203 x 1 = 203

1) Hydrogen gas is generally prepared by the
(a) reaction of granulated zinc with dilute H_2SO_4
(b) reaction of zinc with conc. H_2SO_4
(c) reaction of pure zinc with dil. H_2SO_4
(d) action of steam on red hot coke.

2) Hydrogen peroxide is used as
(a) an oxidizing agent (b) a reducing agent
(c) a bleaching agent **(d) all of the above**

3) Water may be softened using
(a) sodium aluminium silicate (b) Graham's salt
(c) an ion exchange resin (d) trisodium phosphate

4) On treatment of hard water with zeolite, sodium ions get exchanged with
(a) Ca^{2+} ions (b) Mg^{2+} ions (c) H^+ ions (d) OH^-

5) Calgon, which is used as a water softener, has the formula
(a) $Na_4 [Na_2 (PO_3)_6]$ **(b) $Na_2 [Na_4(PO_3)_6]$** (c) $Na_2 [Na_4(PO_4)_5]$
(d) $Na_2 [Na_2 (PO_4)_6]$

6) The higher density of water than that of ice is due to
(a) dipole-dipole interaction (b) dipole-induced dipole interaction
(c) hydrogen bonding (d) all of these

7) Hydrogen is obtained as a by-product in the
(a) electrolysis of water **(b) manufacture of caustic soda**
(c) Bosch process (d) Lane process

8) Zeolite is
(a) hydrated sodium aluminium silicate - $Na_2Al_2Si_2O_8.xH_2O$
(b) hydrated ferric oxide (c) sodium hexametaphosphate
(d) sodium tetraborate

9) Water undergoes self-ionization to a small extent to give
(a) H^+ and OH^- (b) OH^+ and H^- **(c) H_3O^+ and OH^-**
(d) none of the above

10) The decomposition of H_2O_2 is retarded by
(a) acetanilide (b) glycerol (c) sodium bicarbonate
(d) oxalic acid

11) Why does hydrogen occur in a diatomic form rather than in a monoatomic form under normal conditions?
Answer : Hydrogen atom has only one electron in its 1s-orbital. So, to achieve stable inert gas configuration of helium, it exists as diatomic molecule and is called dihydrogen.

12) Name the isotope of hydrogen which contains equal number of protons and neutrons.
Answer : Deuterium (^2_1H) Number of protons (p)=number of electrons =atomic number=1 Number of neutrons (n)=Mass number - atomic number = 2-1=1

13) Which isotope of hydrogen is radioactive?
Answer : Tritium

14) Name the compound each in which hydrogen exists in negative oxidation state
Answer : NaH, here oxidation state of hydrogen is -1.

15) Name the compound each in which hydrogen exists in positive oxidation state
Answer : HCl, here oxidation state of hydrogen is +1.

16) Arrange H_2, D_2 and T_2 in the decreasing order of their boiling points
Answer : $T_2 > D_2 > H_2$

17) Arrange H_2, D_2 and T_2 in the decreasing order of their heat of fusion
Answer : $T_2 > D_2 > H_2$

18) With the help of suitable examples, explain the property of H_2O_2 that is responsible for its bleaching action?
Answer :

19) Name two compounds which retard the decomposition of H_2O_2 solution.

Answer :

20) Name two process in which hydrogen acts as a fuel.

Answer :

21) Give two advantages of using hydrogen over gasoline as a fuel.

Answer : (i) High heat of combustion (ii) It is pollution free.

22) Classify the following as covalent, ionic or interstitial hydrides.
CaH_2, LaH_2 RbH, GeH_2, TiH_2, NaH, NH_3

Answer : Covalent hydrides GeH_2, NH_3 Ionic hydrides CaH_2,RbH,NaH Interstitial hydrides TiH_2, LaH_2

23) Which of the two is heavier, 1 cm^3 or ice of 1 cm^3 of water?

Answer : 1 cm^3 of water is heavier than 1cm^3 of ice. Because density of ice is less than that of water due to formation of cage like structures in ice crystal

24) Suggest a method to show the electronegative nature of hydrogen

Answer : When sodium hydride is eletrolysed, hydrogen is envolved at anode, which shows its electronegative nature.

25) How can saline hydrides remove traces of water from organic compounds?

Answer : Salin hydrieds such as NaH, CaH_2,etc.., react with traces of water present in organic compounds and form theircorresponding metal hydroxides with the evolution of hydrogen gas $NaH(s) + H_2O(aq) \rightarrow NaOH(aq)+H_2(g)$ Infact in saline hydrides M^+H^-, the H^- ion is a strong Bronsted base and thus, it reacts with water easily.

26) Can Phosophorus with outer electronic configuration $3s^2$,$3P^3$ from PH_5?

Answer : Although P exhitbits +3 and +5 oxidation states but it cannot form PH_5. This is because H_2 has high $\Delta H - H$(435.88KJ mol^{-1}) and slightly negative $\Delta_{eg}H$(-73 KJ mol^{-1}) so acts only as a week oxidising agent, and hence,can oxidise P to +3 oxidation state but not to its highest oxidation state of +5 Thus, P forms PH_3, But not PH_5

27) Why is the ionisation enthalpy of hydrogen higher than that of sodium?

Answer : Both H and Na contain one electron in the valence shell.But the size of H is much smaller as compare to that of Na and hence, the ionisation enthalpy of hydrogen is much higher (1312 $kJmol^{-1}$) than that of Na (496 $kJmol^{-1}$).

28) Why does hydrogen react mostly at higher temperatures?

or

Discuss the consequences of high enthalpy of H-H bond in terms of chemical reactivity of dihydrogen.

Answer : Due to high bond dissociation enthalpy of H-H bond, hydrogen is relatively unreactive at room temperature. However, at high temperature or in the presence of catalysts, it combines with many metals and non-metals to form hydrides.

29) Concentrated sulpuric acid is an excellent dehydrating agent and is widely used for drying the gases but it cannot be used for drying hydrogen gas. Why?

Answer : Conc. H_2SO_4 on absorbing H_2O from moist H_2 produces so much heat that hydrogen catches fire.

30) Write one chemical reaction for the preparation of D_2O_2

Answer : D_2O_2 is prepared by distillation of potassium persulphate ($K_2S_2O_8$) with D_2O.

$$\underset{Potassium\ \ persulphate}{K_2S_2O_8} + 2D_2O \xrightarrow{Distilation} D_2O_2 + 2KDSO_4$$

31) Why is hydrogen peroxide stored in wax lined bottles?

Answer : Hydrogen peroxide is decomposed by rough surfaces of glass, alkali oxides present in it and light to form $H_2O and O_2$ $2H_2O_2 \rightarrow 2H_2O + O_2$ To prevent this decomposition, H_2O_2 is usually stored in coloured paraffin wax coated plastic or teflon bottles.

32) Acetanilide prevents the decomposition of H_2O_2. What is this compound called?

Answer : Acetanilide is a neutral compound which suppresses the decomposition of H_2O_2 into H_2O and O_2 .Thus, it is called stabiliser (or negative catalyst).

33) How does H_2O_2behave as a bleaching agent?

Answer : H_2O_2 acts as a bleaching agent due to the nascent oxygen which it liberates on decomposition.
$H_2O_2 \rightarrow H_2O + [O]$ **Coloured matter +[O] $\rightarrow$Colourless matter. It bleaches materials like silk, hair, ivory, cotton, wool etc.**

34) What do you mean by 15 volume H_2O_2solution?

Answer : '15 volume H_2O_2' means 1mL of a 15 volume H_2O_2 solution gives 15 mL of O_2 at NTP >

35) A mixture of hydrazine and $H_2O_2$with Cu(II) catalyst is used as a rocket propellant. Why?

Answer : The reaction between hydrazine and H_2O_2 is highly exothermic and is accompanied by a large increase in the volume of the products and hence, this mixture is used as a rocket propellant.

$$NH_2NH_2(l) + 2H_2O_2(l) \overset{Cu(II)}{\rightarrow} N_2(g)\uparrow + 4H_2O(g)\uparrow$$

36) Complete the following reaction.

$$CO(g) + 2H_2(g) \underset{Catalyst}{\overset{Cobalt}{\rightarrow}}$$

Answer : $CO(g) + 2H_2(g) \underset{Catalyst}{\overset{Cobalt}{\rightarrow}} CH_3OH(l)$

37) What type of bonds are broken when water evaporates.

Answer : Intermolecular hydrogen bonds are broken when water evaporates

38) In Ice structure how many H-bonds are formed by each H_2O molecules

Answer : In ice structure, each H_2O molecule forms four H-bonds, two H-bonds with O-atoms and two H-bonds with hydrogen atom.

39) In Ice structure how many H_2O molecules surround each H_2O molecules surround each H_2O unit

Answer : Each H_2O molecule is tetrahedrally surrounded with four H_2O molecule.

