

Chapter 8. Hydrogen

Question-1

Classify the following hydrides into covalent, ionic and interstitial hydrides.

Solution:

NH_3 , ZrH_2 , CaH_2 , NaH , B_2H_6

Covalent = NH_3 B_2H_6

Ionic = NaH , CaH_2

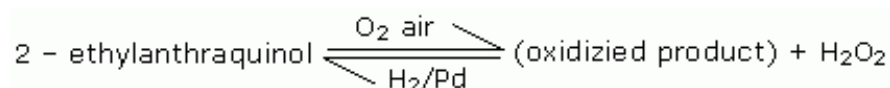
Interstitial = ZrH_2 .

Question-2

How is H_2O_2 manufactured?

Solution:

Industrially H_2O_2 is prepared by the auto oxidation of 2 hydroxy anthraquinols. It involves a cycle of reactions. The net reaction is to catalyst union of H_2 and O_2 to yield H_2O_2



It is concentrated by careful distillation under low pressure.

Question-3

What is the use of Zeolite / permutit?

Solution:

Zeolite or permutit is a sodium aluminium silicate. $\text{Na Al SiO}_4 \cdot 3\text{H}_2\text{O}$. When hard water, which contains Ca^{2+} / Mg^{2+} ions, is passed through Zeolite / permutit, Na^+ ion in the silicate gets exchanged for Ca^+ / Mg^{2+} in hard water. Thus hard water is softened.

Question-4

What is meant by 100-volume of Hydrogen peroxide?

Solution:

Each milliliter of 100-volume H_2O_2 will liberate 100 volumes of oxygen at STP. It may be 30% solution H_2O_2 .

Question-5

Give examples for electron deficient, electron-precise and electron rich molecular hydrides.

Solution:

Electron deficient: B_2H_6 (has less number of electrons to write Lewis structure)

Electron – precise: CH_4

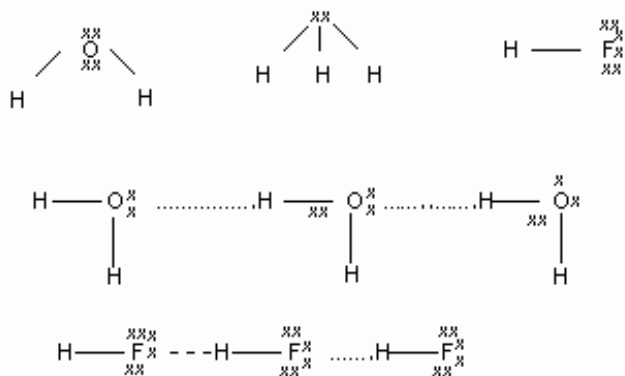
Electron – rich: NH_3 and H_2O (N and O have lone pairs of electrons).

Question-6

Why HF , H_2O and NH_3 have higher boiling points, and aggregation?

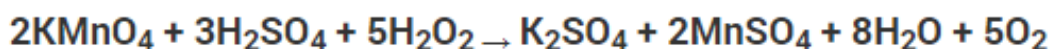
Solution:

Fluorine, oxygen and nitrogen are electronegative elements: They have lone pairs of electron in HF , H_2O and NH_3 , electron rich hydride.



Question-7

Solution:



KMnO_4 is converted into MnSO_4 : Oxidation number of Mn is changed from +7 to +2 by H_2O_2 . That is H_2O_2 acts as a reducing agent, giving electrons to manganese. H_2O_2 is changed to O_2 by KMnO_4 . Oxidation number of oxygen in H_2O_2 is changed from -1 to 0 in oxygen molecule. Hence KMnO_4 removes electron from oxygen of H_2O_2 . Hence H_2O_2 is oxidized by KMnO_4 to H_2O .



S^{2-} in PbS is oxidized to SO_4 ; oxidation number of S in PbS (-2) changed to (+6) in PbSO_4 . Electrons are removed from PbS by H_2O_2 to convert PbS to PbSO_4 . Hence H_2O_2 is an oxidizing agent.

H_2O_2 is converted into H_2O : Oxidation number (-1) in H_2O_2 is changed into (-2) in H_2O . Hence H_2O_2 is reduced by PbS .

Question-8

How is H_2O_2 concentrated?

