→ P,R ;C→ P,S D→ Q,S

### Comprehension Based Questions

**Comprehension#1** **1**. A **2**. D **3**. C **Comprehension#2** **1**. D **2**. B **3**. B

**Comprehension#3** **1**. D **2**. D

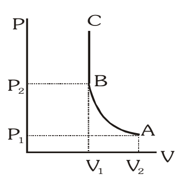
### Assertion–Reason

**1.** B

### Subjective Questions

**1**. **(i)** $P_0V_0$ **(ii)** $\frac{5}{2}P_0V_0$, $3P_0V_0$ **(iii)** $\frac{1}{2}P_0V_0$ **(iv)** $\frac{25}{8}\frac{P_0V_0}{R}$ **2**. $\left[300 + 12.5e^{-\frac{2KAt_1}{CL}}\right]$K

**3**. **(i)**




**(ii)** $W = \frac{3}{2}P_1V_1\left[1 - \left(\frac{V_1}{V_2}\right)^{2/3}\right]$, $\Delta U = \frac{3}{2}P_1V_1\left[\left(\frac{V_1}{V_2}\right)^{2/3} - 1\right]$, $T = \frac{Q}{3R} +$

**4**. **(i)** 1200 R **(ii)** $Q_{AB} = -2100$ R, $Q_{BC} = 1500$ R, $Q_{CA} = 1200R\ \ell n2$ **5**. 0.5 kg

**6**. **(i)** 600 K **(ii)** 1500R, 831.6K, –900R, –831.6R **(iii)** 600R **7**. $4.568 \times 10^{-3}\ {}^0C$

**8**. **(i)** 160K **(ii)** $3.3 \times 10^{-21}$ J **(iii)** 0.3 g **9**. $\frac{Mv_0^2}{3R}$ **10**. **(i)** 595 $W/m^2$ **(ii)** $162.6^0$ **11**. $400\left(\frac{4}{3}\right)^{0.4}$ K

**12.** $\gamma_\ell = 2\alpha_S$ **13.** $\dfrac{K}{4e\sigma LT_S^3 + K}$ **14.** **(i)** $70^0C$ **(ii)** 0.05 J **(iii)** 19999.95 J **15.** 273 K **16.** 9 **17.** 2

**18.** 2 **19.** 9 **20.** 3

## MOCK TEST

**1.** B **2.** D **3.** D **4.** A **5.** C **6.** B **7.** B **8.** D **9.** D **10.** B **11.** A **12.** C **13.** D

**14.** D **15.** C **16.** C **17.** B **18.** A **19.** A **20.** C **21.** C **22.** A **23.** A **24.** C **25.** B

**26.** A,B, C, D **27.** B,D **28.** A,D **29.** A, C **30.** A,C **31.** A,C,D **32.** A,D **33.** B,D **34.** D

**35.** C **36.** A **37.** C **38.** D **39.** B **40.** B **41.** A **42.** C **43.** A $\rightarrow$ P,R,S ; B $\rightarrow$ Q,T ; C $\rightarrow$ P,R,S; D $\rightarrow$ Q,R,T

**44.** A $\rightarrow$ S ; B $\rightarrow$ Q,T; C $\rightarrow$ R,T; D $\rightarrow$ Q,T **45.** 75 **46.** 40 **47.** 4 **48.** 5