40) What causes the temporary and permanent hardness of water?

Answer : Presence of calcium bicarbonates and magnesium biocarbonates in water causes temporary hardness of water. Ppresence of soluble calcium chloride, magnesium chloride,Calcium sulphat and magnesium sulphate in water causes permanent hardness

41) Why does hard water not form lather with soap?

Answer : Hard water contains salts of calcium and magnesium ions. Hard water does not give lather with soap and forms scum/precipitate with soap. Soap containingsodium stearate(C_{17} H_{35} COONA)reacts with hard water to precipitate out as Ca/Mg stearate. $2C_{17}$ H_{35} COONA(aq) + M^{2+} (aq) $\rightarrow$ $(C_{17}$ $H_{35}Coo)_2M\downarrow$ + $2Na^{+}$ (aq) (Where, M is Ca/Mg) It is therfore, unsuitable for laundry.

42) Explain why beryllium forms a covalent hydride while calcium forms an iconic hydride.

Answer : Because of higher electronegativity, Be(EN=1.5) forms a covalent hydride while due to lower electronegativity Ca= (EN=1.0) forms an ionic hydride.

43) Is demineralised or distilled water useful for drinking purposes? If not, how can it be made useful?

Answer : Demineralised or distilled water is not useful for drinking purposes. It can be made useful by adding useful minerals in proper amount.

44) A sample of hard water is allowed to pass through an anion exchanger. Will it produce lather will soap easily?

Answer : No, Ca^{2+} and Mg^{2+} ions are still present and these will interact with soap to form curdy white precipitate. Therefore, it will not produce lather with soapeasily.

45) Name the isotope of hydrogen which is commonly used as a tracer in organic reactions.

Answer : Most commonly deuterium is used as tracers in organic reactions. (Tritium can be used as tracers but it is radioactive in nature and least abundant hydrogen isotope, therefore deuterium is commonly used)

46) Name the constituents of water gas.

Answer : Carbon monoxide and hydrogen

47) Which gaseous compound on treatment with dihydrogen produces methanol?
Answer : Carbon monoxide

48) Name one industrial method for the preparation of dihydrogen.
Answer : Bosch process

49) Describe the bulk preparation of hydrogen by electrolytic method. What is the role of an electrolyte in this process?
Answer : Electrolysis of acidified water using platinum electrodes gives hydrogen.

$$2H_2O(l) \underset{Traces\ of\ acid/base}{\overset{Electrolysis}{\rightarrow}} 2H_2(g) + O_2(g)$$

Here, the role of an electrolyte is to make water conducting.

50) Why is dihydrogen not preferred in balloons these days?
Answer : Dihydrogen is highly combustible and hence, is likely to catch fire in the presence of excess of air. That's why it is not preferred in balloons now a days.

51) Describe the bulk preparation of hydrogen by electrolytic method. What is the role of an electrolyte in this process?
Answer : Electrolysis of acidified water using platinum electrodes gives hydrogen.

$$2H_2O(l) \underset{Traces\ of\ acid/base}{\overset{Electrolysis}{\rightarrow}} 2H_2(g) + O_2(g)$$

Here, the role of an electrolyte is to make water conducting.

52) Why is dihydrogen not preferred in balloons these days?
Answer : Dihydrogen is highly combustible and hence, is likely to catch fire in the presence of excess of air. That's why it is not preferred in balloons now a days.

53) What is the importance of heavy water with regard to nuclear power generation?
Answer : It is used as a moderator and helps to control the nuclear reaction.

54) Give a reaction which shows the reducing nature of dihydrogen.
Answer :

55) What type of elements forms interstitial hydrides?
Answer : d-block and f-block elements.

56) Write two uses of interstitial hydrides.
Answer : (i) In the storage of H_2. (ii) Catalyst for hydrogenation reaction.

57) What is demineralised water? How is it obtained?
Answer :

58) What type of hybridization does the oxygen atom in a water molecule exhibit?
Answer :

59) What is the trade name of sodium hexametaphosphate?
Answer :

60) What is the shape of a H_2O_2 molecule in the gas phase?
Answer :

61) What is perhydrol?
Answer : Perhydrol is the trade name of H_2O_2. It is used as an antiseptic.

62) Complete the reaction, $SiCl_4 + H_2O \longrightarrow$
Answer :

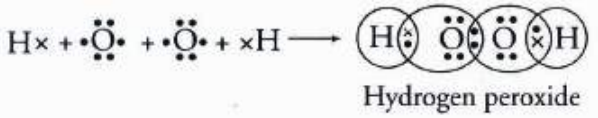
63) Write the name of that isotope of hydrogen of hydrogen which has no neutron?
Answer :

64) Name the constituents of water gas.
Answer :

65) Give one chemical reaction to demonstrate the reducing character of hydrogen?
Answer :

66) Give one use of hydrogen in which its property of combining to form molecular hydrogen is used
Answer :

67) Write the Lewis structure of hydrogen peroxide.
Answer : the Lewis structure of hydrogen peroxide is



68) Which compounds cause temporary hardness of water?
Answer : $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$

69) Name a substance which can oxidise H_2O_2.
Answer : Acified $KMnO_4$.

70) Name the phenomenon of adsorption of hydrogen on metal surface.
Answer : Occlusion.

71) Find the volume strength of 1.6 N H_2 O_2 solution
Answer : 27.2 g/L

72) Hydrogen generally forms covalent compounds. Give reason?
Answer : Hydrogen because of the presence of only one electron in the valence shell can either lose or gain or share it to acquire noble gas, i.e. helium gas, configuration.Therefore, in principle, it can form either ionic or covalent bonds.But the ionisation enthalpy of H is very high (1312 $kJmol^{-1}$) and its electron gain enthalpy is only slightly negative (-73 $kJmol^{-1}$). As a result, it does not have a high tendency to form ionic bonds but rather prefers to form only covalent bonds.

73) Write the name of isotopes of hydrogen. What is mass ratio of these isotopes?
Answer : Protium ${}_1^1H$, deuterium ${}_1^2H$ or D, tritium ${}_1^3H$ or T.
The mass ratioprotium:deuterium:tritium=1:2:3.

74) H_2O_2 is a better oxidising agent than water as discussed below.Explain.
Answer : H_2O_2 is a better oxidising agent than water as discussed below.
(a) H_2O_2 oxidises an acidified solution of KI to give I_2 which gives blue colour with starch solution but H_2O does not.
(b) H_2O_2 turns black PbS to white $PbSO_4$ but H_2O does not.

75) Calculate the strength of 10 volume solution of hydrogen peroxide.

Answer : 10 volume solution of H_2O_2 means that 1L of this H_2O_2 solution will give 10L of oxygen at STP.

$\underset{68\ g}{2H_2O_2(l)} \rightarrow \underset{22.7L\ at\ STP}{O_2(g)} + H_2O(l)$ Thus 22.7 L O_2 is obtained from 68g H_2O_2 at STP $\therefore$ 10 L of O_2 at STP is produced from

$\frac{68X10}{22.7} g = 29.9g \approx 30gH_2O_2$

Thus, the strength of H_2O_2 in 10 volume H_2O_2 solution =30g/L =3% H_2O_2 solution

76) Complete the following equations $PbS(s) + H_2O_2(aq)$

Answer : $PbS(s) + H_2O_2(aq) \rightarrow PbSO_4(s) + 4H_2O$

77) Complete the following equations

$MnO_4^-(aq) + H_2O_2(aq) \rightarrow$

Answer : $MnO_4^-(aq) + H_2O_2(aq) + 6H^+ \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$

78) Why can dilute solutions of hydrogen peroxide not be concentrated solution of hydrogen peroxide be obtained?

Answer : Dilute solutions of H_2O_2 cannot be concentrated by heating because it decomposes much below its boiling point.

$2H_2O_2 \rightarrow 2H_2O + O_2$

79) 10mL of a given solution of H_2O_2 contains 0.91 g of H_2O_2. Express its strength in volume.

Answer : 68 g of H_2O_2 produce O_2=22700 mL at NTP

$\therefore$ 0.91 g of H_2O_2 will produce O_2= $\frac{22700X0.91}{68}$ =303 mL at NTP

$\therefore$ Volume strength $\approx$303/10$\approx$30

80) Explain the correct context in which the following terms are used diprotium

Answer : Diprotium Diprotium is the term used to represent $^1H_2$

81) Explain the correct context in which the following terms are used dihydrogen

Answer : Dihydrogen The diatomic molecule H_2 is called dihydrogen while referring to the isotopic mixture with natural abundance of H and D.

82) Explain the correct context in which the following terms are used
proton
Answer : Proton The ionised form of protium i.e. H^+ is called a proton. This term is used in describing the self ionisation of water and ionisation of acids in water.

