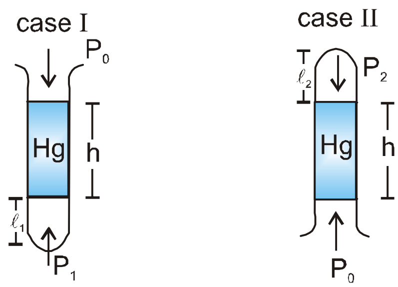
SOLVED EXAMPLES

Ex. 1 A gas column is trapped between closed end of a tube and a mercury column of length (h) when this tube is placed with its open end upwards the length of gas column is (ℓ_1), the length of gas column becomes (ℓ_2) when open end of tube is held downwards. Find atmospheric pressure in terms of height of Hg column.



Sol. for gas $P_1 = (P_O + h)$ $\quad$ $P_2 = (P_O - h)$

$V_1 = \pi r^2 \ell_1$ $\quad$ $V_2 = \pi r^2 \ell_2$

at const T. and moles.

$P_1V_1 = P_2V_2$; $(P_O + h)\,\pi r^2 \ell_1 = (P_O - h)\,\pi r^2 \ell_2$

$P_O\ell_2 + h\ell_1 = P_O\ell_2 - h\ell_2$

$P_O\ell_2 - P_o\ell_1 = h\ell, + h\ell_2$

$$P_0 = \frac{h(\ell_1 + \ell_2)}{(\ell_2 - \ell_1)}$$ cm of Hg column **Ans.**

Ex. 2 The diameter of a bubble at the surface of a lake is 4 mm and at the bottom of the lake is 1 mm. If atmospheric pressure is 1 atm and the temperature of the lake water and the atmosphere are equal. what is the depth of the lake ? (The density of the lake water and mercury are 1 g/ml and 13.6 g/ml respectively. Also neglect the contribution of the pressure due to surface tension)

Sol.

$P_1V_1 = P_2V_2$

$$\therefore\ (760\text{ mm} \times 13.6 \times g)\ \frac{4}{3}\pi(4\text{ mm}/2)^3 = (760\text{ mm} \times 13.6 \times g + h \times 1 \times g)\ \frac{4}{3}\pi(1\text{ mm}/2)^3$$

$760 \times 13.6 \times 64 = (760 \times 13.6 + h)$

$h = 64 \times 760 \times 13.6 - 760 \times 13.6$

$h = 63 \times 760 \times 13.6$ mm

$$h = \frac{63 \times 760 \times 13.6}{1000 \times 1000}\text{ km} = 0.6511\text{ km} = 651.1\text{ m}$$ **Ans.**

Ex. 3 A gas is initially at 1 atm pressure. To compress it to 1/4 th of initial volume, what will be the pressure required ?

Sol. $P_1 = 1$ atm $\quad$ $V_1 = V$

$P_2 = ?$ $\quad$ $V_2 = \frac{V}{4}$

$P_1V_1 = P_2V_2$ $\quad$ at const. T & n

$$P_2 = \frac{P_1V_1}{V_2} = \frac{1\text{ atm} \times V}{\frac{V}{4}} = 4\text{ atm}$$ **Ans.**

Ex. 4 Find the lifting power of a 100 litre balloon filled with He at 730 mm and 25°C. (Density of air = 1.25 g /L).

Sol. Since, PV = nRT

$$PV = \frac{W}{M} RT \qquad \therefore \qquad W = \frac{PVM}{RT} = \frac{730}{760} \times \frac{100 \times 4}{0.082 \times 298} \text{ g}$$

i.e., Wt. of He = 15.72 g

Wt. of air displaced = 100 × 1.25 g/L = 125 g

∴ Lifting power of the balloon = 125 g – 15.72 g = **109.28 g Ans.**

Ex. 5 A weather balloon filled with hydrogen at 1 atm and 300 K has volume equal to 12000 litres. On ascending it reaches a place where temperature is 250 K and pressure is 0.5 atm. The volume of the balloon is :

(A) 24000 litres **(B)** 20000 litres **(C)** 10000 litres **(D)** 12000 litres

Sol. Using $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$; $\frac{1\text{ atm} \times 12000\text{ L}}{300\text{ K}} = \frac{0.5\text{ atm} \times V_2}{250\text{ K}}$

∴ $V_2 = 20{,}000$ L

Hence **Ans. (B)**

Ex. 6 If water is used in place of mercury then what should be minimum length of Barometer tube to measure normal atmospheric pressure.

Sol. $P_{Hg} = P_{H_2O} = P_{atm}$.

$0.76\text{ m} \times 13.6 \times g = h_{H_2O} \times 1 \times g$

$h_{H_2O} = 0.76 \times 13.6 =$ **10.336 m Ans.**

Ex. 7 A car tyre has a volume of 10 litre when inflated. The tyre is inflated to a pressure of 3 atm at 17°C with air. Due to driving the temperature of tyre increases to 47°C.

(a) What would be pressure at this temperature ?

(b) How many litres of air measured at 47°C and pressure of 1 atm should be left out to restore the tyre to 3 atm at 47°C

Sol. V = 10L $\qquad P_1 = 3$ atm $\qquad T_1 = 17^oC = 290K$

$T_2 = 47^oC = 320K$

(a) ∵ Here v & n are constant

$$\therefore \text{ Using } \frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow P_2 = \frac{P_1T_2}{T_1} = \frac{3 \times 320}{290} \text{ atm}$$

i.e. $P_2 = 3.3103$ atm

i.e. Pressuse at 47°C = **3.3103 atm Ans.**

(b) Now, $P_1 = 3$ atm ; $V_1 = 10L$; $T_1 = 17^oC = 290K$

Final $P_2 = 3$atm ; $V_2 = ?$; $T_2 = 47^oC = 320$ K

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad \therefore V_2 = \frac{V_2 \times T_2}{T_1} = \frac{10L \times 320K}{290K} = 11.035L$$

∴ Volume of gas should be removed at 47°C & 3atm = (11.035 – 10) L = 1.035L

Now this vol at 1atm be v′ then

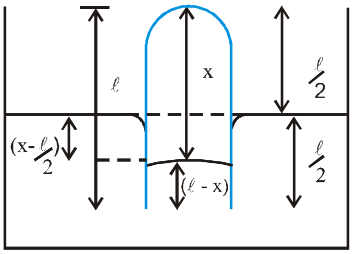
1.0351 × 3atm = v′ × 1atm

∴ v′ = 3.105L

∴ Reqd vol = **3.105 L Ans.**

Ex. 8 A tube of length 50 cm is initially in open atmosphere at a pressure 75 cm of Hg. This tube is dipped in a Hg container upto half of its length. Find the level of mercury column in side the tube.

Sol. If after dipping the tube, the length of air column be x cm (situation shown in the adjoining figure).



Then by using, $P_iV_i = P_fV_f$

We have.

$75 \text{ cm Hg} \times \ell A = P_f \times x \times A$ .... (1) $(\ell = 50 \text{ cm})$

& also, $P_f = 75 \text{ cm Hg} + (x - \frac{\ell}{2})$ .... (2)

(2) & (1) $\Rightarrow$ $[75 + (x - 25)] \times x = 75 \times 50$

$\Rightarrow$ $x^2 + 50x - 3750 = 0$

$\therefore$ $x = 41.14$ or -91.14

But, x can't be – ve $\therefore$ $x = 41.14$

$\therefore$ mercury column inside the tube = (50 – 41.14) cm = **8.86 cm Ans.**

Ex. 9 An open container of volume V contains air at temperature 27ºC or 300 K.The container is heated to such a temperature so that amount of gas coming out is 2/3 of

(a) amount of gas initially present in the container. **(b)** amount of gas finally remaining in the container.

Find the temperature to which the container should be heated.

Sol. **(a)** Here , P & V are constant, n & T are changing. Let, initially the amount of gas present be n & temp is 27ºC or 300K. Finally amount of gas present in container $= n - \frac{2}{3}n = \left(\frac{1}{3} \times n\right)$ & final temp. be T. Then using

$n_1T_1 = n_2T_2$, we have,

$n \times 300 = \frac{n}{3} \times T_2 \Rightarrow T_2 = 900K$

i.e., final temp = **900K Ans.**

Sol. **(b)** Let there be x moles of gas remaining in the container, $\frac{2}{3}$ of x come out

$\therefore$ $(x + \frac{2}{3}x) = n \Rightarrow \frac{5x}{3} = n$ $\therefore x = \frac{3n}{5}$

$\therefore$ Using $n_1 T_1 = n_2 T_2$ $n \times 300 \text{ K} = \frac{3n}{5} \times T_2$

$\therefore$ $T_2 = 500K$

final temperature = **500 K Ans.**

Ex. 10 Four one litre flasks are separately filled with the gases, O_2, F_2, CH_4 and CO_2 under the same conditions. The ratio of number of molecules in these gases :

(A) 2 : 2 : 4 : 3 **(B)** 1 : 1 : 1 : 1 **(C)** 1 : 2 : 3 : 4 **(D)** 2 : 2 : 3 : 4

Sol. According to avogadro's hypothesis.

All the flasks contains same no. of molecules

$\therefore$ Ratio of no. of molecules of O_2, F_2, CH_4 & CO_2

= 1 : 1 : 1 : 1 **Ans (B)**

Ex. 11 A sample of water gas has a composition by volume of 50% H_2, 45% CO and 5% CO_2. Calculate the volume in litres at STP at which water gas which on treatment with excess of steam will produce 5 litre of H_2. The equation for the reaction is :

$$CO + H_2O \longrightarrow CO_2 + H_2$$

Sol. If x L CO in needed then

$$\text{volume of } H_2 \text{ in water gas} = \left(\frac{x}{0.45} \times 50\%\right) L$$

$$= \left(\frac{x}{0.45} \times \frac{1}{2}\right) L = \frac{x}{0.9} L$$

But, from equation : $CO + H_2O \longrightarrow CO_2 + H_2$
& Gay-Lussac's law, we get, that the volume of H_2 produced = volume of CO taken.

$\therefore$ Volume of H_2 due to reaction = x L

$\therefore$ Total volume of $H_2 = \left(\frac{x}{0.9} + x\right) L = 5\ L$

$\Rightarrow$ $\frac{1.9x}{0.9} = 5\ L$

$\therefore$ $x = \frac{0.9 \times 5}{1.9}$

$\therefore$ Volume of water gas $= \frac{x}{0.45} L = \frac{0.9 \times 5}{1.9 \times 0.45} L$ = **5.263 L Ans.**

Ex. 12 5 ml of H_2 gas diffuses out in 1 sec from a hole. Find the volume of O_2 that will diffuse out from the same hole under identical conditions in 2 sec.

Sol. Rate of diffusion of $H_2 = \frac{5ml}{1\ sec} = 5ml/s = r_{H_2}$ (say)

$\therefore r_{O_2} = r_{H_2} \times \frac{1}{4} = 5ml/s \times \frac{1}{4}$

$\therefore$ Volume of O_2 diffused in 2.0 seconds

$= \frac{5}{4} \times 2\ ml =$ **2.5 ml Ans.**

Ex. 13 The partial pressure of hydrogen in a flask containing two grams of hydrogen and 32 gm of sulphur dioxide is :

(A) 1/16th of the total pressure
(B) 1/9th of the total pressure
(C) 2/3 of the total pressure
(D) 1/8th of the total pressure

Ans. **(C)**

Sol. $n_{H_2} = \frac{2g}{2g / mol} = 1 mol.$ $\quad n_{SO_2} = \frac{32g}{64g / mol} = 0.5\ mol$

$\therefore P_{H_2} = \frac{n_{H_2}}{\left(n_{H_2} + n_{SO_2}\right)} \times P_T = \frac{1}{(1+0.5)} \times P_T = \frac{2}{3} P_T.$

$\therefore$ **(C)**

Ex. 14 Equal volume of two gases which do not react together are enclosed in separate vessels. Their pressures are 10 mm and 400 mm respectively. If the two vessels are joined together, then what will be the pressure of the resulting mixture (temperature remaining constant) :

(A) 120 mm **(B)** 500 mm **(C)** 1000 mm **(D)** 205 mm

Ans. **(D)**

Sol. Let, vol of containers be V & temperature be T

$P_1 = 10mm$ $\qquad$ $P_2 = 400mm$

$$\therefore n_1 = \frac{P_1V}{RT} \quad \& \quad n_2 = \frac{P_2V}{RT}$$

$$\therefore n_1 + n_2 = \frac{(P_1 + P_2) \times V}{RT}$$

After joining two containers final vol = (V+V) = 2V(for gases)

$$\therefore P_{final} = \frac{(n_1 + n_2)RT}{V_{final}} = \frac{(P_1 + P_2) \times V}{RT} \times \frac{RT}{2V} = \frac{(P_1 + P_2)}{2}$$

$$= \frac{(10 + 400)mm}{2} = 205 \text{ mm.}$$

Ex. 15 A vessel contains H_2 & O_2 in the molar ratio of 8 : 1 respectively. This mixture of gases is allowed to diffuse through a hole, find composition of the mixture coming out of the hole.

Sol. Here, $n_{H_2} : n_{O_2} = 8 : 1$ $\quad$ & $\quad$ $\frac{r_{H_2}}{r_{O_2}} = \frac{n_{H_2}}{n_{O_2}}\sqrt{\frac{M_{O_2}}{M_{H_2}}}$

$$\Rightarrow \frac{r_{H_2}}{r_{O_2}} = \frac{8}{1} \times \sqrt{\frac{32}{2}} = \frac{32}{1}$$

$$\Rightarrow \frac{(\text{no. of moles of } H_2 \text{ coming out}) / \Delta t}{(\text{no. of moles of } O_2 \text{ coming out}) / \Delta t} = \frac{32}{1}$$

$\therefore$ Required composition of $H_2 : O_2$ coming out = **32 : 1 Ans.**

Ex. 16 **(i)** Calculate the pressure exerted by 10^{23} gas molecules, each mass 10^{-22} g in a container of volume one litre. The rms velocity is 10^5 cm/sec.

(ii) What is the total kinetic energy (in cal) of these particles ?

(iii) What must be the temperature ?

Sol. **(i)** Here $N = 10^{23}$ molecules $m = 10^{-22}g$, $V = 1L = 1000\ cm^3$

rms velocity = 10^5 cm/second

$$\therefore PV = \frac{1}{3} Nm\ \overline{U^2}$$

$$\therefore P = \frac{1}{3} Nm\ \overline{U^2}$$

$$= \frac{1}{3 \times 1000cm^3} \times 10^{23} \times 10^{-22} g \times (10^5)^2 cm^2/s^2$$

$= \mathbf{3.33 \times 10^7\ dyne/cm^2}$ **Ans.**

(ii) Total K · E of the molecules

$$= \frac{1}{2} \text{Nm} \, \overline{U^2}$$

$$= \frac{1}{2} \times 10^{23} \times 10^{-25} \text{ kg} \times (10^3 \text{m/s})^2$$

$$= \frac{10000\text{J}}{2} = 5000 \text{ J} \approx$$ **1195.0 Cal Ans.**

(iii) Avg K · E of one molecule $= \frac{1}{2} \, m\overline{U^2} = \frac{3}{2} \, kT$

$$\therefore \; T = \frac{1}{3} \times \frac{m\overline{U^2}}{k}$$

$$= \frac{1}{3} \times \frac{10^{-25}\text{Kg} \times \left(10^3 \text{m/s}\right)^2 \times 6.023 \times 10^{23}}{8.314} \text{ K} \qquad \left(\because k = \frac{R}{NA}\right)$$

= **2414.8 K Ans.**

Ex. 17 The rate of diffusion of a sample of a ozonized oxygen is 0.98 times than that of oxygen. Find the % (by volume of ozone in the ozonized sample).