Solution:

Aqueous H_2O_2 solutions spontaneously decompose to give H_2O and O_2 . Hence 1% H_2O_2 , formed during preparation cannot be concentrated by distillation under atmospheric pressure. Hence H_2O_2 solution is concentrated to 30% by distillation under reduced pressure. This further concentrated to 85% by careful distillation under low pressure. The remaining water is frozen out to give pure H_2O_2 .

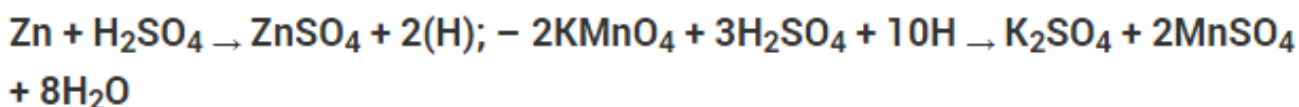
Question-9

What is nascent hydrogen? How is its reactivity?

Solution:

The hydrogen at the time of its production (new born) is much more reactive and is called nascent hydrogen. It is in a atomic state at the moment of its formation.

E.g. H_2 molecule does not reduce $KMnO_4$. But, Zn and HCl reduces $KMnO_4$. Decolourise $KMnO_4$.

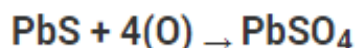
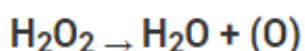


Question-10

What is the reaction involved using H_2O_2 for renovating old painting?

Solution:

Old paintings rendered black PbS by the atmospheric H_2S . Black PbS in painting is oxidized by H_2O_2 to white $PbSO_4$



CBSE Class 11 Chemistry
Important Questions
Chapter 9
Hydrogen

1 Marks Questions

1. Which isotope of hydrogen

(i) does not contain neutron?

(ii) is radioactive?

Ans. (i) Protium

(ii) Tritium

2. Give the electronic configuration of hydrogen

Ans. 1s¹

3. Name the isotopes of hydrogen.

Ans. Hydrogen has three isotopes:

Protium, ${}^1_1\text{H}$

deuterium, ${}^2_1\text{H}$

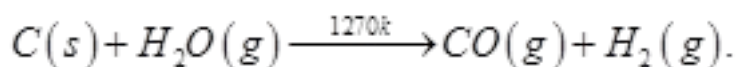
tritium, ${}^3_1\text{H}$

4. What is syn-gas?

Ans. Mixture of CO and H₂ is used for the synthesis of methanol and a number of hydrocarbons it is also called synthesis gas or 'syngas'

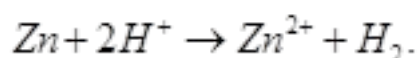
5.What is coal gasification?

Ans. The process of producing syn gas from coal is called ‘coal gasification.



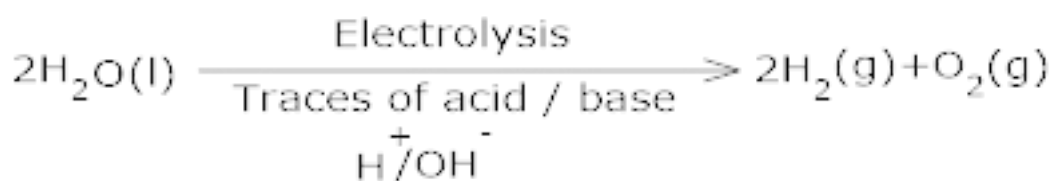
6.Give the laboratory method of preparation of hydrogen.

Ans. Hydrogen is usually prepared by the reaction of granulated zinc with dilute hydrochloric acid



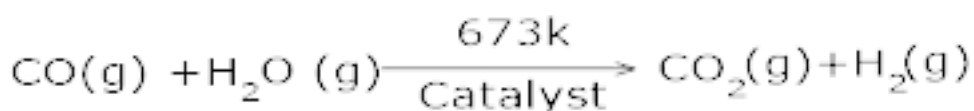
7.Give the commercial method of preparation of dihydrogen.

Ans. Electrolysis of acidified water using platinum electrodes give hydrogen.



8.What is water – gas shift reaction?

Ans.The production of dihydrogen can be increased by reacting carbon monoxide of syn gas mixtures with steam in the presence of iron chromate as catalyst.



This is called water gas – shift reaction.

9.Why is dihydrogen gas not preferred in balloons?

Ans. Dihydrogen is the lightest gas and should have been used in balloons. But it is not preferred due to its highly combustible nature.