83) Explain the correct context in which the following terms are used
hydron
Answer : Hydron $H^+$when used in relation to the isotopic mixture, is called hydron.

84) Basic principle of hydrogen economy is transporation and storage of energy in the form of liquid or gaseous hydrogen.Which property of hydrogen may be usefuk for this chemical equation if required.
Answer : Hydrogen is a gas at room temperature. Because of it occupying large volume, it is difficult to transport it either by rail or by road. However, by cooling and applying high pressure, gaseous H_2 can be converted into liquid H_2which has much smaller volume and hence, can be transported easily. Thus, the basic property of hydrogen which is useful for hydrogen economy is that it can be converted into a liquid by cooling under high pressure.

85) Would you expect the hydrides of N, O and F to have lower boiling points than the hydrides of their subsequent group members? Give reasons
Answer : No, the boling points of hydrides of N, O and Fare higher than the hydrides of their subsequent group members. On the basis of molecular masses of NH_3, H_2O and HF, their boling point are expected to be lower than those of the subsequent group member hydrides. But because of their high electronegativity they aggregates together through hydrogen bonding and thus, have high boiling point.

86) Give reasons.
(i) Lakes freeze from top towards bottom
Answer : Density of ice is less than that of liquid water. During sereve winter, the temperature of surface water keeps on decreasing and ultimately it freezes.
Thus, the ice layer at lower temperature floats over the water below it.Due to this, freezing of water into ice takes place continously from top towards bottom.

87) Give reasons.
Ice floats on water
Answer : Density of ice is less than that of liquid water, so it floats over water.

88) Do you expext the carbon hydrides of the type (C_nH_{2n+2}) to acts as Lewis acid or base? Justify your answer
Carbon contains four valence electrons
Lewis acids are electron deficient species and Lewis bases are electron rich species.
Answer : Carbon hydrides of the type (C_nH_{2n+2}) are electron-precise hydrides. They have exact number of electrons required to foirm covalent bonds. Therfore, they neither act as Lewis acids nor Lewis bases.

89) How do you expect the metallic hydrides to be useful for hydrogen storage? Explain
Answer : In metallic hydrides, hydrogen is absorbed as H-atoms. This property of adsorption of hydrgen on transition metals is widely used as its storage media. Some of the metals such as Pd, Pt can accommodate a very large volume of hydrogen storgae and as a source of energy. Metalic hydrides on heating decompose to form hydrogen and very finely divided metal

90) Among NH_3, H_2O and HF, which would you expect of have highest magnitude of hydrogen bonding and why?
Answer : Since, electronegitivity of F is the highest, therfore, magnitude of the possitive charge on hydrogen and negative charge on F is the highest in HF and hence, electrostatic attraction of the H-bonding is the strongest in H-F.

91) Complete the following reactions.
$CuO(s) + H_2(g) \rightarrow$
Answer : $CuO(s) + H_2(g) \rightarrow H_2O(g) + Cu(s)$

92) Complete the following reactions.
$CH_4(g) + H_2O(g) \rightarrow$
Answer : $CH_4(g) + H_2O(g) \overset{1270K}{\underset{Ni}{\rightarrow}} CO(g) + 3H_2(g)$

93) Describe the bulk preparation of hydrogen by electrolytic method. What is the role of an electrolyte in this process?
Answer : Electrolysis of acidified water using platinum electrodes gives

$hydrogen. \quad 2H_2O(l) \underset{Trace\ of\ acid/base}{\overset{Electrolysis}{\rightarrow}} 2H_2(g) + O_2(g)$

94) How does the atomic hydrogen or oxy-hydrogen torch function for cutting and welding purpose?Explain.

Answer : Atomic hydrogen atoms, produced by dissociation of dihydrogen with the help of an electric arc, are allowed to recombine on the surface to be welded. In this process, a large amount of energy is liberated which is used to generate a temperature of 4000 K for cutting and welding purpose in the form of atomic hydrogen or oxy-hydrogen torches.

95) What is the difference between the terms 'hydrolysis' and 'hydration'?

Answer : Interaction of H^+ and OH^- ions of H_2O with the anion and the cation of a salt respectively to yield the original acid and the original base is called hydrolysis.

eg. $Na2 \quad CO3 + 2H2O \rightarrow 2NaOH + H_2CO_3$

$Salt \qquad\qquad Base \qquad\qquad Acid$

Hydration, on the other hand, means addition of H_2O to ions or moleclues to form hydrated ions or hydrated.

$KCl(s) + H_2O(l) \rightarrow K^+(aq) + cl^-(aq)$

$Salt$

$CuSo_4(s) + 5H_2O(l) \rightarrow \quad CuSO_4.5H_2O(s)$

$Colourless \qquad\qquad\qquad\qquad Blue$

96) What properties of water make it useful as a solvent? What type of compounds can it disolve

Answer : High dipole moment and high dielectric constant, these are the two properties of water which make it useful as a solvent
It can dissolve both ionic compounds as well as those covalent compounds which can form hydrogen bonds with water such as ethyl alchol, sugar, glucose etc.

97) What properties of water make it useful as a solvent? What type of compounds can it hydrolyse

Answer : Water can hydrolyse many metallic and non-metalic oxides, hydrides, phosphides and other salts, e.g.

$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(aq)$

98) Consider the reaction of water with F_2 and suggest, in terms of oxidation and reduction, which species are oxidised/reduced?
Fluorine being more electronegative removes oxygen from water and itself gets reduced to fluoride ion.

Answer : $2F_2(g) + 2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4F^-(aq)$

$Oxidant \quad reductant$

$3F_2(g) + 3H_2O(l) \rightarrow O_3(g) + 6H^+(aq) + 6F^-(aq)$

$Oxidant \quad reductant$

In these reactions, water acts as reducing agent and hence, itself gets oxidised to either oxygen or ozone. Fluorine acts as an oxidising agent and hence, itself reduced to F^- ion.

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99) What is meant by 'demineralised water' and how cn it be obtained?

Answer : Water which is free from all soulbe minerals salts is called determinalised water is obtained by passing water successively through a cation exchange and an anion exchange resins. In cation exchanger, Ca^{2+}, Mg^{2+}, Na^+ and other cations present in water are removed by exchanging them with H^+ ions while in anion exchanger, Cl^-, HCO_3^-, sO^{2-}_4 , etc., present in water are removed by exchanging them with OH^- ions.

$$H^+ \quad + \quad OH^- \quad \rightarrow H_2O$$

$Released \ in \ cation \ exchanger \qquad Released \ in \ anion \ exchanger$

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100) Calculate the concentration in g/L of a 20 volume H_2O_2 solution

Answer : 59.91 g/L

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101) What is hydrolith? How is it prepared?

Answer : Calcium hydirade is also known as hydrolith. It is obtained by treating calcium with hydrogen

$$Ca + H_2 \xrightarrow{\Delta} CaH_2(hydrolith)$$

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102) Knowing the properties of H_2O and D_2O, do you think that D_2O can be used for drinking purposes?

Answer : No, because heavy water is injurious to human beings as rate of biochemical reactions decreases in heavy water.

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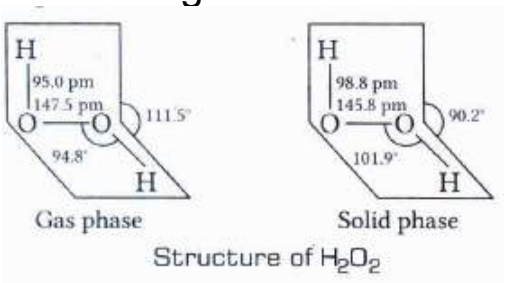
103) Explain why HCl is a gas and HF a liquid?

Answer : F is a smaller and more electronegative than Cl, so it forms stronger H-bonds as compared to Cl. That's why HF is liquid and Hcl is a gas.

104) Compare the structure of H_2O and H_2O_2.

Answer : In water, oxygen is sp^3 -hybridised.Due to stronger lone pair-lone pair repulsions than bond pair-bond pair repulsion, the HOH bond angle decreases from 109.5^0 to 104.5^0. Thus, water is a bent molecule as shown in figure.

It is a highly polar molecule. Hydrogen peroxide has a non-planar structure. Dipole moment value of H_2O_2 suggests that all the four atoms in H_2O_2 do not lie in a plane. The structure of H_2O_2 in gas phase, can be compared with a book open at angle 111.5^0.The H-O-O bind angle is 94.8^0.



Structure of H_2O_2

105) Justify the position of hydrogen in the periodic table on the basis of its electronic configuration.

Answer : Hydrogen has been placed at the top of the alkali metal in group, but it is not a member of the group.
Its position is not justified properly because of its electronic configuration as ($1S^1$). It can be placed with alkali metals because it also has similar configuration (ns^1) as alkali metals.
However, it can also be placed along with halogen in group 17 since just like halogen it can acquire inert gas configuration by accepting one electron.