Sol. Let, rate of diffusion of ozonized oxygen be r_g

& Let, reat of diffusion of oxygen be r_{O_2}

$$\therefore \; \frac{r_g}{r_{O_2}} = 0.98 \text{ (given)} \qquad \text{.........(1)}$$

but $\frac{r_g}{r_{O_2}} = \left(\frac{M_{O_2}}{M_g}\right)^{1/2}$ (mean molar mass of ozonized oxygen = M_g)

Form **(1)** $\Rightarrow 0.98 = \sqrt{\frac{32}{M_g}}$

$$\Rightarrow (0.98)^2 = \frac{32}{M_g} \;\; \therefore \; M_g = \frac{32}{(0.98)^2} = 33.32$$

Let % of O_3 be x $\therefore$ % $O_2 = (100 - x)$ in ozonized oxygen.

$$\therefore \; \frac{48x + (100 - x) \times 32}{100} = 33.32$$

$$\Rightarrow \; 3200 + 16x = 33.32 \;\therefore\; x = \frac{132}{16} = 8.25\,\%$$

i.e. % of O_3 = **8.25 % Ans.**

Ex. 18 A gaseous mixture containing CO, methane CH_4 & N_2 gas has total volume of 40 ml. This mixture is exploded with excess of oxygen on cooling this mixture a contraction of 30 ml is observed & when this mixture is exposed to aqueous KOH a further contraction of 30 ml is observed .find the composition of the mixture.

Sol. Let vol of CO be x mL

vol of CH_4 be y mL

vol of N_2 be z mL

On explosion with excess of oxygen the following reactions takes place

$$CO(g) + \frac{1}{2} O_2(g) \longrightarrow CO_2(g)$$ (By Gaylussac's law of combing volume)

xmL → xmL

$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g)$$

y mL → y mL, 2 ymL

N_2 remains unreacted

On cooling H_2O (g) liquifies hence volume reduction of 30 mL is observed

$\therefore 2y = 30$ $\therefore y = 15$

But, vol of CO_2 obtained = (x + y) mL

This is absorbed in KOH & vol reduction of 30 mL is observed.

$\therefore$ $x + y = 30$ $\Rightarrow x = 30 - y = (30 - 15) = 15$

and, $x + y + z = 40$ $\Rightarrow z = 40 - x - y = 40 - 15 - 15 = 10$

$\therefore$ Composition of mixture is

vol of CO = **15 mL Ans.**

vol of CH_4 = **15 mL Ans.**

vol of N_2 = **10 mL Ans.**

Ex. 19 Under critical states of a gas for one mole of a gas, compressibility factor is :

(A) $\frac{3}{8}$ **(B)** $\frac{8}{3}$ **(C)** 1 **(D)** $\frac{1}{4}$

Sol. For 1 mole of gas $Z = \frac{P_C V_C}{RT_C}$ (Under critical condition)

But, $P_C = \frac{a}{27b^2}$, $V_C = 3b$, $T_C = \frac{8a}{27Rb}$

$$\therefore Z = \left(\frac{a}{27b^2}\right) \times \frac{3b}{R} \times \frac{27Rb}{8a} = \frac{3}{8}$$

Ans. (A)

Ex. 20 One litre of oxygen gas is passed through a ozonizer & the final volume of the mixture becomes 820 ml. If this mixture is passed through oil of turpentine. Find the final volume of gas remaining.

Sol. The reaction that takes place in ozonizer as $3O_2 \longrightarrow 2O_3$.

If Vml of O_2 out of 1000 ml is ozonized then vol of O_3 obtained = $\frac{2}{3}$ V

$\therefore$ Final vol of ozonized oxygen

$$= (1000 - V + \frac{2}{3} V)\ mL = 820\ mL$$

$$\Rightarrow \quad 1000 - \frac{1}{3} V = 820$$

$$\Rightarrow \quad \frac{V}{3} = 180 \qquad \therefore V = 540$$

$\therefore$ O_2 remaining = (1000 – 540) mL ($\because$ O_3 is absorbed in oil of turpentine)

= **460 mL Ans.**

Ex. 21 If for two gases of molecular weights M_A and M_B at temperature T_A and T_B ; $T_A M_B = T_B M_A$, then which property has the same magnitude for both the gases.

(A) Density **(B)** Pressure **(C)** KE per mol **(D)** RMS speed

Sol. Given that $T_A M_B = T_B M_A \Rightarrow \frac{T_A}{M_A} = \frac{T_B}{M_B}$

But, r.m.s. = $\sqrt{\frac{3RT}{M}}$

$\therefore$ r.m.s$_A = \sqrt{\frac{3RT_A}{M_A}}$ & r.m.s$_B = \sqrt{\frac{3RT_B}{M_B}}$

$\therefore$ r.m.s$_A$ = r.m.s$_B$

$\therefore$ **Ans. (D)**

Ex. 22 It has been considered that during the formation of earth H_2 gas was available at the earth. But due to the excessive heat on the earth this had been escaped. What was the temperature of earth during its formation?

(The escape velocity is 1.1 x 10^6 cm/s)

Sol. Escape velocity of H_2 should be equal to average velocity of H_2.

$\therefore$ Avg velocity of $H_2 = 1.1 \times 10^6$ cm/s $= 1.1 \times 10^4$ m/s

But, avg. velocity = $\sqrt{\frac{8RT}{\pi M}}$

$$\Rightarrow 1.1 \times 10^4 = \sqrt{\frac{8 \times 8.314 \times T}{\pi \times 2 \times 10^{-3}}} \quad \left(M_{H_2} = 2g = 2 \times 10^{-3} kg\right)$$

$$\therefore T = \frac{\left(1.1 \times 10^4\right)^2 \times \pi \times 2 \times 10^{-3}}{8 \times 8.314} K = 11430.5\ K = \mathbf{11157.5^oC\ Ans.}$$

Exercise # 1

[Single Correct Choice Type Questions]

1. A thin balloon filled with air at 47ºC has a volume of 3 litre. If on placing it in a cooled room its volume becomes 2.7 litre , the temperature of room is :

(A) 42ºC **(B)** 100ºC **(C)** 15ºC **(D)** 200ºC

2. If a mixture containing 3 moles of hydrogen and 1 mole of nitrogen is converted completely into ammonia, the ratio of initial and final volume under the same temperature and pressure would be :

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

3. SO_2 at STP contained in a flask was replaced by O_2 under identical conditions of pressure, temperature and volume. Then the weight of O_2 will be _______ of SO_2.

(A) half **(B)** one fourth **(C)** twice **(D)** four times.

4. Assuming that O_2 molecule is spherical in shape with radius 2 Å, the percentage of the volume of O_2 molecules to the total volume of gas at S.T.P. is :

(A) 0.09 % **(B)** 0.9 % **(C)** 0.009 % **(D)** 0.045 %

5. If the pressure of a gas contained in a closed vessel is increased by 0.4 % when heated by 1ºC its initial temperature must be :

(A) 250 K **(B)** 250ºC **(C)** 25ºC **(D)** 25 K

6. A gas is heated from 0°C to 100°C at 1.0 atm pressure. If the initial volume of the gas is 10.0 ℓ , its final volume would be :

(A) 7.32 ℓ **(B)** 10.00 ℓ **(C)** 13.66 ℓ **(D)** 20.00 ℓ

7. Under what conditions will a pure sample of an ideal gas not only exhibit a pressure of 1 atm but also a concentration of 1 mol $litre^{-1}$. [R = 0.082 litre atm mol^{-1} K^{-1}]

(A) at S.T.P. **(B)** when V = 22.42 L

(C) when T = 12 K **(D)** impossible under any condition

8. An amount of 1.00 g of a gaseous compound of boron and hydrogen occupies 0.820 liter at 1.00 atm and at 3^0C. The compound is (R = 0.0820 liter atm $mole^{-1}$ K^{-1}; at. wt: H = 1.0, B = 10.8)

(A) BH_3 **(B)** B_4H_{10} **(C)** B_2H_6 **(D)** B_3H_{12}

9. A 0.5 dm^3 flask contains gas A and 1 dm^3 flask contains gas B at the same temperature. If density of A = 3 g/dm^3 and that of B = 1.5 g/dm^3 and the molar mass of A = 1/2 of B, the ratio of pressure exerted by gases is :

(A) $\frac{P_A}{P_B} = 2$ **(B)** $\frac{P_A}{P_B} = 1$ **(C)** $\frac{P_A}{P_B} = 4$ **(D)** $\frac{P_A}{P_B} = 3$

10. A and B are two identical vessels. A contains 15 g ethane at 1atm and 298 K. The vessel B contains 75 g of a gas X_2 at same temperature and pressure. The vapour density of X_2 is :

(A) 75 **(B)** 150 **(C)** 37.5 **(D)** 45

11. The density of neon will be highest at :

(A) STP **(B)** 0°C, 2 atm **(C)** 273°C. 1 atm **(D)** 273°C. 2 atm

12. Equal weights of ethane & hydrogen are mixed in an empty container at 25° C, the fraction of the total pressure exerted by hydrogen is:

(A) 1: 2 **(B)** 1: 1 **(C)** 1: 16 **(D)** 15: 16

13. A mixture of hydrogen and oxygen at one bar pressure contains 20% by weight of hydrogen. Partial pressure of hydrogen will be

(A) 0.2 bar **(B)** 0.4 bar **(C)** 0.6 bar **(D)** 0.8 bar

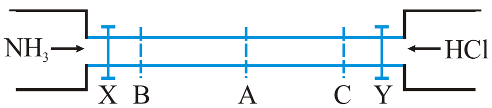
14. A compound exists in the gaseous phase both as monomer **(A)** and dimer (A_2). The atomic mass of A is 48 and molecular mass of A_2 is 96. In an experiment 96 g of the compound was confined in a vessel of volume 33.6 litre and heated to 273ºC. The pressure developed if the compound exists as dimer to the extent of 50 % by weight under these conditions will be :

(A) 1 atm **(B)** 2 atm **(C)** 1.5 atm **(D)** 4 atm

15. 20 ℓ of SO_2 diffuses through a porous partition in 60 seconds. Volume of O_2 diffuse under similar conditions in 30 seconds will be :

(A) 12.14 ℓ **(B)** 14.14 ℓ **(C)** 18.14 ℓ **(D)** 28.14 ℓ

16. See the figure-1 :



The valves of X and Y are opened simultaneously. The white fumes of NH_4Cl will first form at:

(A) A **(B)** B **(C)** C **(D)** A,B and C simultaneously

17. X ml of H_2 gas effuses through a hole in a container in 5 sec. The time taken for the effusion of the same volume of the gas specified below under identical conditions is :

(A) 10 sec. He **(B)** 20 sec. O_2 **(C)** 25 sec. CO_2 **(D)** 55 sec. CO_2

18. Three identical footballs are respectively filled with nitrogen , hydrogen and helium at same pressure. If the leaking of the gas occurs with time from the filling hole, then the ratio of the rate of leaking of gases $(r_{N_2} : r_{H_2} : r_{He})$ from three footballs under identical conditions (in equal time interval) is :

(A) $\left(1 : \sqrt{14} : \sqrt{7}\right)$ **(B)** $\left(\sqrt{14} : \sqrt{7} : 1\right)$ **(C)** $\left(\sqrt{7} : 1 : \sqrt{14}\right)$ **(D)** $\left(1 : \sqrt{7} : \sqrt{14}\right)$

19. The rates of diffusion of SO_3, CO_2, PCl_3 and SO_2 are in the following order -

(A) $PCl_3 > SO_3 > SO_2 > CO_2$ **(B)** $CO_2 > SO_2 > PCl_3 > SO_3$
(C) $SO_2 > SO_3 > PCl_3 > CO_2$ **(D)** $CO_2 > SO_2 > SO_3 > PCl_3$

20. The kinetic energy of N molecules of O_2 is x joule at – 123ºC. Another sample of O_2 at 27ºC has a kinetic energy of 2 x. The latter sample contains _______ molecules of O_2.

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

21. The average kinetic energy (in joules of) molecules in 8.0 g of methane at 27° C is :

(A) 6.21×10^{-20} J/molecule **(B)** 6.21×10^{-21} J/molecule
(C) 6.21×10^{-22} J/molecule **(D)** 3.1×10^{-22} J/molecule

22. According to kinetic theory of gases, for a diatomic molecule :

(A) The pressure exerted by the gas is proportional to the mean velocity of the molecule.
(B) The pressure exerted by the gas is proportional to the r.m.s. velocity of the molecule.
(C) The r.m.s. velocity of the molecule is inversely proportional to the temperature.
(D) The mean translational K.E. of the molecule is proportional to the absolute temperature.

23. Temperature at which r.m.s. speed of O_2 is equal to that of neon at 300 K is :
(A) 280 K **(B)** 480 K **(C)** 680 K **(D)** 180 K

24. The R.M.S. speed of the molecules of a gas of density 4 kg m^{-3} and pressure 1.2×10^5 N m^{-2} is :
(A) 120 ms^{-1} **(B)** 300 ms^{-1} **(C)** 600 ms^{-1} **(D)** 900 ms^{-1}

25. The mass of molecule A is twice that of molecule B. The root mean square velocity of molecule A is twice that of molecule B. If two containers of equal volume have same number of molecules, the ratio of pressure P_A/P_B will be :
(A) 8 : 1 **(B)** 1 : 8 **(C)** 4 : 1 **(D)** 1 : 4

26. Which of the following expression correctly represents the relationship between the average kinetic energy of CO and N_2 molecules at the same temperature.
(A) $\overline{E}(CO) > \overline{E}(N_2)$
(B) $\overline{E}(CO) < \overline{E}(N_2)$
(C) $\overline{E}(CO) = \overline{E}(N_2)$
(D) Cannot be predicted unless volumes of the gases are given

27. Helium atom is two times heavier than a hydrogen molecule. At 298 K, the average kinetic energy of a helium atom is
(A) two times that of a hydrogen molecules **(B)** same as that of a hydrogen molecules
(C) four times that of a hydrogen molecules **(D)** half that of a hydrogen molecules

28. The temperature of an ideal gas is increased from 120 K to 480 K. If at 120 K the root-mean-square velocity of the gas molecules is v, at 480 K it becomes :
(A) 4v **(B)** 2v **(C)** v/2 **(D)** v/4

29. The ratio between the r.m.s. velocity of H_2 at 50 K and that of O_2 at 800 K is:
(A) 4 **(B)** 2 **(C)** 1 **(D)** 1/4

30. Compressibility factor for H_2 behaving as real gas is :
(A) 1 **(B)** $\left(1-\frac{a}{RTV}\right)$ **(C)** $\left(1+\frac{Pb}{RT}\right)$ **(D)** $\frac{RTV}{(1-a)}$

31. At low pressures (For 1 mole), the Vander Waal's equation is written as

$$\left[p + \frac{a}{V^2}\right] V = RT$$

The compressibility factor is then equal to :
(A) $\left(1-\frac{a}{RTV}\right)$ **(B)** $\left(1-\frac{RTV}{a}\right)$ **(C)** $\left(1+\frac{a}{RTV}\right)$ **(D)** $\left(1+\frac{RTV}{a}\right)$

32. Calculate the radius of He atoms if its Vander Waal's constant 'b' is 24 ml mol^{-1}.
(Note 1 ml = 1 cubic centimeter)
(A) 1.355 Å **(B)** 1.314 Å **(C)** 1.255 Å **(D)** 0.355 Å

33. A real gas obeying Vander Waal's equation will resemble ideal gas , if the :
(A) constants a & b are small **(B)** a is large & b is small
(C) a is small & b is large **(D)** constant a & b are large

34. For the non-zero values of force of attraction between gas molecules, gas equation will be :
(A) $PV = nRT - \frac{n^2a}{V}$ **(B)** $PV = nRT + nbP$ **(C)** $PV = nRT$ **(D)** $P = \frac{nRT}{V-b}$

35. The correct order of normal boiling points of O_2, N_2, NH_3 and CH_4, for whom the values of vander Waal's constant 'a' are 1.360, 1.390, 4.170 and 2.253 L^2. atm. mol^{-2} respectively, is :

(A) $O_2 < N_2 < NH_3 < CH_4$ **(B)** $O_2 < N_2 < CH_4 < NH_3$ **(C)** $NH_3 < CH_4 < N_2 < O_2$ **(D)** $NH_3 < CH_4 < O_2 < N_2$

36. NH_3 gas is liquefied more easily than N_2. Hence:

(A) Vander Waal's constants 'a' and 'b' of NH_3 > that of N_2
(B) Vander Waal's constants 'a' and 'b' of NH_3 < that of N_2
(C) a (NH_3) > a (N_2) but b (NH_3) < b (N_2)
(D) a (NH_3) < a (N_2) but b (NH_3) > b (N_2)

37. In vander Waal's equation of state for a non ideal gas the term that accounts for intermolecular forces is :

(A) nb **(B)** nRT **(C)** n^2a/V^2 **(D)** $(nRT)^{-1}$

38. 7.5 ml of a gaseous hydrocarbon was exploded with 36 ml of oxygen. The volume of gases on cooling was found to be 28.5 ml, 15 ml of which was absorbed by KOH and the rest was absorbed in a solution of alkaline pyrogallol. If all volumes are measured under same conditions, the formula of hydrocarbon is

(A) C_3H_4 **(B)** C_2H_4 **(C)** C_2H_6 **(D)** C_3H_6

39. A gaseous alkane is exploded with oxygen. The volume of O_2 for complete combustion to CO_2 formed is in the ratio 7/4. The molecular formula of alkane is :

(A) C_2H_4 **(B)** C_2H_6 **(C)** CH_4 **(D)** C_4H_{12}

40. LPG is a mixture of n - butane & iso - butane. The volume of oxygen needed to burn 1 kg of LPG at NTP would be :

(A) 2240 ℓt **(B)** 2510 ℓt **(C)** 1000 ℓt **(D)** 500 ℓt

41. The volume of CO_2 produced by the combustion of 40 ml of gaseous acetone in excess of oxygen is

(A) 40 ml **(B)** 80 ml **(C)** 60 ml **(D)** 120 ml

42. 500 ml of a hydrocarbon gas burnt in excess of oxygen yields 2500 ml of CO_2 and 3 lts of water vapours. All volume being measured at the same temperature and pressure. The formula of the hydrocarbon is

(A) C_5H_{10} **(B)** C_5H_{12} **(C)** C_4H_{10} **(D)** C_4H_8

43. 15 ml of a gaseous hydrocarbon was required for complete combustion in 357ml of air (21% of oxygen by volume) and the gaseous products occupied 327 ml (all volumes being measured at NTP). What is the formula of the hydrocarbon ?