10. What is the pH of water?

Ans. The pH value of water is 7.

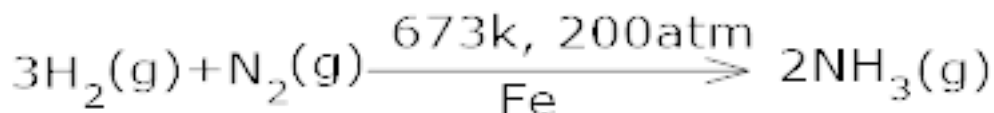
11. How is methanol prepared using dihydrogen?

Ans. CO on reacting with dihydrogen yields bulk amount of methanol.



12. How is ammonia prepared using dihydrogen?

Ans. With dinitrogen it forms ammonia.



This is the method for the manufacture of ammonia by the Haber process.

13. Name the categories into which hydrides are categorized.

Ans. The hydrides are classified into three categories -

(i) Ionic or saline or salt like hydrides.

(ii) Covalent or molecular hydrides

(iii) Metallic or non-stoichiometric hydrides.

14. What are hydrides?

Ans. Dihydrogen under certain reaction conditions combines with almost all elements, except noble gases, to form binary compounds, called hydrides.

15. Give an example of each of an ionic hydride and a covalent hydride.

Ans. Ionic hydride: LiH, NaH Covalent hydride CH₄, NH₃ and H₂O

16. What happens when water is added to calcium hydride?

Ans. Calcium hydroxide is formed

$$\text{CaH}_2 + \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2$$

(Calcium hydride) Calcium hydroxide

17. Give an example of electron – deficient hydride.

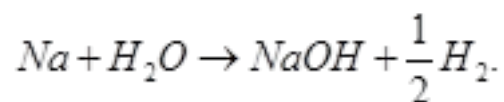
Ans. Diborane.

18. What is the behavioral similarity between NH₃, H₂O HF compounds?

Ans. They behave as Lewis bases i.e. electron donors. The presence of lone pairs on highly electronegative atoms like N, O and F in hydrides results in hydrogen bond formation between the molecules.

19. Give a reaction in which water acts as an oxidizing agent.

Ans.



20. Write the Name of a zeolite used in softening of hard water.

Ans. Sodium aluminum silicate Na₂Al₂Si₂O₈ · X H₂O.

21. Define hard water.

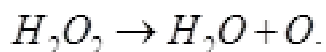
Ans. Water which does not produce lather with soap solution readily is called hard water. eg. hand pump water, river water, sea water etc.

22. What is calgon?

Ans. Sodium hexameta phosphate ($\text{Na}_6\text{P}_6\text{O}_{18}$) is commercially called calgon.

23. Why is H_2O_2 a better oxidant than water?

Ans. H_2O_2 is easily reduced to form O and H_2O .



24. What happens when H_2O_2 reacts with ethylene?

Ans.

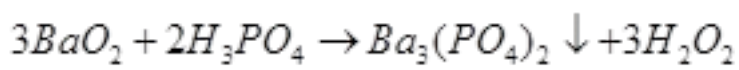


25. What do you mean by 100 volume of hydrogen peroxide?

Ans. It means that one milliliter of 30% H_2O_2 solution will give 100v of oxygen at STP

26. What happens when BaO_2 is treated with phosphoric acid?

Ans. H_2O_2 is obtained



CBSE Class 12 Chemistry

Important Questions

Chapter 9

Hydrogen

2 Marks Questions

1. Why does hydrogen occupy unique position in the periodic table?

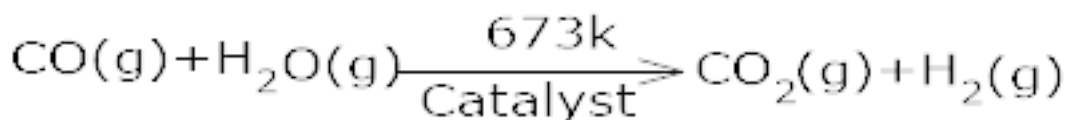
Ans. In spite of the fact that hydrogen, to a certain extent resembles both with alkali metals (ns^1) and halogens ($ns^2 np^5$), it differs from them as well. Hydrogen has very small size as a consequence H^+ does not exist freely and is always associated with other atoms or molecules. Thus, it is unique in behaviors and is therefore, best placed separately in the periodic table.