106) Write the names of isotopes of hydrogen. What is the mass ratio of these isotopes?

Answer : Protium - ${}_1^1H$
Deuterium - ${}_1^2H$ or D
Tritium - ${}_1^3H$ or T
Mass ratio of Protium: Deuterium: Tritium
= 1: 2: 3

107) How can the production of dihydrogen obtained from 'Coal gasification' be increased?

Answer : The production of dihydrogen in coal gasification can be increased by reacting CO(g) present in syngas with steam in the presence of iron chromate catalysts.

$$CO\,(g) + H_2O\,(g) \overset{\underset{(catalyst)}{FeCrO}}{\underset{673K}{\longrightarrow}} CO_2\,(g) + H_2\,(g)$$

With the removal of CO_2 the reaction shifts in the forward direction and thus, the production of dihydrogen will be increased.

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108) What characteristics do you expect from an electron-deficient hydride with respect to its structure and chemical reaction?

Answer : It is expected to be a Lewis acid. They are likely to accept electrons to become stable. They can form coordinate bond with electron rich compound.

$$\underset{Sod.}{2NaH(s)} + B_2H_6(g) \overset{Diethyl\ ether}{\longrightarrow} \underset{borohydride}{2Na^+[BH_4]^-}\,(s)$$

---

109) Do you expect the carbon hydride of type C_nH_{2n+2} to act as 'Lewis' acid or base? Justify your answer.

Answer : Carbon hydrides of the type $C_n\,H_{2n+2}$ are electron precise hydrides. Because they have atom with exact number of electrons to form covalent bonds.

Thus, they do not behave as Lewis acid or base. Since they have no tendency to accept or lose electrons.

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110) What do you understand by the term 'non-stoichiometric hydrides'? Do you expect this type of hydrides to be formed by alkali metals? Justify your answer.

Answer : Those hydrides which do not have fix composition are called non-stoichiometric hydrides, and the composition varies with temperature and pressure. This type of hydrides are formed by d and f block elements. They cannot be formed by alkali metals because alkali metal hydrides form ionic hydrides.

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111) Saline hydrides are known to react with water violently producing fire. Can CO_2, a well known fire extinguisher, be used in this case? Explain.

Answer : No. Because if saline hydrides react with water the reaction will be highly exothermic thus the hydrogen evolved in this case can catch fire. CO_2 cannot be used as fire extinguisher because CO_2 will get absorbed in alkali metal hydroxides.

112) Arrange the following:
(i) CaH_2, BeH_2 and TiH_2 in order of increasing electrical conductance.
(ii) LiH, NaH and CsH in order of increasing ionic character.
(iii) H - H, D - D and F - F in order of increasing bond dissociation enthalpy.
(iv) NaH, MgH_2 and H_2O in order of increasing reducing property.
Answer : (i) $BeH_2 < TiH_2 < CaH_2$
(ii) LiH < NaH < CsH
(iii) F-F < H-H < D-D
(iv) $H_2O < MgH_2 <$ NaH

113) What do you understand by the term 'auto-protolysis' of water? what is its significance?
Answer : Autoprotolysis means self-ionisation of water. It may be represented as

$$\underset{(oxidant)}{2F_2(g)} + \underset{(Reductant)}{2H_2O} \longrightarrow O_2(g) + 4H^+(aq) + 4F^-(aq)$$

Due to auto-protalysis water is amphoteric in nature. i.e., it can act as an acid as well as base.

114) What is Zeolite?
Answer : It is hydrated sodium aluminium silicate, $Na_2Al_2Si_2O_{8.x}H_2O$.

115) What is water gas? How is it prepared?
Answer : Mixture of CO and H_2 in the ratio of 1: 1 is called water gas.
It is prepared by passing steam over red hot coke.

$$C(s) + H_2O(g) \xrightarrow{1270K} CO(g) + H_2(g)$$

116) Give an example of an ionic hydride and a covalent hydride:
Answer : NaH is an ionic hydride and B_2H_6 is a covalent hydride.

117) What is meant by hard water?
Answer : Water which does not produce lathers with soap is known as hard water. Hardness is due to the presence of bicarbonates, sulphates and chlorides of Ca^{2+} and Mg^{2+}.

118) Which gas is evolved when Mg_3N_2 (Magnesium nitride) is treated with H_2O? Give chemical reaction.
Answer : NH_3 gas is evolved

$$Mg_3N_2 + 6H_2O \longrightarrow 3Mg(OH)_2 + 2NH_3$$

119) Which isotope of hydrogen does not have neutron?
Answer : ${}_1^1H$ does not have neutron. It is called protium.

120) Which type of hydrides are generally non-stoichiometric in nature?
Answer : Interstitial hydrides are non-stoichiometric in nature.

121) What is the cause of bleaching action of H_2O_2?
Answer : H_2O_2 (l) $\longrightarrow$ H_2O (l) + O(g)
Nascent oxygen produced is responsible for bleaching action.

122) What is the use of hydrogen in the manufacture of Vanaspati Ghee?
Answer : H_2 is used as reducing agent to convert vegetable oil into vegetable ghee.

123) Calculate the normality of a solution of 1 L of hydrogen peroxide labelled 30 volumes.
Answer : 5.28 N

124) Calculate the amount of hydrogen peroxide present in 10 mL of its solution labelled as 20 volumes.
Answer : 0.599 g

125) Give reasons why hydrogen resembles alkali metals?
Answer : Hydrogen resembles alkali metals, i.e. Li, Na, K, Rb, Cs and Fr of group I of the periodic table in the following respects.
(i) Like alkali metals, hydrogen also contain one electron in its outermost (valence) shell and exhibit +1 oxidation state.
(ii) Like alkali metals, hydrogen also loses its only electron to form hydrogen ion, i.e.H^+ (proton).
(iii) Like alkali metals, hydrogen combines with electronegative elements (non-metals) such as oxygen, halogens and sulphides respectively.
(iv) Like alkali metals, hydrogen also acts as a strong reducing agent.

126) Atomic hydrogen combine with almost all elements but molecular hydrogen does not.Explain.
Answer : Atomic hydrogen is highly unstable.Since, the electronic configuration of atomic hydrogen is $1s^1$, it needs one more electron to complete its configuration and gain stability.Therefore, atomic hydrogen is very reactive and combines with almost all the elements. It, however, reacts in three different ways i.e.
(i) by loss of its single electron to form H^+
(ii) by gain of one electron to form H^- and
(iii) by sharing its electron with other atoms to form single covalent bonds.
In contrast, the bond dissociation energy form H-H bond is very high (435.88 $kJmol^{-1}$). As a result, molecular hydrogen is almost inert at room temperature and hence reacts only with a few elements.

127) Comment on the reactions of dihydrogen with chlorine

Answer : Reaction with chlorine when dihydrogen combines with chlorine, it reduces it to the chloride ion (Cl^-) and itself get oxidised to H+ ion, to give hydrogen chloride, a covalent compound formed by sharing of a pair of electrons between H and Cl.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

128) Comment on the reactions of dihydrogen with sodium

Answer : Reaction with sodium When dihydrogen reacts with sodium, it oxidises the sodium to sodium ion (Na^+) (which loses its one electron) and itself gets reduced to H^- (hydride ion).
The electron lost by sodium is accepted by the hydrogen, thus an ionic compound sodium hydride (NaH) is obtained due to transfer of electron from Na to H.

$$2Na(s) + H_2(g) \rightarrow 2NaH(s)$$

129) Sodium forms a crystalline ionic solid with dihydrogen. The solid is 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?

Answer : Sodium reacts with dihydrogen to form sodium hydride which is a crystalline ionic solid.

$$2Na + H_2 \rightarrow 2Na^+H^-$$

It reacts violently with water to produce H_2 gas

$$2NaH + 2H_2O \rightarrow 2NaOH + 2H_2\uparrow$$

In solid state NaH does not conduct electricity. When electrolysed in its molten state, it gives H_2 at anode and Na at cathode

130) Describe the usefulness of water in biosphere and biological system.

Answer : A major part of all living organisms is made up of water. Human body has about 65% water and some plants have as much as 95% water. It is an essential compound for the survial of all life forms. Iin comparison to other liquids, water has a high specific heat, thermal conductivity, surface tension, dipole moment , dielectric constant etc. These properties allow water to play a key role in biosphere.The high heat of vaporisation and heat capacity are responsible for moderation of the climate any body temprature of living beings. It is an excellent solvent for transportation of minerals and other nutrients for plant and animal metabolism. Water is also required for photosynthesis in plants which releases O_2 into the atmosphere.

$$6CO_2(g) + 6H_2O(l) \xrightarrow[(hv,chlorophyll)]{photosynthesis} C_6H_{12}O_6 + 60_2$$

131) If 1kg of a hard water sample contains 12 mg of $CaCl_2$ and 12mg of $MgCl_2$, then what will be the total hardness in terms of $CaCO_3$ Per 10^6 parts by mass of water sample.