(A) C_3H_8 **(B)** C_4H_8 **(C)** C_5H_{10} **(D)** C_4H_{10}

44. Two flasks of equal volume are connected by a narrow tube (of negligible volume) all at 27ºC and contain 0.70 mole of H_2 at 0.5 atm. One of the flask is then immersed into a bath kept at 127º C, while the other remains at 27º C. The final pressure in each flask is :

(A) Final pressure = 0.5714 atm **(B)** Final pressure = 1.5714 atm
(C) Final pressure = 0.5824 atm **(D)** None of these

45. On the surface of the earth at 1 atm pressure, a balloon filled with H_2 gas occupies 500 mL. This volume is 5/6 of its maximum capacity. The balloon is left in air. It starts rising. The height above which the balloon will burst if temperature of the atmosphere remains constant and the pressure decreases 1 mm for every 100 cm rise of height is

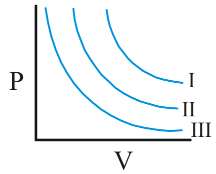
(A) 120 m **(B)** 136.67 m **(C)** 126.67 m **(D)** 100 m

46. A 40 ml of a mixture of H_2 and O_2 at 18 ºC and 1 atm pressure was sparked so that the formation of water was complete. The remaining pure gas had a volume of 10 ml at 18ºC and 1 atm pressure. If the remaining gas was H_2, the mole fraction of H_2 in the 40 ml mixture is :

(A) 0.75 **(B)** 0.5 **(C)** 0.65 **(D)** 0.85

47. I, II, III are three isotherms respectively at T_1, T_2 and T_3 as shown in graph. Temperature will be in order

(A) $T_1 = T_2 = T_3$
(B) $T_1 < T_2 < T_3$
(C) $T_1 > T_2 > T_3$
(D) $T_1 > T_2 = T_3$



48. A vessel of volume 5 litre contains 1.4 g of nitrogen at a temperature 1800 K. The pressure of the gas if 30% of its molecules are dissociated into atoms at this temperature is :

(A) 4.05 atm **(B)** 2.025 atm **(C)** 3.84 atm **(D)** 1.92 atm

49. One litre of a gaseous mixture of two gases effuses in 311 seconds while 2 litres of oxygen takes 20 minutes. The vapour density of gaseous mixture containing CH_4 and H_2 is

(A) 4 **(B)** 4.3 **(C)** 3.4 **(D)** 5

50. Pure O_2 diffuses through an aperture in 224 second, whereas mixture of O_2 and another gas containing 80% O_2 diffuses from the same in 234 second. The molecular mass of gas will be

(A) 51.5 **(B)** 48.6 **(C)** 55 **(D)** 46.6

51. A straight glass tube has 2 inlets X & Y at the two ends of 200 cm long tube. HCl gas through inlet X and NH_3 gas through inlet Y are allowed to enter in the tube at the same time and under the identical conditions. At a point P inside the tube both the gases meet first. The distance of point P from X is :

(A) 118.9 cm **(B)** 81.1 cm **(C)** 91.1 cm **(D)** 108.9 cm

52. Two flasks of equal volume are connected by a narrow tube (of negligible volume) all at 27º C and contain 0.70 moles of H_2 at 0.5 atm. One of the flask is then immersed into a bath kept at 127º C , while the other remains at 27º C. The number of moles of H_2 in flask 1 and flask 2 are :

(A) Moles in flask 1 = 0.4, Moles in flask 2 = 0.3
(B) Moles in flask 1 = 0.2, Moles in flask 2 = 0.3
(C) Moles in flask 1 = 0.3, Moles in flask 2 = 0.2
(D) Moles in flask 1 = 0.4, Moles in flask 2 = 0.2

53. A teacher enters a classroom from front door while a student from back door. There are 13 equidistant rows of benches in the classroom. The teacher releases N_2O, the laughing gas, from the first bench while the student releases the weeping gas ($C_6H_{11}OBr$) from the last bench. At which row will the students starts laughing and weeping simultaneously

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

54. A real gas most closely approaches the behaviour of an ideal gas at -

(A) 15 atm and 200 K
(B) 1 atm and 273 K
(C) 0.5 atm and 500 K
(D) 15 atm and 500 K

55. Calculate the compressibility factor for CO_2, if one mole of it occupies 0.4 litre at 300 K and 40 atm. Comment on the result.

(A) 0.40, CO_2 is more compressible than ideal gas
(B) 0.65, CO_2 is more compressible than ideal gas
(C) 0.55, CO_2 is more compressible than ideal gas
(D) 0.62, CO_2 is more compressible than ideal gas

56. Which of following statement (s) is true

I – Slope of isotherm at critical point is maximum.
II – Larger is the value of T_C easier is the liquification of gas.
III – Vander waals equation of state is applicable below critical temperature at all pressure.

(A) only I **(B)** I & II **(C)** II & III **(D)** only II

57. A certain volume of argon gas (Mol. Wt. = 40) requires 45 s to effuse through a hole at a certain pressure and temperature. The same volume of another gas of unknown molecular weight requires 60 s to pass through the same hole under the same conditions of temperature and pressure. The molecular weight of the gas is :

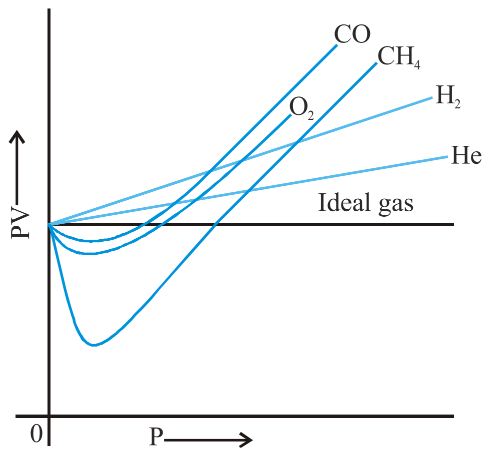
(A) 53 **(B)** 35 **(C)** 71 **(D)** 120

58. A sample of an ideal gas was heated from 30^0C to 60^0C at constant pressure. Which of the following statement(s) is/are true.

(A) Kinetic energy of the gas is doubled **(B)** Boyle's law will apply

(C) Volume of the gas will be doubled **(D)** None of the above

59. The curve of pressure volume (PV) against pressure (P) of the gas at a particular temperature is as shown, according to the graph which of the following is incorrect (in the low pressure region):



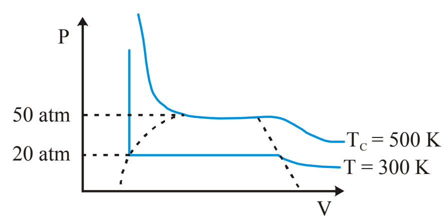
(A) H_2 and He shows +ve deviation from ideal gas equation.

(B) CO, CH_4 and O_2 show negative deviation from ideal gas equation.

(C) H_2 and He show negative deviation while CO, CH_4 and O_2 show positive deviation.

(D) H_2 and He are less compressible than that of an ideal gas while CO, CH_4 and O_2 more compressible than that of ideal gas.

60. For a real gas the P-V curve was experimentally plotted and it had the following appearance. With respect to liquifaction. Choose the **correct** statement.



(A) at T = 500 K, P = 40 atm, the state will be liquid.

(B) at T = 300 K, P = 50 atm, the state will be gas

(C) at T < 300 K, P > 20 atm, the state will be gas

(D) at 300 K < T < 500 K, P > 50 atm, the state will be liquid.

61. Consider the following statements:

The coefficient B in the virial equation of state

$$PV_m = RT\left(1 + \frac{B}{V_m} + \frac{C}{V_m^2} + \dots\dots\dots\right)$$

(i) is independent of temperature

(ii) is equal to zero at boyle temperature

(iii) has the dimension of molar volume

Which of the above statements are correct.

(A) i and ii **(B)** i and iii **(C)** ii and iii **(D)** i, ii and iii

62. Consider the following statements: If the van der Waal's parameters of two gases are given as

	a (atm lit^2 mol^{-2})	b (lit mol^{-1})
Gas X:	6.5	0.056
Gas Y:	8.0	0.011

then (i) : $V_C(X) < V_C(Y)$ (ii) : $P_C(X) < P_C(Y)$ (iii) : $T_C(X) < T_C(Y)$

Select correct alternate:

(A) (i) alone **(B)** (i) and (ii) **(C)** (i), (ii) and (iii) **(D)** (ii) and (iii)

63. Select correct statement(s):

(A) we can condense vapours simply by applying pressure

(B) to liquify a gas one must lower the temperature below T_C and also apply pressure

(C) at T_c, there is no distinction between liquid and vapour state, hence density of the liquid is nearly equal to density of the vapour

(D) all the statements are correct statements

64. A chemist has synthesized a greenish yellow gaseous compound of chlorine and oxygen and finds that its density is 7.71 g/L at 36°C and 2.88 atm. Then the molecular formula of the compound will be

(A) ClO_3 **(B)** ClO_2 **(C)** ClO **(D)** Cl_2O_2

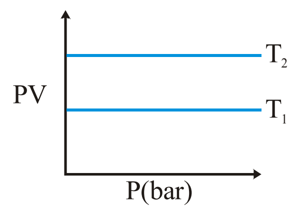
65. At what temperature, the average speed of gas molecules be double of that at temperature, 27ºC?

(A) 120ºC **(B)** 108ºC **(C)** 927ºC **(D)** 300ºC

66. Two glass bulbs A (of 100 mL capacity), and B (of 150 mL capacity) containing same gas are connected by a small tube of negligible volume. At particular temperature the pressure in A was found to be 20 times more than that in bulb B. The stopcock is opened without changing the temperature. The pressure in A will

(A) drop by 75% **(B)** drop by 57% **(C)** drop by 25% **(D)** will remain same

67. The product of PV is plotted against P at two temperatures T_1 and T_2 and the 'result is shown in figure. What is correct about T_1 and T_2?



(A) $T_1 > T_2$ **(B)** $T_2 > T_1$ **(C)** $T_1 = T_2$ **(D)** $T_1 + T_2 = 1$

68. 2.5 L of a sample of a gas at 27°C and 1 bar pressure is compressed to a volume of 500 mL keeping the temperature constant, the percentage increase in pressure is

(A) 100 % **(B)** 400 % **(C)** 500% **(D)** 80%

69. At STP the order of mean square velocity of molecules of H_2, N_2, O_2 and HBr is -

(A) $H_2 > N_2 > O_2 > HBr$ **(B)** $HBr > O_2 > N_2 > H_2$

(C) $HBr > H_2 > O_2 > N_2$ **(D)** $N_2 > O_2 > H_2 > HBr$

70. A quantity of gas is collected in a graduated tube over the mercury. The volume of gas at 18 ºC is 50 ml and the level of mercury in the tube is 100 mm above the outside mercury level. The barometer reads 750 torr. Hence , volume at S.T.P. is approximately :

(A) 22 ml **(B)** 40 ml **(C)** 20 ml **(D)** 44 ml

71. If equal weights of oxygen and nitrogen are placed in separate containers of equal volume at the same temperature, which one of the following statements is true?

(mol wt: $N_2 = 28$, $O_2 = 32$)

(A) Both flasks contain the same number of molecules.

(B) The pressure in the nitrogen flask is greater than the one in the oxygen flask.

(C) More molecules are present in the oxygen flask.

(D) Molecules in the oxygen flask are moving faster on the average than the ones in the nitrogen flask.

(E) The nitrogen has a greater average kinetic energy per mole.

Exercise # 2

Part # I [Multiple Correct Choice Type Questions]

1. A gas cylinder containing cooking gas can withstand a pressure of 14.9 atmosphere. The pressure guaze of cylinder indicates 12 atmosphere at 27 ºC. Due to sudden fire in the building temperature starts rising. The temperature at which cylinder will explode is :

(A) 372.5 K **(B)** 99.5 ºC **(C)** 199 ºC **(D)** 472.5 k

2. Which of the following statements are correct ?

(A) Helium diffuses at a rate 8.65 times as much as CO does.

(B) Helium escapes at a rate 2.65 times as fast as CO does.

(C) Helium escapes at a rate 4 times as fast as CO_2 does.

(D) Helium escapes at a rate 4 times as fast as SO_2 does.

3. The rate of diffusion of 2 gases 'A' and 'B' are in the ratio 16: 3. If the ratio of their masses present in the mixture is 2 : 3. Then

(A) The ratio of their molar masses is 16 : 1

(B) The ratio of their molar masses is 1 : 4

(C) The ratio of their moles present inside the container is 1 : 24

(D) The ratio of their moles present inside the container is 8 : 3

4. For two gases, A and B with molecular weights M_A and M_B, it is observed that at a certain temperature, T, the mean velocity of A is equal to the root mean square velocity of B. Thus the mean velocity of A can be made equal to the mean velocity of B, if

(A) A is at temperature, T_1 and B at T_2 $T_1 > T_2$

(B) A is lowered to a temperature $T_2 < T$ while B is at T

(C) Both A and B are raised to a higher temperature

(D) Both A and B are lowered in temperature.

5. Match of following (where U_{rms} = root mean square speed, U_{av} = average speed, U_{mp} = most probable speed)

	List I		List II
(A)	U_{rms} / U_{av}	(i)	1.22
(B)	U_{av} / U_{mp}	(ii)	1.13
(C)	U_{rms} / U_{mp}	(iii)	1.08

(A) (A)-(iii), (B)-(ii), (C)-(i) **(B)** (A)-(i), (B)-(ii), (C)-(iii)

(C) (A)-(iii), (B)-(i), (C)-(ii) **(D)** (A)-(ii), (B)-(iii), (C)-(i).

6. $N_2 + 3H_2 \longrightarrow 2NH_3$. 1 mol N_2 and 4 mol H_2 are taken in 15 L flask at 27°C. After complete conversion of N_2 into NH_3, 5 L of H_2O is added. Pressure set up in the flask is :

(A) $\frac{3 \times 0.0821 \times 300}{15}$ atm **(B)** $\frac{2 \times 0.0821 \times 300}{10}$ atm

(C) $\frac{1 \times 0.0821 \times 300}{15}$ atm **(D)** $\frac{1 \times 0.0821 \times 300}{10}$ atm

7. Which of the following is not the correct set of pressure and volume at constant temperature and constant moles of gas ?