2. Give the main characteristics of isotopes.

Ans. Since, the isotopes have the same electronic configuration, they have almost the same chemical properties. The only difference is in their rates of reactions, mainly due to their different enthalpy of bond dissociation. However, in physical properties of these isotopes differ considerably due to their large mass differences.

3. How can the production of dihydrogen obtained from 'coal gasification be increased'?

Ans. By reacting carbon monoxide of syngas mixtures with steam in the presence of iron chromate as catalyst



4. Why is dihydrogen used in fuel cells for generating electrical energy?

Ans. Because it does not produce any pollution and releases greater energy per unit mass of fuel in comparison to gasoline or any other fuel.

5.What is understood by hydrogenation?

Ans. Hydrogenation is used for the conversion of polyunsaturated oils into edible fats.

6.Which fuel is used as a rocket fuel?

Ans. Dihydrogen is used as a rocket fuel in space research.

7.What happens when sodium hydride reacts with water?

Ans. Saline hydride (sodium hydride) react violently with water producing dihydrogen gas



8.What is the geometry of the compound formed by group 14 to form molecular hydride?

Ans. Tetrahedral in structure.

9.What are the characteristic features of ionic or saline hydrides?

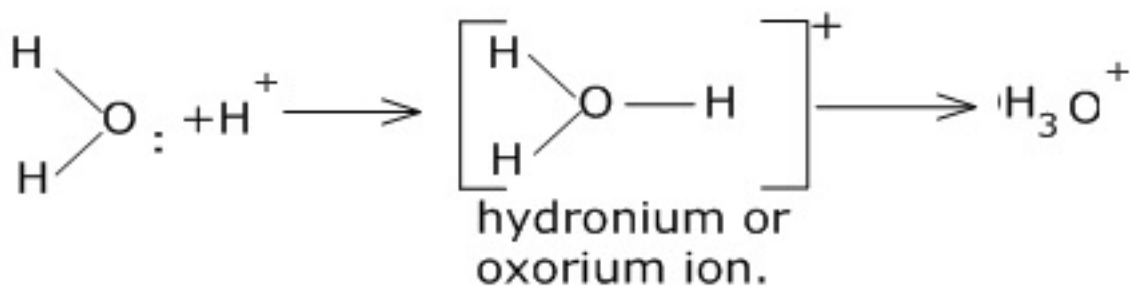
Ans. The ionic hydrides are crystalline, non – volatile non – conducting in solid state. However their melts conduct electricity.

10.Which gas is produced on electrolysis of ionic hydride?

Ans. Dihydrogen gas is produced at the anode on electrolysis of ionic hydride.

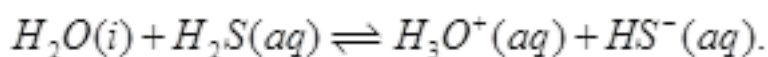
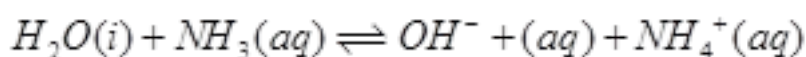
11.How does H⁺ ion forms hydronium ion (OH₃⁺) in water?

Ans. In water H⁺ ion forms a covalent bond with H₂O and forms hydronium ion, (H₃O⁺).



12. Show with reaction the amphoteric nature of water.

Ans. Water acts as an acid with NH_3 and base with H_2S

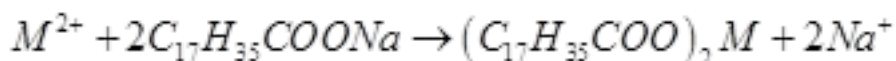


13. Why is ice less dense than water and what kind of attractive forces must be overcome to melt ice?

Ans. The structure of ice is an open structure having a number of vacant spaces. Therefore, the density of ice is less than water. When ice melts the hydrogen bonds are broken and the water molecules go in between the vacant spaces. As a result, the structure of liquid water is less open than structure of ice. Thus ice is less dense than water

14. Why does hard water not form lather with soap?

Ans. Hard water does not produce lather with soap readily because the cations (Ca^{2+} and Mg^{2+}) present in hard water react with soap to precipitate of calcium and magnesium salts of fatty acids.