Answer : Given $CaCl_2$ present in 10^3 g=12 mg

$CaCl_2$ Present in 10^6g= 12g

∴ $MgCl_2$ present in 10^6g = 12g

Now, 1 mol (111g) $CaCl_2$=1mol (100g) $CaCo_3$

∴ 12g $CaCl_2$ = $\frac{100\times12}{111} = 10.81g$

Similarly 1 mol (95g) $MgCl_2$= 1 mol (100g)$CaCo_3$

∴ 12g$MgCl_2$ $\frac{100\times12}{95} = 12.63g$

Total hardness in terms of $CaCO_3$= (10.81+12.63)

= 23.44 ppm

132) Write equations for the reactions

Peroxydisulphuric acid is hydrolysed.

Answer :

$$\underset{Peroxydisulphuric\ \ acid}{HO_3SOOSO_3H}\ (aq) \overset{H_2O}{\rightarrow} 2HSO_4^-(aq) + 2H^+(aq) + \underset{Hydrogen\ \ peroxide}{H_2O_2(aq)}$$

133) Rohan heard that instructions were given to the laboratory attendent to store 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.

Write the name of this compound

Answer : The name of the compound is hydrogen peroxide, H_2O_2It acts as an oxidising agent as well as reducing agent in both acidic and basic nedium.

134) Rohan heard that instructions were given to the laboratory attendent to store 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.

Explain why such precautions are taken for storing this chemical.

Answer : H_2O_2decomposes slowly on exposure to light and dust particles. In the presence of metal surfaces or traces of alkali present in glass containers, the traces of alkali present in glass containers, the decomposition of $H_2O_2$is catalysed. It is, therefore, stored in wax lined glass or plastic vessels in dark. Urea is added as a negative catalyst or stabiliser to check its decomposition.

$$2H_2O_2(l) \overset{hv}{\rightarrow} 2H_2O(l) + O_2(g)$$

135) Write chemical reactions to justify that hydrogen peroxide can function as an oxidising as well as reducing agent.

Answer : H_2O_2 can act as an oxidising as well as a reducing agent both in acidic and basic medium (i) Oxidising agent in acidic medium

$2Fe^{2+}(aq) + 2H^+(aq) + H_2O_2(aq) \rightarrow 2Fe^{3+}(aq) + 2H_2O(l)$

Here, Fe^{2+} get oxidised to Fe^{3+}

(ii) Oxidising agent in acidic medium

$Mn^{2+}(aq) + 6H^+(aq) + 5H_2O(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 5O_2(g)$

Here, Mn^{2+} is oxidised to Mn^{4+}

(iii) Reducing agent in acidic medium

$2MnO_4^-(aq) + 6H^+(aq) + 5H_2O_2(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 5O_2(g)$

Here, oxidation state of Mn is reduced from +7 to +2

(iv)Reducing agent in basic medium

$I_2(s) + H_2O_2(aq) + 2OH^-(aq) \rightarrow 2I^-(aq) + 2H_2O(l) + O_2(g)$

her,oxidation state of I is reduced from zero to -1.

---

136) Calculate the volume strength of a 3% solution of H_2O_2

Answer : 100 mL of H_2O_2 solution contains H_2O_2=3g

$\therefore$ 1000 mL of H_2O_2 solution will contains $H_2O_2 = \frac{3}{100} X 1000 = 30g$

Consider the chemical equation, $\underset{2X34=68g}{2H_2O_2} \rightarrow \underset{22.7\ L\ at\ NTP}{2H_2O + O_2}$

Now 68 g of H_2O_2 gives O_2 at NTP=22.7 L

$\therefore$ 30 g of H_2O_2 will give O_2 at NTP= $\frac{22.7}{68} X 30 \approx 10.014$

But 30g of H_2O_2 are present in 1000 mL of H_2O_2

Hence, 1000mL of H_2O_2 solution gives O_2 at NTP

$= \frac{10014}{1000} = 10.01mL$

Hence, the volume strength of 3% H_2O_2 solution =10.01

---

137) What are the advantages in using hydrogen as a fuel?

Answer : Hydrogen as a fuel has the following advantages.

(i) It has calorific value.

(ii) During combustion, it does not produce smoke or any unpleasant fumes.

(iii) It leaves no ash after burning. The only product of combustion is water.

(iv) It can be used in a fuel cell to generate electricity.

(v) It can be used in the internal combustion engines with slight modifications.

(vi) It does not pollute the air because no pollutant is produced during its combustion.

138) Why is hydrated barium peroxide used in the preparation of hydrogen peroxide instead of anhydrous barium peroxide?

Answer : Anhydrous BaO_2 is not used because the $BaSO_4$ formed during the reaction forms a protective layer around unreacted BaO_2 and the reaction stops after sometime.

139) Comment on the reactions of dihydrogen with copper(II) oxide

Answer : **Reaction with copper (II) oxide** Dihydrogen reduces the copper (II) oxide to metallic copper and itself gets oxidised to water (H_2O).

$Cu_2O(s) + H_2(g) \rightarrow 2Cu(s) + H_2O(l)$

In Cu_2O the oxidation state of Cu is +2 but in Cu it is present in 0 oxidation state, i.e. dihydrogen reduces Cu from +2 to 0 state.

140) How is dihydrogen obtained from dilute sulphuric acid

Answer : When metal reacts with dilute sulphuric acid, hydrogen is obtained along with metal salts.

$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$

141) How is dihydrogen obtained from sodium hydroxide

Answer : When zinc reacts with sodium hydroxide, sodium zincate is formed and hydrogen gas is evolved.

$Zn(s) + 2NaOH(aq) \rightarrow Na_2ZnO_2(aq) + H_2(g)$

142) How is dihydrogen obtained from water

Answer : When acidified water is electrolysed using platinum electrodes, hydrogen gas is evolved at cathode.

$H_2O \rightarrow H^+(aq) + OH^-(aq)$

$At \quad cathode \quad 2H^+ + 2e^- \rightarrow 2H \rightarrow H_2$

$At \quad anode \quad 4OH^- \rightarrow 4OH + 4e^- \rightarrow 2H_2O + O_2$

143) Phosphoric acid is preferred over sulphuric acid in preparing hydrogen peroxide from peroxides. Why?

Answer : H_2SO_4 acts as a catalyst for decomposition of H_2O_2. Therefore, some weaker acids such as H_3PO_4, H_2CO_3 are preferred over H_2SO_4 for preparing H_2O_2 from peroxides.

$3BaO_2 + 2H_3PO_4 \rightarrow \underset{Insoluble}{Ba_3(PO_4)_2} + 3H_2O_2$

144) Hydrogen peroxide acts both as an oxidising agent as well as a reducing agent in alkaline solution towards certain first row transition metal ions. Illustrate both these properties of H_2O_2using chemical equations.

Answer : Oxidising agent

$2Cr(OH)_3 + 4NaOH + 3H_2O_2 \rightarrow 2Na_2CrO_4 + 8H_2O$

Here,Cr^{3+} gets oxidised to Cr^{6+}

Reducing agent

$2K_3[Fe(CN)_6] + 2KOH + H_2O_2 \rightarrow 2K_4[Fe(CN)_6] + 2H_2O + O_2$

Here, Fe^{3+} gets reduced to Fe^{2+}

---

145) Name the products obtained when hydrogen reacts under suitable conditions with nitrogen

Answer : $3H_2(g) + N_2(g) \underset{673K,200atm}{\overset{Fe,Mo}{\rightleftharpoons}} \underset{Ammonia}{2NH_3\ (g)}$

---

146) Name the products obtained when hydrogen reacts under suitable conditions with carbon monoxide

Answer : $CO(g) + 2H_2(g) \underset{ZnO,CrO_3}{\overset{700k,200atm}{\rightarrow}} \underset{Methanol\ \ or\ \ methyl\ \ alcohol}{CH_3OH(l)}$

---

147) Name the products obtained when hydrogen reacts under suitable conditions with lead oxide

Answer : $PbO(s) + H_2(g) \rightarrow \underset{Lead}{Pb(s)} + H_2O(l)$

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148) Do you expect different products in solution when aluminium (III) chloride and pottassium chloride are treated separately with
(i) normal water
(ii)acidified water, and
(iii) alkaline water? Write equations whatever necessary.