	P	V		P	V
(A)	1 atm	200 ml	**(B)**	760 mm	0.2 L
(C)	0.5 atm	100 L	**(D)**	2 atm	100 mL

8. At what temperature will the total KE of 0.3 mol of He be the same as the total KE of 0.40 mol of Ar at 400 K ?
(A) 533 K (B) 400 K (C) 346 K (D) 300 K

9. Potassium hydroxide solutions are used to absorb CO_2. How many litres of CO_2 at 1.00 atm and 22ºC would be absorbed by an aqueous solution containing 15.0 g of KOH ? (Take $R = \frac{1}{12}\ \ell$ atm / K/mole)

$$2KOH + CO_2 \longrightarrow K_2CO_3 + H_2O$$

(A) 3.24 L (B) 1.62 L (C) 6.48 L (D) 0.324 L

10. The volume of a gas increases by a factor of 2 while the pressure decreases by a factor of 3. Given that the number of moles is unaffected, the factor by which the temperature changes is :
(A) $\frac{3}{2}$ (B) 3×2 (C) $\frac{2}{3}$ (D) $\frac{1}{2} \times 3$

11. If V_0 is the volume of a given mass of gas at 273 K at constant pressure , then according to Charle's law , the volume at 10 ºC will be :
(A) $10\,V_0$ (B) $\frac{2}{273}(V_0 + 10)$ (C) $V_0 + \frac{10}{273}$ (D) $\frac{283}{273} V_0$

12. When a gas is compressed at constant temperature :
(A) the speeds of the molecules increase
(B) the collisions between the molecules increase
(C) the speeds of the molecules decrease
(D) the collisions between the molecules decrease

13. 2 litres of moist hydrogen were collected over water at 26^0C at a total pressure of one atmosphere. On analysis, it was found that the quantity of H_2 collected was 0.0788 mole. What is the mole fraction of H_2 in the moist gas
(A) 0.989 (B) 0.897 (C) 0.953 (D) 0.967

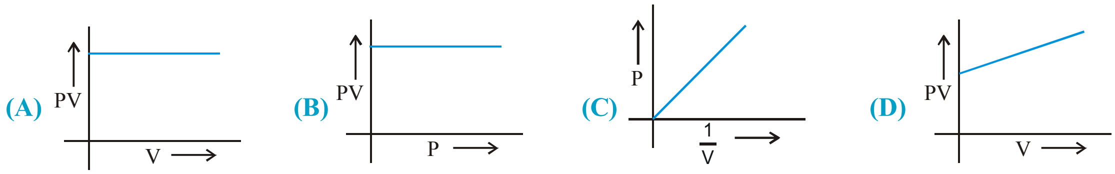
14. When CO_2 under high pressure is released from a fire extinguisher, particles of solid CO_2 are formed, despite the low sublimation temperature (– 77ºC) of CO_2 at 1.0 atm. It is
(A) the gas does work pushing back the atmosphere using KE of molecules and thus lowering the temperature
(B) volume of the gas is decreased rapidly hence, temperature is lowered
(C) both **(A)** and **(B)**
(D) None of the above

15. If a gas is allowed to expand at constant tempeature then which of the following does not hold true :
(A) the kinetic energy of the gas molecules decreases
(B) the kinetic energy of the gas molecules increases
(C) the kinetic energy of the gas molecules remains the same
(D) Can not be predicted

16. The vander waal gas constant 'a' is given by
(A) $\frac{1}{3} V_C$ (B) $3P_C V_C^2$ (C) $\frac{1}{8}\frac{RT_C}{P_C}$ (D) $\frac{27}{64}\frac{R^2 T_C^2}{P_C}$

17. Which of the following are correct statements ?
(A) vander Waals constant 'a' is a measure of attractive force
(B) van der Waals constant 'b' is also called co-volume or excluded volume
(C) 'b' is expressed in L mol^{-1}
(D) 'a' is expressed in atm L^2 mol^{-2}

18. For gaseous state at constant temperature which of the following plot is correct ?



19. A hypothetical gaseous element having molecular formula Mx may be changed to another gaseous allotrope having molecular formula My at 310 K. In this act volume of the gas is contracted by 12 ml to a volume of 8 ml. The simplest possible molecular formula of the two allotropes is :

(A) M_5 & M_3 **(B)** M_3 & M_5 **(C)** M_1 & M_2 **(D)** M_2 & M_3

20. What is the total pressure exerted by the mixture of 7.0 g of N_2, 2g of hydrogen and 8.0 g of sulphur dioxide gases in a vessel of 6 L capacity that has been kept in a reservoir at 27°C?

(A) 2.5 bar **(B)** 4.5 bar **(C)** 10 atm **(D)** 5.7 bar

21. At what temperature root mean square speed of N_2 gas is equal to that of propane gas at S.T.P. conditions.

(A) 173.7°C **(B)** 173.7 K **(C)** S.T.P. **(D)** – 40°C

22. A gaseous mixture of three gases A, B and C has a pressure of 10 atm. The total number of moles of all the gases is 10. If the partial pressure of A and B are 3.0 and 1.0 atm respectively and if C has mol. wt. of 2.0, what is the weight of C in g present in the mixture ?

(A) 6 **(B)** 8 **(C)** 12 **(D)** 3

23. 1 mol of a gaseous aliphahatic compound $C_nH_{3n}O_m$ is completely burnt in an excess of oxygen. The contraction in volume is (assume water get condensed out)

(A) $\left(1+\frac{1}{2}n-\frac{3}{4}m\right)$ **(B)** $\left(1+\frac{3}{4}n-\frac{1}{4}m\right)$ **(C)** $\left(1-\frac{1}{2}n-\frac{3}{4}m\right)$ **(D)** $\left(1+\frac{3}{4}n-\frac{1}{2}m\right)$

24. A cylinder is filled with a gaseous mixture containing equal masses of CO and N_2. The partial pressure ratio is :

(A) $P_{N_2} = P_{CO}$ **(B)** $P_{CO} = 0.875\, P_{N_2}$ **(C)** $P_{CO} = 2\, P_{N_2}$ **(D)** $P_{CO} = \frac{1}{2} P_{N_2}$

25. Helium atom is two times heavier than a hydrogen molecule at 298 k , the average kinetic energy of helium is :

(A) two times that of hydrogen molecule
(B) same as that of the hydrogen molecule
(C) four times that of a hydrogen molecule
(D) half that of a hydrogen molecule

26. Two glass bulbs A and B are connected by a very small tube having a stop cock. Bulb A has a volume of 100 cm^3 and contained the gas, while bulb B was empty. On opening the stop cock, the pressure fell down to 40%. The volume of the bulb B must be :

(A) 75 cm^3 **(B)** 125 cm^3 **(C)** 150 cm^3 **(D)** 250 cm^3

27. One mole of a gas is defined as -

(A) The number of molecules in one litre of gas
(B) The number of molecules in one formula weight of gas
(C) The number of molecules contained in 12 grams of (12 C) isotope
(D) The number of molecules in 22.4 litres of a gas at S.T.P.

28. If two moles of an ideal gas at 546 K occupies a volume of 44.8 litres, the pressure must be -

(A) 2 atm **(B)** 3 atm **(C)** 4 atm **(D)** 1 atm

29. At constant pressure which of the following does not represent Charle's law ?

(A) $V \propto \frac{1}{T}$ **(B)** $V \propto T$ **(C)** $V \propto \frac{1}{T^2}$ **(D)** $V \propto d$

30. Which of the following does not shows explicitly the relationship between Boyle's law and Charles' law ?

(A) $\frac{P_1}{P_2} = \frac{T_1}{T_2}$ **(B)** $PV = K$ **(C)** $\frac{P_2}{P_1} = \frac{V_1}{V_2}$ **(D)** $\frac{V_2}{V_1} = \frac{P_1}{P_2} \times \frac{T_2}{T_1}$

31. The vander waal gas constant 'a' is given by

(A) $\frac{1}{3} V_C$ **(B)** $3P_C V_C^2$ **(C)** $\frac{1}{8}\frac{RT_C}{P_C}$ **(D)** $\frac{27}{64}\frac{R^2 T_C^2}{P_C}$

Part # II [Assertion & Reason Type Questions]

Each question has 5 choices (A), (B), (C), (D) and (E) out of which only one is correct.

(A) Statement-1 is true, Statement-2 is true and Statement-2 is correct explanation for Statement-1

(B) Statement-1 is true, Statement-2 is true and Statement-2 is not correct explanation for Statement-1

(C) Statement-1 is true, Statement-2 is false

(D) Statement-1 is false, Statement-2 is true

(E) Both Statements are false

1. **Statement-1 :** Pressure exerted by a mixture of gases is equal to the sum of their partial pressures.
Statement-2 : Reacting gases react to form a new gas having pressure equal to the sum of both.

2. **Statement-1 :** CH_4,CO_2 has value of Z (compressibility factor) less than one at low pressure and at low temperature.
Statement-2 : $Z < 1$ is due to repulsive forces among the molecules.

3. **Statement-1 :** Excluded volume or co-volume equals to (V–nb) for n moles gas.
Statement-2 : Co-volume depends on the effective size of gas molecules.

4. **Statement-1 :** Gases like N_2, O_2 behave as ideal gases at high temperature and low pressure.
Statement-2 : Molecular interaction diminishes at high temperature and low pressure .

5. **Statement-1 :** Absolute zero temperature is a theoretically possible temperature at which the volume of the gas becomes zero.
Statement-2 : The total kinetic energy of the molecules is zero at this temperature.

6. **Statement-1 :** In a container containing gas 'A' at temp 400 K, some more gas A at temp. 300 K is introduced. The pressure of the system increases.
Statement-2 : Increase in gaseous particles increases the number of collisions among the molecules.

7. **Statement-1 :** Noble gases can be liquefied.
Statement-2 : Attractive forces can exist between non-polar molecules.

8. **Statement-1 :** The diffusion rate of oxygen is smaller than that of nitrogen under identical conditions.

Statement-2 : Molecular mass of nitrogen is smaller than that of oxygen.

9. **Statement-1 :** Most probable velocity of particles of gas is the velocity possessed by maximum fraction of particles at the same temperature.

Statement-2 : On collision, more and more molecules acquire higher speed at the same temperature.

10. **Statement-I :** Plot of P Vs. 1/V (volume) is a straight line.

Statement-II : Pressure is directly proportional to volume.

11. **Statement-I :** Critical temperature of the gas is the temperature at which it occupies 22.4 L of volume.

Statement-II : Molar volume of every gas at NTP is 22.4 L.

12. **Statement-I :** Carbondioxide has greater value of root mean square velocity u_{rms} than carbon monoxide.

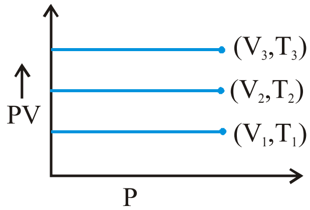
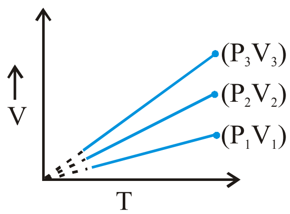
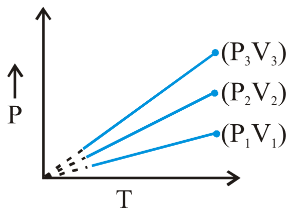
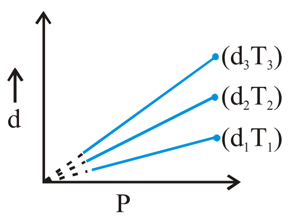
Statement-II : u_{rms} is directly proportional to molar mass.

13. **Statement-I :** The effusion rate of oxygen is smaller than that of nitrogen.

Statement-II : Molecular size of nitrogen is smaller than that of oxygen.

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

1. For a fixed amount of the gas match the two column :

Column-I	Column-II
(A) 	**(p)** $T_1 > T_2 > T_3$
(B) 	**(q)** $P_1 > P_2 > P_3$
(C) 	**(r)** $V_1 > V_2 > V_3$
(D) 	**(s)** $d_1 > d_2 > d_3$

2.

Column-I	Column-II
(A) $P_1V_1 = P_2V_2 = P_3V_3 = $	**(1)** Dalton's law of partial pressures at constant temperature
(B) $\frac{V_1}{T_1} = \frac{V_2}{T_2} = \frac{V_3}{T_3} = $ .... at constant pressure.	**(2)** Kinetic equation of ideal gases.
(C) $r \propto \sqrt{\frac{1}{d}}$	**(3)** 22.4 litre at STP
(D) $P = P_1 + P_2 + P_3 + $..............	**(4)** Isotherm
(E) $(V-b)\left(P+\frac{a}{V^2}\right) = RT$	**(5)** Isobar
(F) R/N	**(6)** Charles' law
(G) Molar volume	**(7)** Graham's law
(H) $PV = \frac{1}{3}mnc^2$	**(8)** Boyle's law
(I) Graph between P and V at constant temperature	**(9)** Equation for real gases.
(J) Graph between V and T at constant pressure	**(10).** Boltzmann's constant.

3. **Column – I** | **Column – II**

Column – I	Column – II
(A) At low pressure	**(p)** $Z = 1 + \frac{pb}{RT}$
(B) At higher pressure	**(q)** $Z = 1 - \frac{a}{V_m RT}$
(C) At low density of gas	**(r)** gas is more compressible than ideal gas
(D) For H_2 and He at 0°C	**(s)** gas is less compressible than ideal gas

Part # II [Comprehension Type Questions]

Comprehension # 1

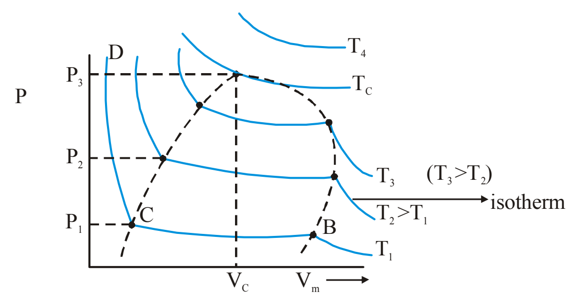
Critical constant of A gas

When pressure is incerases at constant temp volume of gas decreases

AB → gases, BC → vapour + liquid, CD → liquid

critical point : At this point all the physical properties of liquid phase will be same as the physical properties in vapour such as, density of liquid = density of vapour

TC or critical temp : Temperature above which a gas can not be liquified



PC or critical pressure : minimum pressure which must be applied at critical temp to convert the gas into liquid.

VC or critical volume : volume occupied by one mole of gas at T_C & P_C

Critical constant using vander wall equations

$$\left(P + \frac{a}{V_m^2}\right)(V_m - b) = RT \quad \Rightarrow \quad (PV_m^2 + a)(V_m - b) = RT\,V_m^2$$

$$PV_m^3 + aV_m - PbV_m^2 - ab - RTV_m^2 = 0 \quad \Rightarrow \quad V_m^3 + V_m^2\left(b + \frac{RT}{P}\right) + \frac{a}{P}\,\frac{V}{m} - \frac{ab}{P} = 0$$

since equation is cubic in V_m hence there will be three roots of equation at any temperature and pressure.