From hard water sodium stearate form Ca/Mg stearate

15. Why is water an excellent solvent for ionic or polar substances?

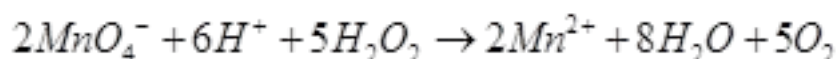
Ans. Water is a polar solvent with a high dielectric constant. Due to high dielectric constant of water the force of attraction between cation and anion gets weakened. Thus water molecules are able to remove ions from the lattice site using in dipole forces easily.

16. How many hydrogen – bonded water molecule are associated in $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$?

Ans. Only one water molecule, which is outside the brackets (coordinator spheres), is hydrogen bonded. The other four molecules of water are co-ordinated.

17. What happens when H_2O_2 reacts with acidified KMnO_4 ?

Ans. Reducing property of H_2O_2 is observed.



18. Hydrogen peroxide acts as oxidizing agent as well as a reducing agent. Why?

Ans. Hydrogen peroxide can act as an oxidizing agent because it readily decomposes to evolve oxygen and also take up oxygen from water.

19. Why is hydrogen peroxide stored in wax-lined glass or plastic vessels in dark?

Ans. H_2O_2 decomposes slowly on exposure to light



In the presence of metal surfaces or traces of alkali (present in glass containers), the above reaction is catalyzed.

20. What is the volume strength of 2M- H_2O_2 ?

Ans. Since 1M – H_2O_2 solution contains 17g H_2O_2

∴ 2 M – H₂O₂ solution contains 34g of H₂O₂

$$\text{But 68g of H}_2\text{O}_2 \text{ contains} = \frac{22400 \times 34}{68}$$

= 11200ml of O₂ at NTP

Thus 1000ml of H₂O₂ soln. gives off O₂ = 11200ml at NTP

Hence 1 ml of H₂O₂ soln gives off

$$= \frac{11200}{1000} = 11.2 \text{ ml}$$

Thus volume strength of H₂O₂ = 11.2

21. Calculate the strength in volumes of a solution containing 30.36 g/l of H₂O₂.



22.4l at NTP

68g of H₂O₂ produce 22.4 l O₂ at NTP

$$30.36\text{g of H}_2\text{O}_2 \text{ produce} = \frac{22.4}{68} \times 30.36$$

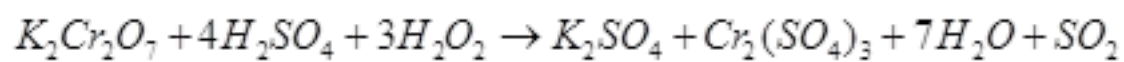
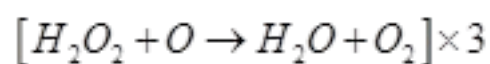
= 10l O₂ at NTP

∴ volume strength = 10 volumes.

22. What happens when hydrogen peroxide reacts with acidified K₂Cr₂O₇?

Ans. Acidified K₂Cr₂O₇ is oxidized to blue peroxide of chromium (Cr₂O₃) which is unstable.

However, it is soluble in ether and produces blue colored solution.



Orange

green.

Hydrogen

Short Answer Type Questions

1. How can production of hydrogen from water gas be increased by using water gas shift reaction?
2. What are metallic/interstitial hydrides? How do they differ from molecular hydrides?
3. Name the classes of hydrides to which H_2O , B_2H_6 and NaH belong.
4. If same mass of liquid water and a piece of ice is taken, then why is the density of ice less than that of liquid water?
5. Complete the following equations:

(i) $\text{PbS (s)} + \text{H}_2\text{O}_2(\text{aq}) \longrightarrow$ (ii) $\text{CO (g)} + 2\text{H}_2(\text{g}) \xrightarrow[\text{Catalyst}]{\text{Cobalt}} \longrightarrow$
6. Give reasons:
 - (i) Lakes freeze from top towards bottom.
 - (ii) Ice floats on water.
7. What do you understand by the term 'auto protolysis of water'? What is its significance?
8. Discuss briefly de-mineralisation of water by ion exchange resin.
9. Molecular hydrides are classified as electron deficient, electron precise and electron rich compounds. Explain each type with two examples.
10. How is heavy water prepared? Compare its physical properties with those of ordinary water.
11. Write one chemical reaction for the preparation of D_2O_2 .
12. Calculate the strength of 5 volume H_2O_2 solution.
13. (i) Draw the gas phase and solid phase structure of H_2O_2 .
(ii) H_2O_2 is a better oxidising agent than water. Explain.
14. Melting point, enthalpy of vapourisation and viscosity data of H_2O and D_2O is given below :

	H₂O	D₂O
Melting point / K	373.0	374.4
Enthalpy of vapourisation at (373 K)/ kJ mol ⁻¹	40.66	41.61
Viscosity/centipoise	0.8903	1.107

On the basis of this data explain in which of these liquids intermolecular forces are stronger?