Answer : $AlCl_3$ is a salt of weak base, $Al(OH)_3$ and a strong acid, HCl. Therfore , in normal water, it undergoes hydrolysis.

$$Alcl_3(s) + 3H_2O(l) \rightarrow Al(OH)_3(s) + 3H^+(aq) + 3Cl^-(aq)$$

Its aqueous solution is acidic in nature. In acidified water, H^+ ions reacts with $Al(OH)_3$ to produce Al^3 (aq) ions and Al^{3+}(aq) and C^{-1} (aq) ions.

In alkaline water $AlCl_3$ yields following products

$$Alcl_3(s) + 3H_2O(l) \rightarrow Al(OH)_3(s) + 3H^+(aq) + 3Cl^-(aq)$$

$$Al[OH]_4^- \rightarrow AlO_2^-(aq) + 2H_2O(l)$$

KCl is the salt of a strong acid and a strong base, It does not undergo hydrolysis in normal water. It only dissociates in eater to give K^+ (aq)+Cl^-(aq)

Aqueous solution of KCl is neutral. Hence, in acidifield water or in alkaline water, the ions do not react further.

149) If a given sample of water has degree of hardness equal to 46ppm. If entire hardness is due to $MgSO_4$, How much $MgSO_4$ is present per kg of water?

Answer : Given, degree of hardness = 46ppm

Which menas that 10^6 g of sample require 46g of $CaCo_3$

$CaCO_3$ present in 1000g of water = $\frac{46\times1000}{10^6}$

= 46X 10^{-3}g

1 mol (or 100g) of $CaCO_3$= 1 mol (or 120g) of $MgSO_4$

46X 10^{-3} g of $CaCo_3$ = $\frac{120\times46\times10^{-3}}{100}$ g

= 0.055 g or 55 mg

150) Describe the industrial applications of hydrogen dependent on the heat liberated when its atoms are made to combine on the surface of a metal.

Answer : Due to this property hydrogen is used in atomic hydrogen welding/cutting torch.

151) Describe the industrial applications of hydrogen dependent on its effect on the unsaturated organic systems in the presence of a catalyst

Answer : Due to this property hydrogen is used for the manufacture of vanaspati ghee from edible oils such as cotton-seed oil, soyabean oil, corn oil etc.

$$unsaturated \quad oil \quad + \quad H_2(g) \overset{Ni}{\underset{catalyst}{\longrightarrow}} Vanaspati \quad ghee$$

152) Due to this property hydrogen is used for the manufacture of vanaspati ghee from edible oils such as cotton-seed oil, soyabean oil, corn oil etc.

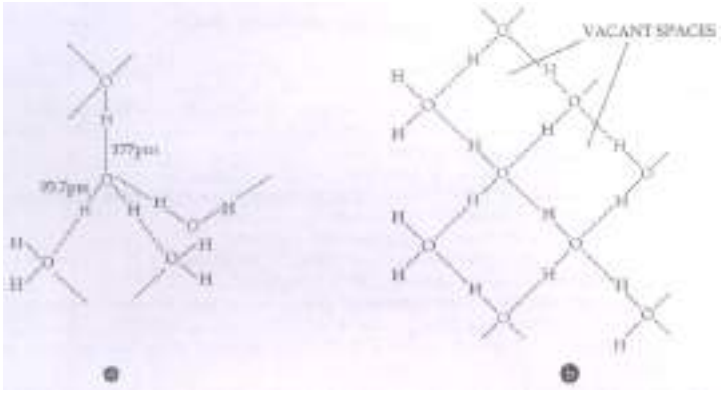
Answer : Due to this property dihydrogen is used for the manufacture of ammonia (Haber's process)

$$N_2(g) + 3H_2(g) \overset{673K,\ 200\ atm}{\underset{Fe,Mo}{\rightleftharpoons}} 2NH_3(g)$$

153) What do you understand by (i) Electron-deficient (ii) Electron-precise (iii) Electron-rich compounds of hydrogen? Provide justification with suitable examples.

Answer : (i) **Electron deficient hydrides:** Compounds in which central atom has incomplete octet, are called electron deficient hydrides. For example, BeH_2, BH_3 are electron deficient hydrides.
(ii) **Electron precise hydrides:** Those compounds in which exact number of electrons are present in central atom or the central atom contains complete octet are called precise hydrides e.g., CH_4, SiH_4, GeH_4 etc. are precise hydrides.
(iii) **Electron rich hydrides:** Those compounds in which central atom has one or more lone pair of excess electrons are called electron rich hydrides" e.g., NH_3, H_2O.

154) Describe the structure of common form of ice.



(a) Structure of water in the liquid state
(b) Tetrahedral arrangement of oxygen atoms in ice.

Answer : Ice crystallizes in the normal hexagonal form. However, at very low temperatures it condenses in cubic form. In the normal hexagonal ice each oxygen atom is tetrahedrally surrounded by four other hydrogen atoms.

155) Discuss the principle and method of softening of hard water by synthetic ion-exchange resins.

Answer : Cation exchange resins have large organic molecule with SO_3H group which are insoluble in water. Ion exchange resin (RSO_3H) is changed to RNa on treatment with NaCl. The resin exchange Na" ions with Ca^{2+} and Mg^{2+} ions present in hard water and make it soft.

$$2RNa(s) + M^{2+}(aq) \longrightarrow R_2M(s) + 2Na^{+}(aq)$$

where, M = Mg, Ca.

The resins can be regenerated by adding aqueous NaCl solution.

156) Write chemical reaction to show the amphoteric nature of water.

Answer : Water is amphoteric in nature because it acts as an acid

$$\underset{Base\ \ 1}{H_2O(l)} + \underset{Acid\ \ 2}{H_2S(aq)} \longrightarrow \underset{Acid\ \ 1}{H_3O^{+}(aq)} + \underset{Base\ \ 2}{HS^{-}(aq)}$$

$$\underset{Acid\ \ 1}{H_2O(l)} + \underset{Base\ \ 2}{NH_3(aq)} \longrightarrow \underset{Acid\ \ 2}{NH_4^{+}(aq)} + \underset{Base\ \ 1}{OH^{-}(aq)}$$

157) Show how H_2O functions both as a reducing and as an oxidising agent.

Answer : As oxidising agent.

$$2I^{-} + H_2O_2 + 2H^{+} \longrightarrow I_2 + 2H_2O$$

As reducing agent.

$$H_2O_2 + Ag_2O \longrightarrow 2Ag + H_2O + O_2$$

158) What are interstitial hydrides? Give two examples.

Answer : Many transition and inner-transition metals absorb hydrogen into the interstices of their lattices to yield metal like hydrides also called the interstitial hydrides. These hydrides are generally non-stoichiometric and their composition vary with temperature and pressure.

For example, $TiH_{1.73}$, $CeH_{2.7}$

159) The aqueous solution of H_2O_2 is acidic in nature. Explain with the help of example. Name two substances which catalyse the decomposition reaction of H_2O_2.

Answer : The aqueous solution of H_2O_2 is weakly acidic in nature.

$$H_2O_2 + H_2O \rightleftharpoons H_3O^{+} + HO_2^{-}$$

It gives two types of salts with alkalies, peroxides and hydroperoxides.

$$2NaOH + H_2O_2 \longrightarrow NaO_2 + 2H_2O$$

$$NaOH + H_2O_2 \longrightarrow \underset{\substack{Sodium\\ hydroperoxide}}{NaOH_2} + H_2O$$

MnO_2 and finely divided metals like Pt and Fe catalyse the decomposition of H_2O_2.

160) Complete the following reactions:

(i) $SiCl_4 + LiAlH_4 \longrightarrow$

(ii) $Mg_3N_2 + H_2O \longrightarrow$

(iii) $NaH + CO \longrightarrow$

Answer : (i) $SiH_4 + LiAlH_4 \longrightarrow SiH_4 + LiCl + AlCl_3$

(ii) $Mg_3N_2 + 6H_2O \longrightarrow 3Mg(OH)_2 + 2NH_3$

(iii) $NaH + 2CO \longrightarrow HCOONa + C$

---

161) Explain the following:

(i) Temporary hardness can remove by boiling

(ii) Soft water lathers with soap but hard water not.

Answer : (i) On boiling, the bicarbonates of calcium and magnesium decompose to insoluble carbonate which can be removed by filteration.

$$Ca(HCO_3)_2 \xrightarrow{Boil} CaCO_3\downarrow + H_2O + CO_2\uparrow$$

$$Mg(HCO_3)_2 \xrightarrow{Boil} MgCO_3\downarrow + H_2O + ppt + CO_2\uparrow$$

(ii) Because of the presence of Ca^{2+} and Mg^{2+} ions in hard water which exchange with Na^+ ions of the soap to form corresponding calcium and magnesium salts that form insoluble ppt.

$$\underset{Soap}{RCOONa} + \underset{Hardwater}{Ca^{2+}} \longrightarrow \underset{ppt.}{(RCOO)_2Ca} + 2Na^+$$

$$\underset{Soap}{RCOONa} + \underset{(Hardwater)}{Mg^{2+}} \longrightarrow \underset{ppt.}{(RCOO)_2} + 2Na^+$$

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162) (a) How is dihydrogen preparedfrom water by using a reducing agent?