At critical point all three roots will coincide and will give single value of $V_m = V_c$

at critical point, Vander Waal equation will be

$$V_m^3 - V_m^2\left(b + \frac{RT_C}{P_C}\right) + \frac{a}{P_C}V_m - \frac{ab}{P_C} = 0 \qquad ...(1)$$

But at critical point all three roots of the equation should be equal, hence equation should be :

$V_{m,} = V_c$

$(V_m - V_c)^3 = 0$

$$V_m^3 - 3V_m^2 V_C + 3V_m V_C^2 - V_C^3 = 0 \qquad ...(2)$$

comparing with equation (1)

$$b + \frac{RT_C}{P_C} = 3V_C \quad ....(i) \qquad \frac{a}{P_C} = 3\,V_C^2 \quad ...(ii) \qquad \frac{ab}{P_C} = V_C^3 \quad ...(iii)$$

From (ii) and (iii), $V_C = 3b$

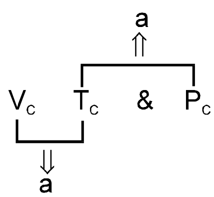
From (ii) $P_C = \dfrac{a}{3V_C^2}$ substituting $P_C = \dfrac{a}{3\,(3b)^2} = \dfrac{a}{27b^2}$

From (i) $\dfrac{RT_C}{P_C} = 3\,V_C - b = 9b - b = 8b \quad \Rightarrow \quad T_C = \dfrac{8a}{27\,Rb}$

At critical point, the slope of PV curve (slope of isotherm) will be zero at all other point slope will be negative zero is the maximum value of slope.

$$\left(\frac{\partial P}{\partial V_m}\right)_{T_C} = 0 \qquad \text{...(i)} \qquad\qquad \frac{\partial}{\partial V_m}\left(\frac{\partial P}{\partial V_m}\right)_{T_C} = 0 \qquad \text{....(ii)}$$

{Mathematically such points an known as point of inflection (where first two derivatives becomes zero)}
using the two T_C P_C and V_C can be calculate

by 

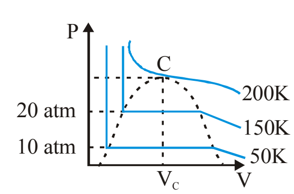
1. A scientist proposed the following equation of state $P = \dfrac{RT}{V_m} - \dfrac{B}{V_m^2} + \dfrac{C}{V_m^3}$. If this equation leads to the critical behaviour then critical temperature is :

(A) $\dfrac{8B}{27RC}$ **(B)** $\dfrac{B}{8RC}$ **(C)** $\dfrac{B^2}{3RC}$ **(D)** None of these

2. If the critical constants for a hypothetical gas are $V_C = 150\ cm^3\ mol^{-1}$. $P_C = 50$ atm and $T_C = 300$ K. Then the approximate radius of the molecule is : [Take $R = \dfrac{1}{12}$ Ltr atm $mol^{-1}\ K^{-1}$]

(A) $\left(\dfrac{75}{2\pi N_A}\right)^{1/3}$ **(B)** $\left(\dfrac{75}{8\pi N_A}\right)^{1/3}$ **(C)** $\left(\dfrac{3}{\pi N_A}\right)^{1/3}$ **(D)** $\left(\dfrac{3}{256\pi N_A}\right)^{1/3}$

3. Identify the wrong statement related to the above graph :



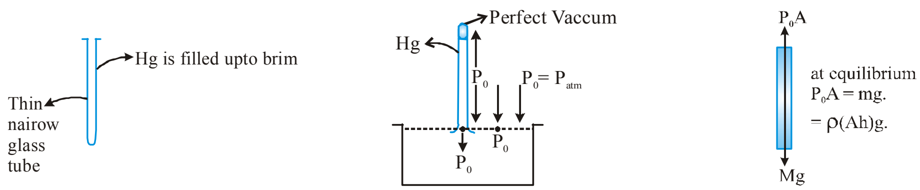
(A) between 50 K and 150 K temperature and pressure ranging from 10 atm to 20 atm matter may have liquid state.
(B) zero is the maximum value of the slope of P-V Curve
(C) If vander wall equation of state is applicable above critical temperature then cubic equation of V_m will have one real and two imaginary roots.
(D) At 100 K and pressure below 20 atm it has liquid state only

Comprehension # 2

MEASUREMENT OF PRESSURE

Barometer

A barometer is an instrument that is used for the measurement of pressure. The construction of the barometer is as follows



Cross sectional view of the capillary column

A thin narrow calibrated capillary tube is filled to the brim, with a liquid such as mercury, and is inverted into a trough filled with the same fluid. Now depending on the external atmospheric pressure, the level of the mercury inside the tube will adjust itself, the reading of which can be monitored. When the mercury column inside the capillary comes to rest, then the net forces on the column should be balanced.

Applying force balance, we get,

$P_{atm} \times A = m \times g$ ('A' is the cross-sectional area of the capillary tube)

If 'ρ' is the density of the fluid, then $m = \rho \times g \times h$ ('h' is the height to which mercury has risen in the capillary)

hence, $P_{atm} \times A = (\rho \times g \times h) \times A$

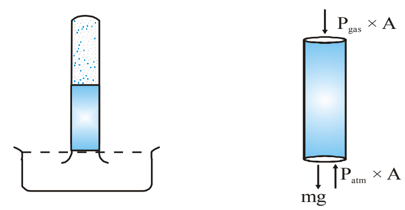
or, $P_{atm} = \rho gh$

Faulty Barometer

An ideal barometer will show a correct reading only if the space above the mercury column is vacuum, but in case if some gas column is trapped in the space above the mercury column, then the barometer is classified as a faulty barometer. The reading of such a barometer will be less than the true pressure.

For such a faulty barometer

$$P_0A = mg + P_{gas}A$$
$$P_0 = \rho gh + P_{gas}$$
or $$\rho gh = P_0 - P_{gas}$$



1. A tube closed at one end is dipped in mercury as shown in figure-3 such that the closed surface coincides with the mercury level in the container. By how much length of the tube should be extended such that the level of Hg in the tube is 5 cm below the mercury level inside the container. (assume temperature remains constant)

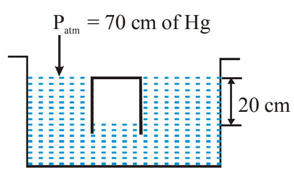
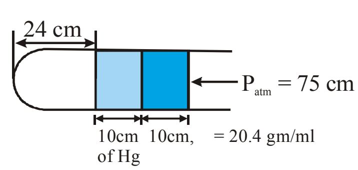


Fig.-3

(A) 18 cm **(B)** 19 cm **(C)** 24 cm **(D)** 30 cm

2. If above tube is placed vertically with the open end upward then the length of the air column will be (assume temperature remains constant)



(A) 20 cm **(B)** 36 cm
(C) 18 cm **(D)** 15 cm

3. A gas column is trapped between closed end of a tube and a mercury column of length (h) when this tube is placed with its open end upwards the length of gas column is (ℓ_1) the length of gas column becomes (ℓ_2) when open end of tube is held downwards (as shown in fig.-4). Find atmospheric pressure in terms of height of Hg column. (assume temperature remains constant)

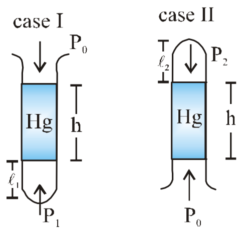


Fig.-4

(A) $\dfrac{h(\ell_1+\ell_2)}{(\ell_2-\ell_1)}$ **(B)** $\dfrac{h(\ell_2-\ell_1)}{(\ell_1+\ell_2)}$

(C) $\dfrac{(\ell_1+\ell_2)}{h\,(\ell_2-\ell_1)}$ **(D)** $(h_1\ell_1+h_2\ell_2)$

Comprehension # 3

One of the important approach to the study of real gases involves the analysis of a parameter Z called the compressibility factor $Z=\dfrac{PV_m}{RT}$ where P is pressure, V_m is molar volume, T is absolute temperature and R is the universal gas constant. Such a relation can also be expressed as $Z=\left(\dfrac{V_{m\ real}}{V_{m\ ideal}}\right)$ (where $V_{m\ ideal}$ and $V_{m\ real}$ are the molar volume for ideal and real gas respectively). Gas corresponding $Z > 1$ have repulsive tendencies among constituent particles due to their size factor, whereas those corresponding to $Z < 1$ have attractive forces among constituent particles. As the pressure is lowered or temperature is increased the value of Z approaches 1. (reaching the ideal behaviour)

1. Choose the conclusions which are appropriate for the observation stated.

	Observation		Conclusion
I .	$Z = 1$	I.	The gas need not be showing the ideal behaviour
II.	$Z > 1$	II.	On applying pressure the gas will respond by increasing its volume
III.	$Z < 1$	III.	The gas has the ability to be liquefied.
IV.	$Z \to 1$ for low P	IV.	The gas is approaching the ideal behaviour.

(A) All conclusions are true **(B)** Conclusions I, II & IV are true

(C) Conclusions I,III & IV are true **(D)** Conclusions III & IV are true

2. For a real gas 'G' $Z > 1$ at STP Then for 'G' :
Which of the following is true :

(A) 1 mole of the gas occupies 22.4 L at NTP

(B) 1 mole of the gas occupies 22.4 L at pressure higher than that at STP (keeping temperature constant)

(C) 1 mole of the gas occupies 22.4 L at pressure lower than that at STP (keeping temperature constant)

(D) None of the above

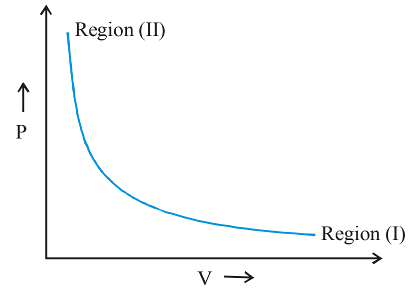
3. Following graph represents a pressure (P) volume (V) relationship at a fixed temperature (T) for n moles of a real gas. The graph has two regions marked (I) and (II). Which of the following options is true.

(A) Z < 1 in the region (II)

(B) Z = 1 in the region (II)

(C) Z = 1 for the curve

(D) Z approaches 1 as we move from region (II) to region (I)



Comprehension # 4

The rate of change of pressure (p) of a gas at constant temperature and constant external pressure due to effusion of gas from a vessel of constant volume is related to rate of change of number of molecules present by

$$\frac{dp}{dt} = \frac{kT}{V}\frac{dN}{dt}$$

where k = Boltzmann constant, T = temperature, V = volume of vessel & N = No. of molecules and

$\frac{dN}{dt} = \frac{-pA_0}{(2\pi mkT)^{1/2}}$, where A_0 = area of orifice and m = mass of molecule.

1. Time required for pressure inside vessel to reduce to 1/e of its initial value in (ln e = 1)

(A) $\left(\frac{2\pi m}{kT}\right)^{1/2}\frac{V}{A_0}$ **(B)** $\left(\frac{kT}{2\pi m}\right)^{1/2}\frac{V}{A_0}$ **(C)** $\left(\frac{2\pi mkT}{A_0}\right)^{1/2}$ **(D)** $\frac{2\pi m}{kT}\frac{V}{A_0}$

2. If the gas inside the vessel had molecular weight 9 times the gas in previous example and area of orifice was doubled and temperature maintained at 4T, time required for pressure to fall to 1/e times of its initial value would be (t = answer of previous option)

(A) 1.33 t **(B)** 4.24 t **(C)** 0.75 t **(D)** 1.125 t

3. The incorrect statement (s) is/are.

[I] Pressure will not fall to zero in infinite time.

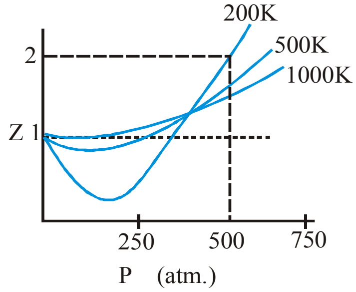
[II] Time required for pressure to decrease to half its initial value is independent of initial pressure.

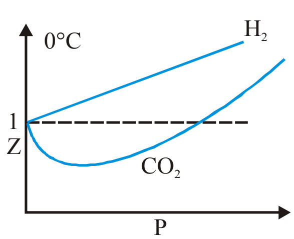
[III] The relations given above are true for real gases also.

(A) I **(B)** II **(C)** III **(D)** I and III

Comprehension # 5

Sketch shows the plot of Z v/s P for a hypothetical gas for one mole at three distinct temperature.





Boyle's temperature is the temperature at which a gas shows ideal behaviour over a pressure range in the low pressure region. Boyle's temperature $(T_b) = \frac{a}{Rb}$. If a plot is obtained at temperatures well below Boyle's temperature then the curve will show negative deviation, in low pressure region and positive deviation in the high pressure region. Near critical temperature the curve is more likely as CO_2 and the temperature well above critical temperature curve is more like H_2 at 0°C as shown above. At high pressure suppose all the constant temperature curve varies linearly with pressure according to the following equation $Z = 1 + \frac{Pb}{RT}$ $(R = 2\ cal\ mol^{-1}\ K^{-1})$

1. Which of the following is correct :

(A) $\frac{a}{b} < 0.4$ k cal mol^{-1} **(B)** 0.4 k cal $mol^{-1} < \frac{a}{b} < 2$ k cal mol^{-1}

(C) $\frac{a}{b} > 0.4$ k cal mol^{-1} **(D)** $\frac{a}{b} = 1$ K cal mol^{-1}

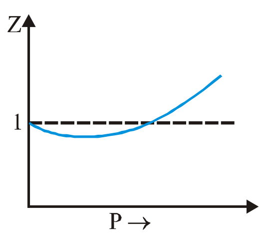
2. For 500 K plot value of Z changes from 2 to 2.2 if pressure is varied from 1000 atm to 1200 atm (high pressure) then the value of $\frac{b}{RT}$ will be :-

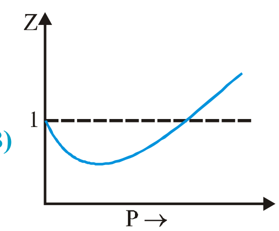
(A) $10^{-3}\ atm^{-1}$ **(B)** $2 \times 10^{-3}\ atm^{-1}$ **(C)** $5 \times 10^{-4}\ atm^{-1}$ **(D)** $10^{-4}\ atm^{-1}$

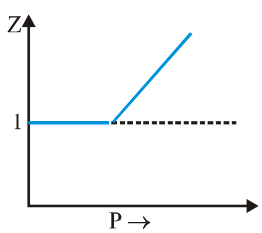
3. As shown in the figure at 200 K and 500 atm value of compressibility factor is 2 (approx). Then volume of the gas at this point will be :-

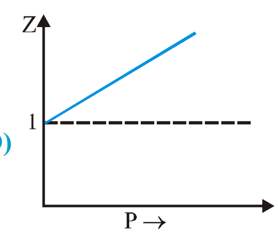
(A) 0.01 L **(B)** 0.09 L **(C)** 0.065 L **(D)** 0.657 L

4. Plot at Boyle's temperature for the gas will be :

(A)


(B)


(C)


(D)


5. In very high pressure region if Z v/s P is plotted at 1200 K for the above gas then it will have greatest slope.

(A) true **(B)** false

(C) can't say **(D)** not related to the paragraph

Exercise # 4 [Subjective Type Questions]

1. A quantity of an ideal gas is collected in a graduated tube over the mercury. The volume of gas at 20 ºC is 50 ml and the level of mercury is 100 mm above the outside of the mercury level. The atmospheric pressure is 750 mm. Volume of gas at STP is : (Take R = 0.083 lt. atm/K/mole)

2. A quantity of hydrogen is confined in a chamber of constant volume. When the chamber is immersed in a bath of melting ice, the pressure of the gas is 1000 torr. (a) What is the Celsius temperature when the pressure manometer indicates an absolute pressure of 400 torr ? (b) What pressure will be indicated when the chamber in brought to 100ºC ?

3. An open vessel at 27ºC is heated until (3/5)th of the air in it has been expelled. Assuming that the volume of the vessel remains constant. Find out.
(a) The temperature at which vessel was heated.
(b) Volume of the air escaped out if vessel is heated to 900 K
(c) The temperature at which half of the air escapes out.

4. A gas cylinder contains 320 g oxygen gas at 24.6 atm pressure and 27ºC. What mass of oxygen would escape if first the cylinder were heated to 133ºC and then the valve were held open until the gas pressure was 1.00 atm, the temperature being maintained at 133ºC ? (R = 0.0821 L. atm/K/mole)

5. A volume V of a gas at a temperature T_1 and a pressure p is enclosed in a sphere. It is connected to another sphere of volume $\frac{V}{2}$ by a tube and stopcock. The second sphere is initially evacuated and the stopcock is closed. If the stopcock is opened the temperature of the gas in the second sphere becomes T_2. The first sphere is maintained at a temperature T_1 . What is the final pressure p_1 within the apparatus ?

6. A gas occupies 100.0 mL at 50°C and 1 atm pressure. The gas is cooled at constant pressure so that volume is reduced to 50.0 mL. What is the final temperature of the gas.

7. A sample of gas at 27ºC and 1.00 atm pressure occupies 2.50 L. What temperature is required to adjust the pressure of that gas to 1.50 atm after it has been transferred to a 2.00 L container ?

8. Assuming the same pressure in each case, calculate the mass of hydrogen required to inflate a balloon to a certain volume V at 127ºC if 8 g helium is required to inflate the balloon to half the volume, 0.50 V, at 27ºC.

9. A mixture of gases at 760 torr contains 55.0% nitrogen, 25.0% oxygen and 20.0% carbon dioxide by mole. What is the partial pressure of each gas in torr ?

10. What will be pressure exerted by a mixture of 3.2g of methane of 4.4g of carbon dioxide contained in a $9 dm^3$ flask at 27°C ?