15. Dihydrogen reacts with dioxygen (O₂) to form water. Write the name and formula of the product when the isotope of hydrogen which has one proton and one neutron in its nucleus is treated with oxygen. Will the reactivity of both the isotopes be the same towards oxygen? Justify your answer.
16. Explain why HCl is a gas and HF is a liquid.
17. When the first element of the periodic table is treated with dioxygen, it gives a compound whose solid state floats on its liquid state. This compound has an ability to act as an acid as well as a base. What products will be formed when this compound undergoes autoionisation?
18. Rohan heard that instructions were given to the laboratory attendant to store a particular chemical i.e., keep it in the dark room, add some urea in it, and keep it away from dust. This chemical acts as an oxidising as well as a reducing agent in both acidic and alkaline media. This chemical is important for use in the pollution control treatment of domestic and industrial effluents.
 - (i) Write the name of this compound.
 - (ii) Explain why such precautions are taken for storing this chemical.
19. Give reasons why hydrogen resembles alkali metals?
20. Hydrogen generally forms covalent compounds. Give reason.
21. Why is the Ionisation enthalpy of hydrogen higher than that of sodium?
22. Basic principle of hydrogen economy is transportation and storage of energy in the form

of liquid or gaseous hydrogen. Which property of hydrogen may be useful for this purpose? Support your answer with the chemical equation if required.

23. What is the importance of heavy water?
24. Write the Lewis structure of hydrogen peroxide.
25. An acidic solution of hydrogen peroxide behaves as an oxidising as well as reducing agent. Illustrate it with the help of a chemical equation.
26. With the help of suitable examples, explain the property of H_2O_2 that is responsible for its bleaching action?
27. Why is water molecule polar?
28. Why does water show high boiling point as compared to hydrogen sulphide? Give reasons for your answer.
29. Why can dilute solutions of hydrogen peroxide not be concentrated by heating. How can a concentrated solution of hydrogen peroxide be obtained?
30. Why is hydrogen peroxide stored in wax lined bottles?
31. Why does hard water not form lather with soap?
32. Phosphoric acid is preferred over sulphuric acid in preparing hydrogen peroxide from peroxides. Why?
33. How will you account for 104.5° bond angle in water?
34. Write redox reaction between fluorine and water.
35. Write two reactions to explain amphoteric nature of water.

Long Answer Type Questions

1. Atomic hydrogen combines with almost all elements but molecular hydrogen does not. Explain.
2. How can D_2O be prepared from water? Mention the physical properties in which D_2O differs from H_2O . Give at least three reactions of D_2O showing the exchange of hydrogen with deuterium.
3. How will you concentrate H_2O_2 ? Show differences between structures of H_2O_2 and H_2O by drawing their spatial structures. Also mention three important uses of H_2O_2 .
4. (i) Give a method for the manufacture of hydrogen peroxide and explain the reactions involved therein.
(ii) Illustrate oxidising, reducing and acidic properties of hydrogen peroxide with equations.
5. What mass of hydrogen peroxide will be present in 2 litres of a 5 molar solution? Calculate the mass of oxygen which will be liberated by the decomposition of 200 mL of this solution.
6. A colourless liquid 'A' contains H and O elements only. It decomposes slowly on exposure to light. It is stabilised by mixing urea to store in the presence of light.
 - (i) Suggest possible structure of A.
 - (ii) Write chemical equations for its decomposition reaction in light.
7. An ionic hydride of an alkali metal has significant covalent character and is almost unreactive towards oxygen and chlorine. This is used in the synthesis of other useful hydrides. Write the formula of this hydride. Write its reaction with Al_2Cl_6 .
8. Sodium forms a crystalline ionic solid with dihydrogen. The solid is nonvolatile and non-conducting in nature. It reacts violently with water to produce dihydrogen gas. Write the formula of this compound and its reaction with water. What will happen on electrolysis of the melt of this solid.