(b) Give the industrial use of dihydrogen which depends upon heat liberated when it burns.

Answer : (a) Dihydrogen is prepared from water by the action of alkali metals like Na and K which is a strong reducing agent.

$2Na + 2H_2O \longrightarrow 2NaOH + H_2$

$2K + 2H_2O \longrightarrow 2KOH + H_2$

(b) For welding purposes.

$$H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(g) + heat$$

---

163) Water molecule is bent, not linear. Explain?

Answer : In water molecule, O is sp^3 hybridized. Due to stronger lone pair-lone pair repulsion than bond pair-bond pair repulsions, the HOH bond angle decreases from 109.5° to 104.5°. Thus water is bent molecule.

164) Account for the following:
(i) dihydrogen gas is not preferred in balloons.
(ii) Cone. H_2SO_4 cannot be used for drying H_2.
Answer : (i) Dihydrogen is the lightest gas but due to its highly combustible nature, it is not preferred in balloons.
(ii) Cone. H_2SO_4 on absorbing H_2O forms moist H_2 produces so much heat that hydrogen catches fires.

165) Account for the following:
(a) Can phosphorus with electronic configuration $3s^2\ 3p^3$ form PH_3?
(b) Water is responsible for moderation of body temperature. How?
(c) Hard water is not suitable for boilers as well as for laundry?
Answer : (a) High $\Delta_a H$ value of dihydrogen and less negative value of $\Delta_{eg} H$ of hydrogen do not favour to exhibit highest oxidation state of P and consequently the formation of PH_5, although P exhibit +3, +5 oxidation states.
(b) Because of high heat of vapourisation and high heat capacity.
(c) Hard water form precipitate with soap and deposition of salts in the form of scales.

166) A colourless liquid A contains H and O elements only. It decomposes slowly one 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 the light.
Answer : Since, a colourless liquid A contains only H and O and decomposes slowly on exposure to light but is stabilised by additions of urea, therefore, liquid A may be hydrogen peroxide.
(ii) $2H_2O_2\,(l) \xrightarrow{hv} 2H_2O\,(l) + O_2\,(g)$

167) 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 its reaction with Al_2Cl_6
Answer : It is LiH because it has significant covalent character due to the smallest alkali metal Li. LiH is very stable. It is almost unreactive towards oxygen and chlorine.
It reacts with Al_2Cl_6 to form lithium aluminium hydride.
$8LiH + Al_2Cl_6 \longrightarrow 2LiAlH_4 + 6LiCl$

168) If 5.0 cm^3 of H_2O_2 liberates 0.508 g of iodine from an acidified potassium iodide solution, then calculate the strength of H_2O_2 in term of volume strength at STP.

Answer : The reaction of H_2O_2 with acidified KI Solution.

$$2KI + H_2SO_4 + H_2O_2 \longrightarrow K_2SO_4 + I_2 + 2H_2O$$

$$34 \quad g \qquad\qquad 254 \quad g$$

$$5 \quad cm^3 \qquad\qquad 0.508 \quad g$$

$254 \quad g \quad af \quad I_2 \quad is \quad liberated \quad by \quad H_2O_2 = 34g$

$0.508 \quad g \quad I_2 \quad is \quad liberated \quad by \quad H_2O_2 = \frac{34}{254} \times 0.508 = 0.068g$

$Now, 5cm^3 \quad of \quad H_2O_2 \quad contains = 0.068g \quad of \quad I_2$

$then, 1cm^3 \quad of \quad H_2O_2 \quad contains = \frac{0.068}{5} = 0.0136g \quad of \quad I_2$

$now, \quad 2H_2O_2 \longrightarrow 2H_2O + O_2$

$$68g \qquad\qquad 22400mL \quad at \quad STP$$

$68g \quad of \quad H_2O_2 \quad gives \quad 22400mL \quad O_2 \quad at \quad STP$

$1cm^3 \quad or \quad 0.0136g \quad of \quad H_2O_2 \quad give \quad O_2 \quad at \quad STP$

$= \frac{22400}{68} \times 0.0136$

$= 4.48mL \quad of \quad STP$

$\therefore \quad Strength \quad of \quad H_2O_2 = 4.48 \quad volumes$

169) 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 auto ionisation?

Answer : The first element of the periodic table is H and its molecular form is dihydrogen (H_2). When dihydrogen reacts with dioxygen, water is formed.

Water is a liquid at room temperature. When liquid water freezes, it expands to form ice. In other words, the density of ice is lower than that of liquid water and hence, ice floats over water.

Water is amphoteric in nature, i.e. it acts as an acid in presence of strong bases and as a base in the presence of strong acids.

$$\underset{Acid_1}{H_2O\,(l)} + \underset{Base_2}{NH_3\,(aq)} \longrightarrow \underset{Acid_2}{NH_4^+\,(aq)} + \underset{Base_1}{OH^-\,(aq)}$$

$$\underset{Base_1}{H_2O\,(l)} + \underset{Acid_2}{H_2S\,(aq)} \longrightarrow \underset{Acid_1}{H_3O^+\,(aq)} + \underset{Base_2}{HS^-\,(aq)}$$

Due to amphoteric character, water undergoes self-ionisation as shown below.

$$\underset{Acid_1}{H_2O\,(l)} + \underset{Base_2}{H_2O\,(base)} \rightleftharpoons \underset{(Conjugate\ \ acid)}{\underset{Acid_1}{H_3O^+\,(aq)}} + \underset{(Conjugate\ \ Base)}{\underset{Base_2}{OH^-\,(aq)}}$$

The self-ionisation of water is called autoprotolysis.

170) Statues coated with white lead on long exposure to atmosphere turn black and the original colour can be restored on treatment with H_2O_2 . Why?

Answer : On long exposure to the atmosphere, white lead is converted into black PbS due to the action of H_2S present in the atmosphere. As a result, statues turn black

$$PbO_2 + 2H_2S \longrightarrow PbS + 2H_2O$$

On treatment of these blackened statues with H_2O_2 , the black PbS gets oxidised to white $PbSO_4$ and the colour is restored.

$$PbS + 4H_2O_2 \longrightarrow PbSO_4 + 4H_2O$$

171) At the home of Mr.Kumar, Dalda ghee is generally used. He is suffering from high blood pressure and diabetes. Mr.Sharma, a friend of Mr.Kumar has advised him to change from ghee to vegetable oil like mustard oil.
Dihydrogen (H_2) is used in manufacture of vanaspathi ghee by hydrogenation of polyunsaturated vegetable oils using nickel as a catalyst.

$$\text{Vegetable oil} \xrightarrow[H_2]{Ni} \text{vanaspati ghee}$$

Should we use vanaspathi gheee in our cooking? Give reason
Answer : No, Because it is saturated fat and hence, leads to the formation of cholesterol. Moreover, nickel used for its preparation as a catalyst is carcinogenic.

172) At the home of Mr.Kumar, Dalda ghee is generally used. He is suffering from high blood pressure and diabetes. Mr.Sharma, a friend of Mr.Kumar has advised him to change from ghee to vegetable oil like mustard oil.
Dihydrogen (H_2) is used in the manufacture of vanaspati ghee by hydrogenation of polyunsaturated vegetable oils using nickel as a catalyst.

$$\text{Vegetable oil} \xrightarrow[H_2]{Ni} \text{vanaspati ghee}$$

Should we use vegetable oils for cooking? why?
Answer : Yes, because these are unsaturated fats and hence,good for health. They do not form cholesterol if taken in small quantity.

173) At the home of Mr.Kumar, Dalda ghee is generally used. He is suffering from high blood pressure and diabetes. Mr.Sharma, a friend of Mr.Kumar has advised him to change from ghee to vegetable oil like mustard oil.
Dihydrogen (H_2) is used in the manufacture of vanaspati ghee by hydrogenation of polyunsaturated vegetable oils using nickel as a catalyst.

$$\text{Vegetable oil} \xrightarrow[H_2]{Ni} \text{vanaspati ghee}$$

Why are olive oil, mustard oil, rice bran oil better than others?
Answer : It is because they contain MUFA(monounsaturated fatty acids) and PUFA (polyunsaturated fatty acids) which are good for health.

174) At the home of Mr.Kumar, Dalda ghee is generally used. He is suffering from high blood pressure and diabetes. Mr.Sharma, a friend of Mr.Kumar has advised him to change from ghee to vegetable oil like mustard oil.
Dihydrogen (H_2) is used in the manufacture of vanaspati ghee by hydrogenation of polyunsaturated vegetable oils using nickel as a catalyst.