11. Oxygen and cyclopropane at partial pressures of 570 torr and 170 torr respectively are mixed in a gas cylinder. What is the ratio of the number of moles of cyclopropane to the number of moles of oxygen?

12. At the top of a mountain the thermometer reads –23ºC and the barometer reads 700 mm Hg. At the bottom of the mountain the temperature is 27ºC and the pressure is 750 mm Hg. Compare the density of the air at the top with that at the bottom.

13. A 300 mL sample of hydrogen was collected over water at 21ºC on a day and the pressure over water was 748 Torr and vapour pressure of water was 19 Torr.
(a) How many mmoles of H_2O were present ?
(b) What is the mole fraction of H_2 in the moist gas mixture ?
(c) What would be the mass of the gas sample if it were dry ?

14. A container contains the mixture of water vapour and oxygen gas with total pressure 1.1 atm at certain temperature. If volume is made one third then find the total pressure (assume aqueous tension of water at this temperature is 0.1 atm.) ?

15. For 10 minute each, at 0 ºC, from two identical holes nitrogen and an unknown gas are leaked into a common vessel of 4 litre capacity. The resulting pressure is 2.8 atm and the mixture contains 0.4 mole of nitrogen. What is the molar mass of unknown gas?

16. The pressure in a vessel that contained pure oxygen dropped from 2000 torr to 1500 torr in 40 min as the oxygen leaked through a small hole into a vacuum. When the same vessel was filled with another gas, the pressure dropped from 2000 torr to 1500 torr in 80 min. What is the molecular weight of the second gas ?

17. The rates of diffusion of two gases A and B are in the ratio 1 : 4. If the ratio of their masses present in the mixture is 2 : 3. The ratio of their mole fraction is :

18. A gaseous mixture contains oxygen and another unknown gas in the molar ratio of 4 : 1 diffuses through a porous plug in 245 seconds. Under similar conditions same volume of oxygen takes 220 sec to diffuse. Find the molecular mass of the unknown gas.

19. The root mean square speed of gas molecules at a temperature 27 K and pressure 1.5 bar is 1×10^4 cm/sec. If both temperature and pressure are raised three times, calculate the new rms speed of gas molecules.

20. At what temperature would the most probable speed of CO_2 molecules be twice that at 127ºC

21. Suppose a gas sample in all have 6×10^{23} molecules. Each 1/3 rd of the molecules have rms speed 10^4 cm/sec, 2×10^4 cm/sec and 3×10^4 cm/sec. Calculate the rms speed of gas molecules in sample.

22. At what temperature will hydrogen molecules have the same root mean square speed as nitrogen molecules have at 35ºC ?

23. If density of vapours of a substance of molar mass 18 gm at 1 atm pressure and 500 K is 0.36 kg m^{-3}, then calculate the value of Z for the vapours. (Take R = 0.082 L atm $mole^{-1}$ K^{-1})

24 One litre gas at 400 K and 300 atm pressure is compressed to a pressure of 600 atm and 200 K. The compressibility factor is changed from 1.2 to 1.6 respectively. Calculate the final volume of the gas.

25. Reduced temperature for benzene is 0.7277 and its reduced volume is 0.40. Calculate the reduced pressure of benzene.

26. The critical temperature and critical pressure of a gas are 31ºC and 728 atmospheres respectively. Calculate the constants 'a' and 'b'.

27. Calculate the volume occupied by 2.0 mole of N_2 at 200 K and 8.21 atm pressure, if $\frac{P_C V_C}{RT_C} = \frac{3}{8}$ and $\frac{P_r V_r}{T_r} = 2.4$.

28. Explain the physical significance of van der waals parameters.

29. Using the van der Waals equation, calculate the pressure of 10.0 mol NH_3 gas in a 10.0 L vessel at 27ºC.

$$\left(P + n^2 \frac{a}{V^2}\right)(V - nb) = nRT \qquad a = 4.2\ L^2.\ atm/mol^2 \qquad b = 0.037\ L/mol$$

30. 1 litre of a mixture of CO and CO_2 is taken. This mixture is passed through a tube containing red hot charcoal. The volume now becomes 1.6 litres. The volumes are measured under the same conditions. Find the composition of the mixture by volume.

31. 40 ml of ammonia gas, taken in an eudiometer tube, was subjected to sparks till the volume did not further change. The volume was found to increase by 40 ml. 40 ml of oxygen gas then mixed and the mixture was further exploded. The gases remained were 30 ml. Deduce the formula of ammonia.

32. When 100 ml of a $O_2 - O_3$ mixture was passed through turpentine, there was reduction of volume by 20 ml. If 100 ml of such a mixture is heated, what will be the increase in volume? **[Hint:** O_3 is absorbed by turpentine**]**

33. 60 ml of a mixture of nitrous oxide and nitric oxide was exploded with excess of hydrogen. If 38 ml of N_2 was formed, calculate the volume of each gas in the mixture.

34. A mixture of formic acid and oxalic acid is heated with concentrated H_2SO_4. The gases produced are collected and on its treatment with KOH solution the volume of the gas decreased by one-sixth. Calculate the molar ratio of the two acids in the original mixture. [**Hint :** H_2SO_4 is a dehydrating agent. HCOOH produces H_2O and CO; $H_2C_2O_4$ produces H_2O, CO_2 and CO]

35. A sample of a gaseous hydrocarbon occupying 1.12 litres at NTP when completely burnt in air produced 2.2 g of CO_2 and 1.8 g of H_2O. Calculate the weight of the compound taken and the volume of O_2 at NTP required for its burning. Find the molecular formula of the hydrocarbon.

36. A vertical hollow cylinder of height 1.52 m is fitted with a movable piston of negligible mass and thickness. The lower half of the cylinder contains an ideal gas and the upper half is filled with mercury. The cylinder is initially at 300 K. When the temperature is raised, half of the mercury comes out of the cylinder. Find the temperature, assuming the thermal expansion of mercury to be negligible.

37. A column of Hg of 100 mm in length is contained in the middle of a narrow tube 1 m long which is closed at both ends. Both the halves of the tube contained air at a pressure of 760 mm of Hg. By what distance will the column of Hg lie displaced if the tube is held vertical. Assume decrease in length of mercury column to be negligible , also take the process at constant temperature. (isothermal process).

38. A container holds 22.4 litre of a gas at 1 atmospheric pressure and at 0ºC. The gas consists of a mixture of argon, oxygen and sulphur dioxide in which :

(a) Partial pressure of SO_2 = (Partial pressure O_2) + (Partial pressure of Ar)

(b) Partial pressure of $O_2 = 2 \times$ partial pressure of Ar

Calculate the density of the gas mixture under these conditions.

39. A mixture of nitrogen and water vapours is admitted to a flask which contains a solid drying agent. Immediately after admission, the pressure of the flask is 760 mm. After some hours the pressure reached a steady value of 745 mm.

(a) Calculate the composition, in mol and per cent of original mixture.

(b) If the experiment is done at 20ºC and the drying agent increases in weight by 0.15 g, what is the volume of the flask ? (the volume occupied by the drying agent may be ignored) ?

40. A flask of 1.5 L capacity contains 400 mg of O_2 and 60 mg of H_2 at 100°C. Calculate the total pressure of the gaseous mixture. If the mixture is permitted to react to form water vapours at 100°C, what materials will be left and what will be their partial pressures.

41. A spherical balloon of 21 cm diameter is to be filled up with hydrogen at NTP, from a cylinder containing the gas at 20 atm at 27° C. If the cylinder can hold 2.82 litre of water, calculate the number of balloons that can be filled up.

42. An LPG cylinder weighs 14.8 kg when empty. When full, it weighs 29.0 kg & shows a pressure of 2.5 atm. In the course of use at 27° C. The weight of the full cylinder reduced to 23.2 kg. Find out the volume of the gas in cubic metres used up at the normal usage conditions and the final pressure inside the cylinder. Assume LPG to be n-butane with normal boiling point 0°C.

43. A closed container of volume 0.02 m^3 contains a mixture of neon and argon gases, at a temperature of 27°C and pressure of 1×10^5 Nm^{-2}. The total mass of the mixture is 28 g. If the gram molecular weights of neon and argon are 20 and 40 respectively. Find the masses of the individual gases in the container, assuming them to be ideal. (Universal gas constant R = 8.314 J/mole K)

44. 6.0 g He and 12.0 g Ne molecules both having average velocity 4×10^2 ms^{-1} are mixed. Calculate kinetic energy per mol of the mixture.

45. 1 mole of CCl_4 vapours at 77°C occupies a volume of 35.0 L.If van der Waal's constant are a = 20.39 L^2 atm mol^{-2} and b = 0.1383 L mol^{-1}, calculate compressibility factor Z under,

(a) low pressure region (b) high pressure region

46. At 27°C, hydrogen is leaked through a tiny hole into a vessel for 20 min. Another unknown gas at the same T & P as that of H_2, is leaked through the same hole for 20 min. After the effusion of the gases the mixture exerts a pressure of 6 atm. The hydrogen content of the mixture is 0.7 mole. If the volume of the container is 3 litre, what is molecular weight of unknown gas. (Use R = 0.0821 L atm K^{-1} $mole^{-1}$)

47. At 20ºC, two balloons of equal volume and porosity are filled to a pressure of 2 atm, one with 14 kg N_2 and other with 1 kg of H_2. The N_2 balloon leaks to a pressure of 1/2 atm in 1 hr. How long will it take for H_2 balloon to reach a pressure of 1/2 atm ?

48. A mixture of ethane & ethene occupies 40 litre at 1 atm pressure & 400 K temperature. The mixture reacts completely with 130 g of O_2 to produce CO_2 & H_2O. Assuming ideal gas behaviour, calculate the mole fractions of ethane and ethene in the mixture.

49. 10 ml of a mixture of CH_4, C_2H_4 and CO_2 was exploded with excess of air. After explosion there was a contraction of 17 ml and after treatment with KOH, there was further reduction of 14ml. What was the composition of the mixture?

50. To an evacuated 504.2 mL steel container is added 25 g $CaCO_3$ and the temperature is raised to 1500 K causing a complete decomposition of the salt. If the density of CaO formed is 3.3 g/cc, find the accurate pressure developed in the container using the Van der waals equation of state. The van der waals constants for CO_2(g) are $a = 4\ \frac{L^2 - atm}{mol^2}$, $b = 0.04\ \frac{L}{mol}$. (Ca - 40, C - 12, O - 16)

Exercise # 5 Part # I [Previous Year Questions] [AIEEE/JEE-MAIN]

1. As the temperature is raised from 20ºC to 40ºC, the average kinetic energy of neon atoms changes by a factor : **[AIEEE - 2004]**

(A) 2 **(B)** $\sqrt{\frac{313}{293}}$ **(C)** $\frac{313}{293}$ **(D)** $\frac{1}{2}$

2. In vander Waal's equation of state of the gas law, the constant 'b' is a measure of : **[AIEEE - 2004]**

(A) Intermolecular collisions per unit volume **(B)** Intermolecular attractions

(C) Volume occupied by the molecules **(D)** Intermolecular repulsions

3. Which one of the following statements regarding helium is incorrect ? **[AIEEE - 2004]**

(A) It is used to fill gas balloons instead of hydrogen because it is lighter and non-inflammable

(B) It is used as a cryogenic agent for carrying out experiments at low temperatures

(C) It is used to produce and sustain powerful superconducting magnets

(D) It is used in gas-cooled nuclear reactors

4. Which one of the following statements is not true about the effect of an increase in temperature on the distribution of molecular speeds in a gas ? **[AIEEE - 2005]**

(A) The area under the distribution curve remains the same as under the lower temperature

(B) The distribution becomes broader

(C) The fraction of the molecules with the most probable speed increases

(D) The most probable speed increases

5. Equal masses of methane and oxygen are mixed in an empty container at 25°C. The fraction of the total pressure exerted by oxygen is **[AIEEE - 2007]**

(A) 1/3 **(B)** 1/2 **(C)** 2/3 **(D)** $\frac{1}{3} \times \frac{273}{298}$

6. 'a' and 'b' are van der Waals' constants for gases. Chlorine is more easily liquefied than ethane because : **[AIEEE - 2011]**

(A) a and b for Cl_2 > a and b for C_2H_6

(B) a and b for Cl_2 < a and b for C_2H_6

(C) a and Cl_2 < a for C_2H_6 but b for Cl_2 > b for C_2H_6

(D) a for Cl_2 > a for C_2H_6 but b for Cl_2 < b for C_2H_6

7. When r, P and M represent rate of diffusion, pressure and molecular mass, respectively, then the ratio of the rates of diffusion (r_A/r_B) of two gases A and B, is given as: **[AIEEE - 2011]**

(A) $(P_A/P_B)(M_B/M_A)^{1/2}$ **(B)** $(P_A/P_B)^{1/2}(M_B/M_A)$ **(C)** $(P_A/P_B)(M_A/M_B)^{1/2}$ **(D)** $(P_A/P_B)^{1/2}(M_A/M_B)$

8. The molecular velocity of any gas is: **[AIEEE - 2011]**

(A) inversely proportional to absolute temperature.

(B) directly proportional to square of temperature.

(C) directly proportional to square root of temperature.

(D) inversely proportional to the square root of temperature.

9. The compressibility factor for a real gas at high pressure is : **[AIEEE - 2012]**

(A) 1 + RT/pb **(B)** 1 **(C)** 1 + pb /RT **(D)** 1 –pb/RT

10. For gaseous state, if most probable speed is denoted by C*, average speed by $\overline{C}$ and mean square speed by C, then for a large number of molecules the ratios of these speeds are : **[JEE(Main) 2013]**

(A) $C^* : \overline{C} : C = 1.225 : 1.128 : 1$
(B) $C^* : \overline{C} : C = 1.128 : 1.225 : 1$
(C) $C^* : \overline{C} : C = 1 : 1.128 : 1.225$
(D) $C^* : \overline{C} : C = 1 : 1.225 : 1.128$

11. A gaseous hydrocarbon gives upon combustion 0.72 g of water and 3.08 g. of CO_2. The empirical formula of the hydrocarbon is : **[JEE(Main) 2013]**

(A) C_2H_4 **(B)** C_3H_4 **(C)** C_6H_5 **(D)** C_7H_8

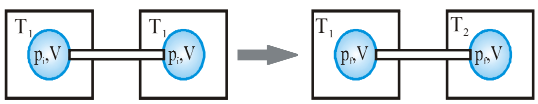
12. If Z is a compressibility factor, van der Waals equation at low pressure can be written as : **[JEE(Main) 2014]**

(A) $Z = 1 - \frac{Pb}{RT}$ **(B)** $Z = 1 + \frac{Pb}{RT}$ **(C)** $Z = 1 + \frac{RT}{Pb}$ **(D)** $Z = 1 - \frac{a}{VRT}$

13. The ratio of masses of oxygen and nitrogen in a particular gaseous mixture is 1 : 4. The ratio of number of their molecule is ; **[JEE(Main) 2014]**

(A) 1 : 8 **(B)** 3 : 16 **(C)** 1 : 4 **(D)** 7 : 32

14. Two closed bulbs of equal volume (V) containing an ideal gas initially at pressure p_i and temperature T_1 are connected through a narrow tube of negligible volume as shown in the figure below. The temperature of one of the bulbs is then raised to T_2. The final pressure p_f is : **[JEE(Main) 2016]**



(A) $2p_i\left(\frac{T_1}{T_1+T_2}\right)$ **(B)** $2p_i\left(\frac{T_2}{T_1+T_2}\right)$ **(C)** $2p_i\left(\frac{T_1T_2}{T_1+T_2}\right)$ **(D)** $p_i\left(\frac{T_1T_2}{T_1+T_2}\right)$

Part # II [Previous Year Questions][IIT-JEE ADVANCED]

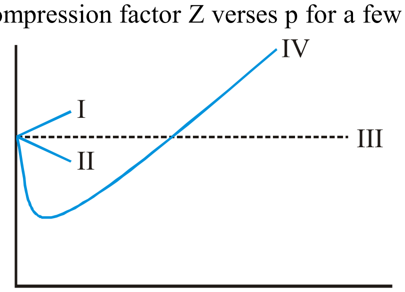
1. For one mole of gas the average kinetic energy is given as E. The U_{rms} of gas is : **[JEE-2004]**

(A) $\sqrt{\frac{2E}{M}}$ **(B)** $\sqrt{\frac{3E}{M}}$ **(C)** $\sqrt{\frac{2E}{3M}}$ **(D)** $\sqrt{\frac{3E}{2M}}$

2. Ratio of rates of diffusion of He and CH_4 (under identical conditions). **[JEE-2005]**

(A) $\frac{1}{2}$ **(B)** 3 **(C)** $\frac{1}{3}$ **(D)** 2

3. Figure displays the plot of the compression factor Z verses p for a few gases **[JEE-2006]**



Which of the following statements is/are correct for a van-der waals gas :
(A) The plot I is applicable provided the vander waals constant a is negligible.
(B) The plot II is applicable provided the vander waals constant b is negligible.
(C) The plot III is applicable provided the vander waals constants a and b are negligible.
(D) The plot IV is applicable provided the temperature of the gas is much higher than its critical temperature.

4. Match gases under specified conditions listed in Column-I with their properties / laws in Column-II. **[JEE-2007]**

	Column-I		Column-II
(A)	Hydrogen gas (P = 200 atm, T = 273 K)	(p)	compressibility factor ≠ 1
(B)	Hydrogen gas (P ~ 0, T = 273 K)	(q)	attractive forces are dominant
(C)	CO_2 (P = 1 atm, T = 273 K)	(r)	PV = nRT
(D)	Real gas with very large molar volume	(s)	P (V – nb) = nRT

5. A gas described by van der Waals equation **[JEE-2008]**
(A) behaves similar to an ideal gas in the limit of large molar volumes
(B) behaves similar to an ideal gas is in limit of large pressures
(C) is characterised by van der Waals coefficients that are dependent on the identity of the gas but are independent of the temperature.
(D) has the pressure that is lower than the pressure exerted by the same gas behaving ideally

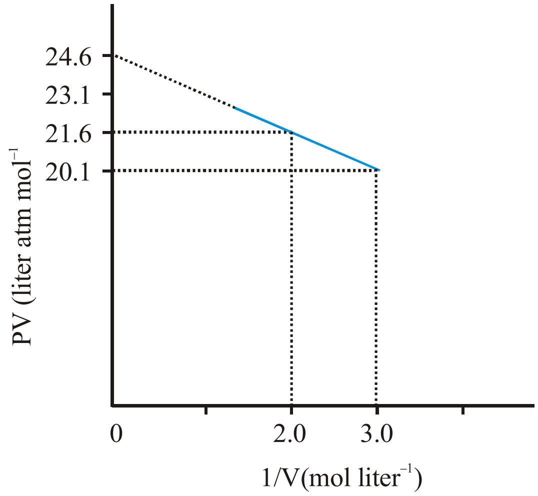
6. The term that corrects for the attractive forces present in a real gas in the vander Waals equation is : **[JEE-2009]**
(A) nb
(B) $\frac{an^2}{V^2}$
(C) $-\frac{an^2}{V^2}$
(D) –nb

7. At 400 K, the root mean square (rms) speed of a gas **X** (molecular weight = 40) is equal to the most probable speed of gas **Y** at 60 K. The molecular weight of the gas **Y** is. **[JEE-2009]**

8. According to kinetic theory gases **[JEE-2011]**
(A) collisions are always elastic
(B) heavier molecules transfer more momentum to the wall of the container
(C) only a small number of molecules have very high velocity
(D) between collisions, the molecules move in straight lines with constant velocities.

9. To an evacuated vessel with movable piston under external pressure of 1 atm., 0.1 mol of He and 1.0 mol of an unknown compound (vapour pressure 0.68 atm. at 0ºC) are introduced. Considering the ideal gas behaviour, the total volume (in litre) of the gases at 0°C is close to **[JEE-2011]**

10. For one mole of a van der Waals gas when b = 0 and T = 300 K, the PV vs.1/V plot is shown below. The value of the vanderWaals constant a (atm.liter^2 mol^{-2}) : **[JEE-2012]**

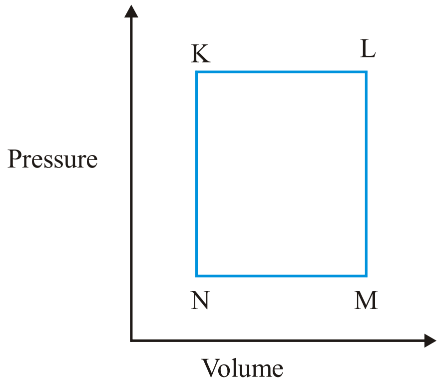


(A) 1.0 **(B)** 4.5 **(C)** 1.5 **(D)** 3.0

11. The atomic masses of He and Ne are 4 and 20 a.m.u., respectively. The value of the de Broglie wavelength of He gas at –73 °C is "M" times that of the de Broglie wavelength of Ne at 727 °C. M is **[JEE(ADVANCED)-2013]**

Paragraph for Questions 12 to 13

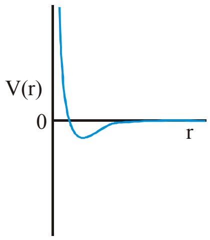
A fixed mass 'm' of a gas is subjected to transormation of states from K to L to M to N and back to K as shown in the figure

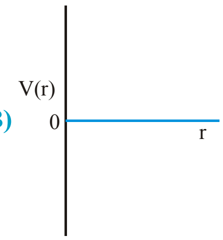


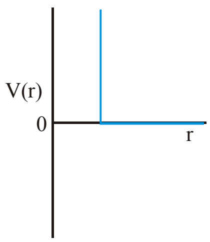
12. The succeeding operations that enable this transformation of states are **[JEE(ADVANCED)-2013]**
(A) Heating, cooling, heating, cooling
(B) Cooling, heating, cooling, heating
(C) Heating, cooling, cooling, heating
(D) Cooling, heating, heating, cooling

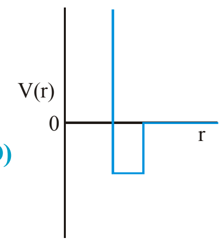
13. The pair of isochoric processes among the transormation of states is **[JEE(ADVANCED)-2013]**
(A) K to L and L to M
(B) L to M and N to K
(C) L to M and M to N
(D) M to N and N to K

14. One mole of a monatomic real gas satisfies the equation p(V – b) = RT where b is a constant. The relationship of interatomic V(r) and interatomic distance r for the gas is given by **[JEE(ADVANCED)-2015]**

(A) 

(B) 

(C) 

(D) 

15. The diffusin coefficeint of an ideal gas is proportional to its mean free path and mean speed. The absolute temperature of an ideal gas is increased 4 times and its pressure is increased 2 times. As a result, the diffusion coefficient of this gas increases x times. The value of x is **[JEE(ADVANCED)-2016]**

16. A closed tank has two compartments A and B, both filled with oxygen (assumed to be ideal gas). The partition separating the two compartments is fixed and is a perfect heat insulator (Figure 1). If the old partition is replaced by a new partition which can slide and conduct heat but does NOT allow the gas to leak across (Figure 2), the volume (in m^3) of the compartment A after the system attains equilibrium is **[JEE(ADVANCED)-2018]**

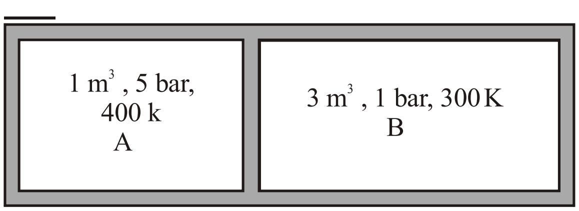


Figure 1

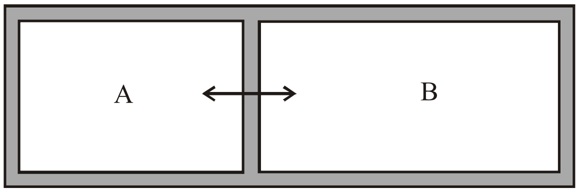


Figure 2

MOCK TEST

SECTION - I : STRAIGHT OBJECTIVE TYPE

1. If density of vapours of a substance of molar masss 18gm/mole at 1 atm pressureand 500K is 0.36 kg m^{-3}, then value of Z for the vapours is : (Take R = 0.082 L atm $mole^{-1}$ K^{-1})

(A) $\frac{41}{50}$ **(B)** $\frac{50}{41}$ **(C)** 1.1 **(D)** 0.9

2. The density of gaseous HF at 1.0 atm and 300 K is 3.17 g/L. Hence, HF in gaseous state is -
(F = 18)

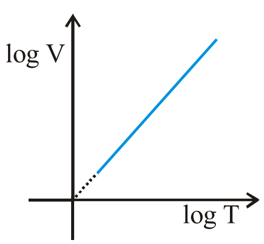
(A) Dimer **(B)** Monomer **(C)** Tetramer **(D)** Data insufficient

3. Equal amount (mass) of methane and ethane have their total translational kinetic enegy in the ratio 3 : 1 then their temperature are in the ratio.

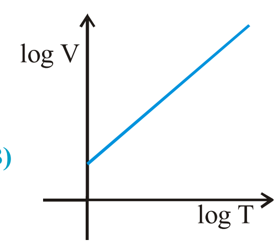
(A) 5 : 8 **(B)** 45 : 8 **(C)** 15 : 8 **(D)** 8 : 5

4. Which of the following sketches is an isobar $\left(\frac{nR}{P} > 1\right)$

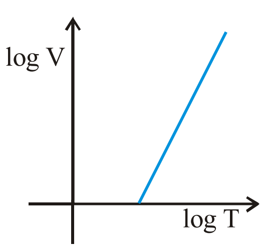
(A)



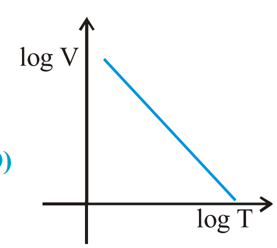
(B)



(C)



(D)



5. For a certain gas which deviates a litlle from ideal behaviour, the values of density, ρ were measured at different values of pressure, P. The plot of P/ρ on the Y-axis versus P on the X- axis was nonlinear and had an intercept on the Y-axis,which was equal to

(A) $\frac{RT}{M}$ **(B)** $\frac{M}{RT}$ **(C)** RT **(D)** $\frac{RT}{V}$

6. A sample of water gas has a composition by volume of 50% H_2, 45% CO and 5% of CO_2. Calculate the volume in litre at S.T.P of water gas wwhich on treatment with excess of steam will produce 5 litre H_2. THe equation for the reaction is

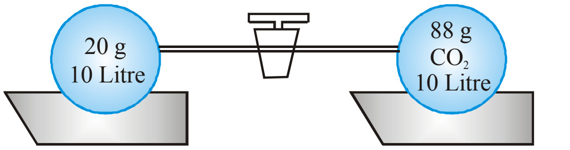
$CO + H_2O \longrightarrow CO_2 + H_2$

(A) 4.263 Litre **(B)** 5.263 Litre **(B)** 6.263 Litre **(D)** 7.263 Litre

7. The rate of diffusion of a sample of ozonized oxygen is 0.98 times than that of oxygen find the percentage (by volume) of ozone in the ozonised sample.

(A) 7.25 **(B)** 8.25 **(C)** 10.25 **(D)** 15.25

8. Flask A of volume 10 litre containing 20 gram of H_2 and flask B of volume 10 litre containing 88 gram of CO_2 are connected by a connector having negligible volume. When valve of the connector iss opened what is the composition of H_2 gas in the flask B after opening the valve.



(A) 10% **(B)** 13% **(C)** 15% **(D)** 20%

9. Consider the reaction

$$2X(g) + 3Y(g) \longrightarrow Z(g)$$

Where gases X and Y are insoluble and inert to water and Z form a basic solution. In an experiment 3 mole each of X and Y are allowed to react in 15 Litre flask at 500 K.When the reaction is complete, 5L of water is added to the flask and temperature is reduced to 300 K.
The pressure in the flask is (neglect aqueous tension).

(A) 1.64 atm **(B)** 2.46 atm **(C)** 4.92 atm **(D)** 3.28 atm

10. Three gases A, B and C are at same temperature if their r.m.s are in the ratio $1 : \frac{1}{\sqrt{2}} : \frac{1}{\sqrt{3}}$ then their molar masses will be in the ratio :

(A) 1 : 2 : 3 **(B)** 3 : 2 : 1 **(C)** $1 : \sqrt{2} : \sqrt{3}$ **(D)** $\sqrt{3} : \sqrt{2} : 1$

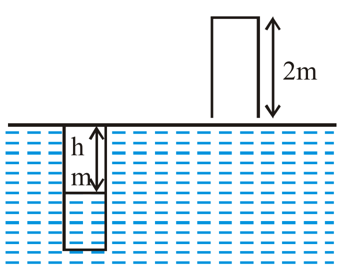
11. There are n containers having volumes V, 2V,.........., nV. A fixed mass of a gas is filled in all the containers connected with stopcock. All containers are at same temperature if pressure of first container is P then final pressure when all stopcocks are opened is :

(A) $\frac{np}{n(n+1)}$ **(B)** $\frac{2np}{n(n+1)}$ **(C)** $\frac{3np}{n(n+1)}$ **(D)** $\frac{np}{2n(n+1)}$

12. A mixture of two gases A and B in the mole ratio 2 : 3 is kept in a 2 litre vessel. A second 3 litre vessel has the same two gases in the mole ratio 3 : 5. Both gas mixtures have the same temperature and same total pressure. They are allowed to intermix and the final temperature and total pressure are the same as the initial values, the final volume being 5 litres. Given that the molar masses are M_A and M_B, what is the mean molar masses of the final mixture ?

(A) $\frac{77M_A + 123M_B}{200}$ **(B)** $\frac{123M_A + 77M_B}{200}$ **(C)** $\frac{77M_A + 123M_B}{250}$ **(D)** $\frac{123M_A + 77M_B}{250}$

13. A 2 m long tube closed at one end is lowered vertically into water until the closed end is flush with the water surface. See figure below. Calculate the water level heigtht in the tube. (Barometric pressure - 1 atm = 10 m of hydrostatic water head, Temperature = 25°C, Density of water = 1.00 g/ml. Neglect water vapour pressure).



(A) 1.01 m **(B)** 0.29 m **(C)** 1.71 m **(D)** 0.92 m

14. At a certain temperature for which RT = 25 lit. atm. mol^{-1}, the density of a gas, in gm lit^{-1}, is $d = 2.00P + 0.020\ P^2$, where P is the pressure in atmosphere. The molecular weight of the gas in gm/mol is :
(A) 25 **(B)** 50 **(C)** 75 **(D)** 100

15. A mixture of carbon monoxide and carbon dioxide is found to have a density of 1.7 g/lit at S.T.P. The mole fraction of carbon monoxide is :
(A) 0.37 **(B)** 0.40 **(C)** 0.30 **(D)** 0.50

16. The molecular radius for a certain gas = 1.25 Å. What is a reasonable estimate of the magnitude of the van der Waals constant, b, for the gas ?
(A) 0.98×10^{-2} litre /mole **(B)** 1.43×10^{-2} litre/mole **(C)** 1.97×10^{-2} litre/mole **(D)** 3.33×10^{-2} litre/mole

17. Given the value of their van der Waals' constant 'a' arrange the following gases in the order of their expected liquification pressure at a temperature T. T is below the critical point of all the gases.

Gas	CH_4	Kr	N_2	Cl_2
'a'(atmL²mol-1)	2.283	2.439	1.408	6.579

(A) $CH_4 < Kr < N_2 < Cl_2$ **(B)** $N_2 < CH_4 < Kr < Cl_2$
(B) $Cl_2 < Kr < CH_4 < N_2$ **(D)** $Cl_2 < N_2 < Kr < CH_4$

18. The critical volume of a gas is 0.072 lit. mol-1. The radius of the molecule will be, in cm

(A) $\left(\frac{3}{4\pi}\times 10^{-23}\right)^{\frac{1}{3}}$ **(B)** $\left(\frac{4\pi}{3}\times 10^{-23}\right)^{\frac{1}{3}}$ **(C)** $\left(\frac{3\pi}{4}\times 10^{-23}\right)^{\frac{1}{3}}$ **(D)** $\left(\frac{3}{4\pi}\times 10^{-8}\right)^{\frac{1}{3}}$

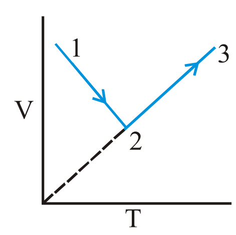
19. Which of the following statements is not true ?
(A) The ratio of the mean speed to the rms speed is independent of the temperature.
(B) The square of the mean speed of the molecules is equal to the mean squared speed at a certain temperature.
(C) Mean kinetic energy of the gas molecules at any given temperature is independent of the mean speed.
(D) The difference between rms speed and mean speed at any given temperature for different gases diminishes as larger if larger molar masses are considerd.

20. A capillary tube of uniform diameter contains gas samples A and B, separated by a short column of Hg, 'ℓ' mm in length. The ends are sealed. In horizontal position, the confined gases occupy 'a' mm and 'b' mm in length with a common unknown pressure (P). In vertical position, the lengths become respectively a' mm and b' mm. Then P is equal to

(A) $\dfrac{\ell}{\left(\frac{b}{b'}-\frac{a}{a'}\right)}$ **(B)** $\dfrac{\ell}{\left(\frac{a}{a'}-\frac{b}{b'}\right)}$ **(C)** $\ell\left(\frac{a}{a'}-\frac{b}{b'}\right)$ **(D)** $\ell\left(\frac{b}{b'}-\frac{a}{a'}\right)$

SECTION - II : MULTIPLE CORRECT ANSWER TYPE

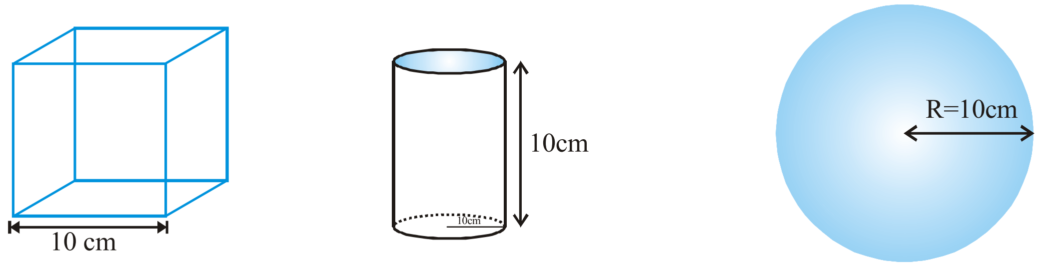
21. Following graph is constructed foe the fixed amount of gas.



(A) From 1-2 pressure will increase.
(B) From 2-3 pressure remains constant
(C) Gas pressure at (3) is greater at state (1)
(D) From 1-2 pressure will decrease

22. Which of the following statements are correct
(A) Average velocity of molecules of a gas in a container is zero.
(B) All molecules in a gas are moving with the same speed.
(C) If an open container is heated from 300 K to 400 K the percentage of air which goes out with respect to originally present is 25%.
(D) If compressibility factor of a gas at STP is less than unity then its molar volume is less than 222.4 L at STP.

23. There are three closed containers in which equal amounts of the gas are filled.



(I) (II) (III)

If the containers are placed at the same temperatures the find the correct options :

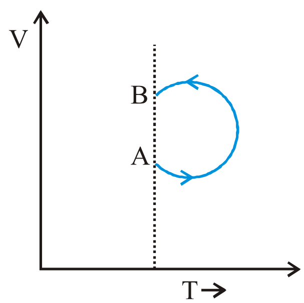
(A) Pressure of the gas is minimum in (III) container

(B) Pressure of the gas is equal in (I) and (II) container

(C) Pressure of the gas is maximum in (I)

(D) The ratio of pressure in II and III container is 3 : 4

24.



With reference to the above graph, shoose the correct alternatives

(A) $P_B > P_A$

(B) $P_A > P_B$

(C) Pressure first increases then decreases

(D) Pressure first decreases then increases.

SECTION - III : ASSERTION AND REASON TYPE

25. Statement - 1 : The value of vander waal's constant **(A)** is larger for ammonia than for nitrogen.

Statement - 2 : Hydrogen bonding is present in ammonia.

(A) Statement - 1 is True, Statement - 2 is True and Statement - 2 is correct explanation for statement - 1

(B) Statement - 1 is True, Statement - 2 is True and 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.

26. Statement - 1 : At Boyle's temperature a real gas behaves as ideal gas for wide range of temperature and pressure.

Statement - 2 : At Boyle's temperature vander waal constant 'a' and 'b' componsate each other.

(A) Statement - 1 is True, Statement - 2 is True and Statement - 2 is correct explanation for statement - 1

(B) Statement - 1 is True, Statement - 2 is True and Statement - 2 is NOT a correct explana tion for statement - 1.

(C) Statement - 1 is True, Statement - 2 is False

(D) Statement - 1 is False, Statement - 2 is True

27. Statement - 1 : Greater is critical temperature more easily a gas can be liquified.
Statement -2 : Critical temperature depends on the magnitude of intermolecular forces of attraction between the gases.
(A) Statement - 1 is True, Statement - 2 is True and Statement - 2 is correct explanation for statement - 1
(B) Statement - 1 is True, Statement - 2 is True and Statement - 2 is NOT a correct explana tion 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

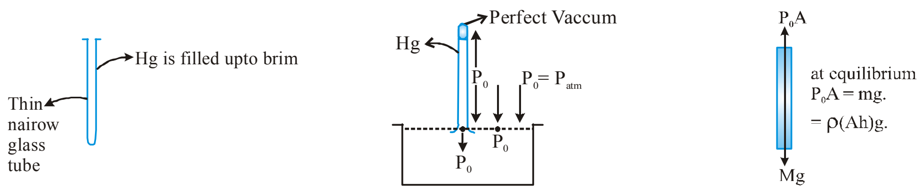
Read the following comprehensions carefully and answer the questions.

Comprehension # 1

MEASUREMENT OF PRESSURE

Barometer

A barometer is an instrument that is used for the measurement of pressure. The construction of the barometer is as follows

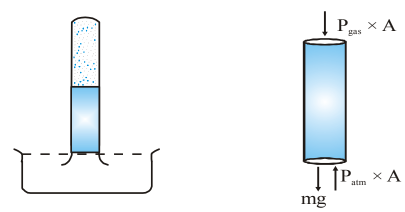


Cross sectional view of the capillary column

A thin narrow calibrated capillary tube is filled to the brim, with a liquid such as mercury, and is inverted into a trough filled with the same fluid. Now depending on the external atmospheric pressure, the level of the mercury inside the tube will adjust itself, the reading of which can be monitored. When the mercury column inside the capillary comes to rest, then the net forces on the column should be balanced.
Applying force balance, we get,
$P_{atm} \times A = m \times g$ ('A' is the cross-sectional area of the capillary tube)
If 'ρ' is the density of the fluid, then $m = \rho \times g \times h$ ('h' is the height to which mercury has risen in the capillary)
hence, $P_{atm} \times A = (\rho \times g \times h) \times A$
or, $P_{atm} = \rho gh$

Faulty Barometer

An ideal barometer will show a correct reading only if the space above the mercury column is vacuum, but in case if some gas column is trapped in the space above the mercury column, then the barometer is classified as a faulty barometer. The reading of such a barometer will be less than the true pressure.
For such a faulty barometer



$$P_0A = mg + P_{gas}A$$
$$P_0 = \rho gh + P_{gas}$$
or $$\rho gh = P_0 - P_{gas}$$

28. A tube closed at one end is dipped in mercury as shown in figure-3 such that the closed surface coincides with the mercury level in the container. By how much length of the tube should be extended such that the level of Hg in the tube is 5 cm below the mercury level inside the container. (assume temperature remains constant)
(A) 18 cm
(B) 19 cm
(C) 24 cm
(D) 30 cm

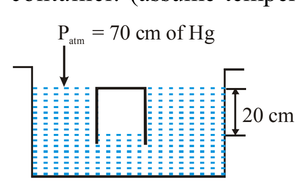
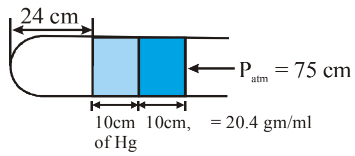


Fig. 3

29. If above tube is placed vertically with the open end upward then the length of the air column will be (assume temperature remains constant)



(A) 20 cm **(B)** 36 cm **(C)** 18 cm **(D)** 15 cm

30. A gas column is trapped between closed end of a tube and a mercury column of length (h) when this tube is placed with its open end upwards the length of gas column is (ℓ_1) the length of gas column becomes (ℓ_2) when open end of tube is held downwards (as shown in fig.-4). Find atmospheric pressure in terms of height of Hg column. (assume temperature remains constant)

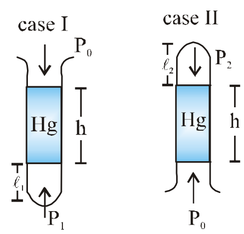
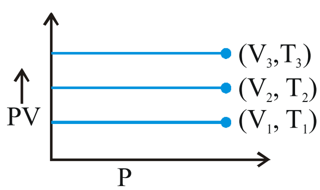
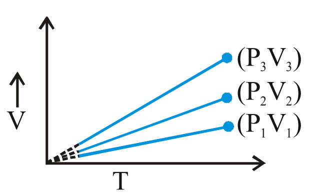
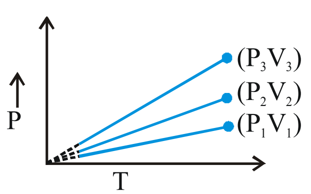
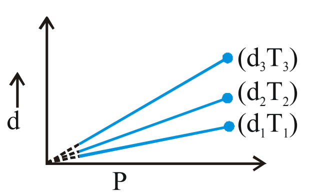


Fig.-4

(A) $\frac{h(\ell_1+\ell_2)}{(\ell_2-\ell_1)}$ **(B)** $\frac{h(\ell_2-\ell_1)}{(\ell_1+\ell_2)}$ **(C)** $\frac{(\ell_1+\ell_2)}{h(\ell_2-\ell_1)}$ **(D)** $(h_1\ell_1+h_2\ell_2)$

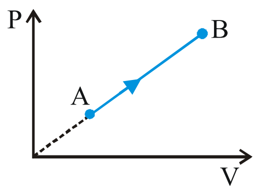
SECTION - V : MATRIX - MATCH TYPE

31. For a fixed amount of the gas match the two column :

Column - I	Column - II
(A) 	**(p)** $T_1 > T_2 > T_3$
(B) 	**(q)** $P_1 > P_2 > P_3$
(C) 	**(r)** $V_1 > V_2 > V_3$
(D) 	**(s)** $d_1 > d_2 > d_3$

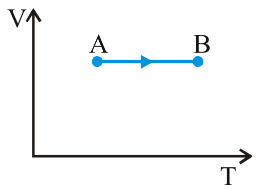
32. Match the following :

(A)



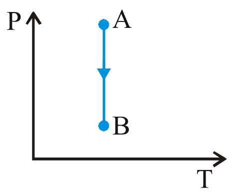
(p) Temperature is increasing

(B)



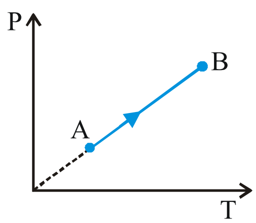
(q) Temperature is constant

(C)



(r) Volume is constant

(D)



(s) Pressure is increasing

33. Match the following

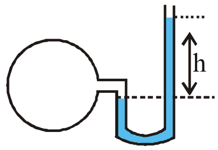
Column I	Column II
(A) attractive tendency dominates	(p) $Z = 3/8$
(B) at the Boyle's temperature in the high pressure region	(q) $Z < 1$
(C) For a gas at very low pressure and very very high temperature	(r) $Z > 1$
(D) At the critical point	(s) $Z = 1$

SECTION - VI : SUBJECTIVE TYPE

34. A bilb of constant volume is attached to a manometer tube open at other end as shown in the figure. The manometer is filled with a liquid of density (1/3)rd that of mercury. Initially h was 228 cm. Through a small hole in the bulb gas leaked causing pressure decrease as $\frac{dp}{dt} = -kp$. If value of h is 114 cm after 7 minutes. Calculate value of k in units of hour^{-1}.

(Report answer in multiple of 10^{-1})

[Use : in (4/3) = 0.28 & density of Hg = 13.6 g/ml]



ANSWER KEY

EXERCISE - 1

1. C	**2.** C	**3.** A	**4.** A	**5.** A	**6.** C	**7.** C	**8.** C	**9.** C	**10.** A	**11.** B	**12.** D	**13.** D
14. B	**15.** B	**16.** C	**17.** B	**18.** A	**19.** D	**20.** A	**21.** B	**22.** D	**23.** B	**24.** B	**25.** A	**26.** C
27. B	**28.** B	**29.** C	**30.** C	**31.** A	**32.** A	**33.** A	**34.** A	**35.** B	**36.** C	**37.** C	**38.** B	**39.** B
40. B	**41.** D	**42.** B	**43.** A	**44.** A	**45.** C	**46.** A	**47.** C	**48.** D	**49.** B	**50.** A	**51.** B	**52.** A
53. C	**54.** C	**55.** B	**56.** B	**57.** C	**58.** D	**59.** C	**60.** C	**61.** C	**62.** D	**63.** D	**64.** D	**65.** C
66. B	**67.** B	**68.** B	**69.** A	**70.** B	**71.** B							

EXERCISE - 2 : PART # I

1. A, B	**2.** B, D	**3.** B, D	**4.** B	**5.** A	**6.** D	**7.** C	**8.** A	**9.** A
10. C	**11.** D	**12.** B	**13.** D	**14.** A	**15.** B	**16.** C	**17.** D	
18. A, B, C	**19.** D	**20.** D	**21.** B	**22.** C	**23.** D	**24.** A	**25.** B	**26.** C
27. D	**28.** A	**29.** A,C,D	**30.** A,B,C	**31.** B, D				

PART # II

1. C **2.** **C** **3.** D **4.** **A** **5.** **B** **6.** B **7.** **A** **8.** A **9.** **C** **10.** **C** **11.** D **12.** **E** **13.** C

EXERCISE - 3 : PART # I

1. $A \to (s), B \to (q, s), C \to (r), D \to (p)$

2. $A \to (8), B \to (6), C \to (7), D \to (1), E \to (9), (F) \to (10), (G) \to (3), (H) \to (2), (I) \to (4), (J) \to (5)$

3. $A \to (q, r), B \to (p, s), C \to (q, r), D \to (p, r)$

PART # II

Comprehension # 1 : **1.** C **2.** D **3.** D

Comprehension # 2 : **1.** B **2.** C **3.** A

Comprehension # 3 : **1.** D **2.** B **3.** D

Comprehension # 4 : **1.** A **2.** C **3.** C

Comprehension # 5 : **1.** B **2.** A **3.** C **4.** C **5.** B

EXERCISE - 5 : PART # I

1. C **2.** C **3.** C **4.** C **5.** A **6.** D **7.** A **8.** C **9.** C **10.** C **11.** D **12.** D **13.** D
14. B

PART # II

1. 434 m/s **2.** A **3.** D **4.** A, B, C **5.** $A \rightarrow (p, s)$, $B \rightarrow (r)$, $C \rightarrow (p, q)$, $D \rightarrow (r)$ **6.** A,C,D **7.** B
8. $M_{\gamma} = 4$ **9.** A, B, C, D **10.** 7 **11.** C **12.** 5 **13.** C **14.** B **15.** C **16.** 2.22

MOCK TEST

1. B **2.** C **3.** D **4.** A **5.** A **6.** B **7.** B **8.** B **9.** B
10. A **11.** B **12.** A **13.** C **14.** B **15.** A **16.** C **17.** C **18.** A
19. B **20.** A **21.** A, B, C **22.** A, C, D **23.** A, C, D **24.** B, C **25.** A **26.** A **27.** A
28. B **29.** C **30.** A
31. $A \rightarrow (p, r)$, $B \rightarrow (q, s)$, $C \rightarrow (r)$, $D \rightarrow (p, s)$
32. $A \rightarrow (p, s)$, $B \rightarrow (p, r, s)$, $C \rightarrow (q)$, $D \rightarrow (p, r, s)$
33. $A \rightarrow (q)$, $B \rightarrow (r)$, $C \rightarrow (s)$, $D \rightarrow (p)$