Vegetable oil $\xrightarrow[H_2]{Ni}$ vanaspati ghee

What values are shown by Mr.Sharma.
Answer : Mr.Sharma is caring, knowledgeable and helping person.

175) In India, there is the shortage of drinking water. Thus, projects like rainwater harvesting are used by Green Park Association to increase the amount of underground water. Rainwater is the almost pure form of water after the heavy shower as it is, in fact, the distilled water. The first shower contains dissolved gases from the atmosphere. Being a good solvent, when it flows on the surface of the earth, it dissolves many salts in the form of hydrogen carbonate, chloride and sulphate in water which make it hard
What is soft water?
Answer : Water free from ca^{2+} and Mg^{2+} ions is called soft water.

176) In India, there is the shortage of drinking water. Thus, projects like rainwater harvesting are used by Green Park Association to increase the amount of underground water. Rainwater is the almost pure form of water after the heavy shower as it is, in fact, the distilled water. The first shower contains dissolved gases from the atmosphere. Being a good solvent, when it flows on the surface of the earth, it dissolves many salts in the form of hydrogen carbonate, chloride and sulphate in water which make it hard
Write the disadvantage of hard water?
Answer : It is unsuitable for laundry as it does not form enough lather with soap
It is harmful to boilers due to deposits of salts in the form of scale which reduces the efficiency of the boilers.

177) In India, there is the shortage of drinking water. Thus, projects like rainwater harvesting are used by Green Park Association to increase the amount of underground water. Rainwater is the almost pure form of water after the heavy shower as it is, in fact, the distilled water. The first shower contains dissolved gases from the atmosphere. Being a good solvent, when it flows on the surface of the earth, it dissolves many salts in the form of hydrogen carbonate, chloride and sulphate in water which make it hard
Can we use hard water for drinking?Give reason.
Answer : Yes, because Ca^{2+} and Mg^{2+} ions are needed for our body but too much hard water is not good as it contains a lot of salts.

178) In India, there is the shortage of drinking water. Thus, projects like rainwater harvesting are used by Green Park Association to increase the amount of underground water. Rainwater is the almost pure form of water after the heavy shower as it is, in fact, the distilled water. The first shower contains dissolved gases from the atmosphere. Being a good solvent, when it flows on the surface of the earth, it dissolves many salts in the form of hydrogen carbonate, chloride and sulphate in water which make it hard
Give the values possessed by the office bearer of Green Park Association?
Answer : The value possessed by the office bearer of Green Park Association are best to use of rainwater, saving water for drinking irrigation, domestic purpose etc.

179) Scientist of UK has designed the cars, working on hydrogen fuel cells instead of petrol engines. Here hydrogen is used as sources of electrical energy i.e. a reaction of hydrogen and oxygen is used to generate electrical energy. It has many advantages over the conventional fossil fuels and electric power generation.
Give two advantages of hydrogen over fossil fuels?
Answer : It produce more energy per unit mass of fuel and does not create pollution.

180) Scientist of UK has designed the cars, working on hydrogen fuel cells instead of petrol engines. Here hydrogen is used as sources of electrical energy i.e. a reaction of hydrogen and oxygen is used to generate electrical energy. It has many advantages over the conventional fossil fuels and electric power generation.
What is the efficiency of the fuel cell as the comparison to other conventional fuels?
Answer : The efficiency of fuel cells is 70% whereas other conventional cells are only 40% efficient.

181) Scientist of UK has designed the cars, working on hydrogen fuel cells instead of petrol engines. Here hydrogen is used as sources of electrical energy i.e. a reaction of hydrogen and oxygen is used to generate electrical energy. It has many advantages over the conventional fossil fuels and electric power generation.
What are the values possessed by scientists of UK?
Answer : The values possessed by UK scientists are control of environmental pollution and generation of new sources of energy which are highly efficient.

182) What do you expect the nature of hydrides is, if formed by elements of atomic numbers 15, 19, 23, 44 with dry dilhydrogen? Compare their behaviour towards water.
Answer : (a) Element with Z=15, belongs to p-block. It forms covalent hydride, PH_3
(b) Element with Z=19 belongs to s-block. It forms ionic or saline hydride, KH
(c) Element5 with Z= 23 belongs to d-block and Vth group elements. It forms interstitial hydride, $VH_{1.6}$. It is non-stoichiometric hydride.
(d) Element with Z=44 belongsto d-block and VIIth group elements . It is ruthinium. It does not form any hydride (hydride gap). Only ionic hydride, KH reacts violently with water producing dihydrogen gas
$KH(s) + H_2O(aq) \rightarrow KOH(aq) + H_2(g)$

183) How would you prepare dihydrogen from water by using a reducing agent?
Answer : sodium metal is a good reducing agent.It reduces water to hydrogen(or dihydrogen)
$2H_2O + 2Na \rightarrow 2NaOH + H_2(g)$

184) How would you prepare dihydrogen from a substance other than water?
Answer : Dihydrogen can be obtained by treating zinc with dilute HCl
$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

185) How would you prepare very pure dihydrogen in the laboratory?

Answer : I.Highly pure Dihydrogen (hydrogen gas) can be prepared by the following methods.
Fairly pure hydrogen can be obtained by treating pure magnesium or pure aluminium with chemically pure H_2SO_4 or HCl diluted with distilled water.The gas is passed over P_2O_5
and is collected by the displacement of mercury.

$$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$$

Highly pure hydrogen gas can be obtained by electrolyzing a warm solution of $Ba(OH)_2$ in a U tube using nickel electrodes.The gas is purified by passing it over heated platinum gauze when traces of oxygen combine with hydrogen forming water.
The gas is then dried by passing it over caustic potash sticks and photash sticks and phophorous pentoxide.Hydrogen is finally absorbed in palladium and the impurities remain unadsorbed.On heating palladium under reduced pressure, pure hydrogen is liberated.

186) What mass of hydrogen peroxide will be present in 2L of a 5M solution?

Answer : Molar mass of $H_2O_2 = 34 \quad gmol^{-1}$
1L of 5M solution of H_2O_2will contain 34x5g H_2O_2
2L of 5M solution of H_2O_2will contain 34x5x2=340gH_2O_2
Mass of H_2O_2present in 2L of 5 molar solution =340g

187) Calculate the mass of oxygen which will be liberated by the decomposition of 200mL of this solution.

Answer : 0.2 L(or 200 mL) of 5M solution will contain

$\frac{340X0.2}{2} = 34gH_2O_2$

$$\underset{2\times34=68g}{2H_2O_2} \rightarrow 2H_2O + \underset{2\times16=32g}{O_2}$$

$\because \quad 68g \quad H_2O_2$ on decomposition will give 32gO_2
$\therefore \quad 34g \quad H_2O_2$ on decomposition will give
$\frac{32\times34}{68} = 16gO_2$

188) Give ion electron equations for the reactions.
Oxidation of ferrous ions to ferric ions by hydrogen peroxide both in acidic and basic media.

Answer : (a) In acidic medium

$$2Fe^{2+}(aq) + 2H^+(aq) + H_2O_2(aq) \rightarrow 2Fe^{3+}(aq) + 2H_2O(l)$$

(b) In basic medium

$$2Fe^{2+}(aq) + H_2O_2(aq) \rightarrow 2Fe^{3+}(aq) + 2OH^-(aq)$$

189) Give ion electron equations for the reactions.
Oxidation of iodide ion to iodine by hydrogen peroxide in acidic medium.

Answer : $2I^- + H_2O_2 + 2H^+ \rightarrow I_2 + 2H_2O$

190) Give ion electron equations for the reactions.
Oxidation of ferrocyanide ions to ferricyanide ions in acidic medium.

Answer :

$2K_4[Fe(CN)_6] + H_2SO_4 + H_2O_2 \rightarrow 2K_3[Fe(CN)_6] + K_2SO_4 + 2H_2O$

191) Complete the following chemical reactions and classify the above into (a) hydrolysis,(b) redox and (c) hydration reactions.

$PbS(s) + 4H_2O_2(aq) \rightarrow$

Answer : $PbS(s) + 4H_2O_2(aq) \rightarrow PbSO_4(s) + 4H_2O(l)$ (redox reaction)

192) Complete the following chemical reactions and classify the above into (a) hydrolysis,(b) redox and (c) hydration reactions.

$MnO_4^-(aq) + H_2O_2(aq) \rightarrow$

Answer :

$2MnO_4^-(aq) + 5H_2O_2(l) + 6H^+(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 5O_2(g)$

(Redox reductio

193) Complete the following chemical reactions and classify the above into (a) hydrolysis,(b) redox and (c) hydration reactions.

$CaO(s) + H_2O(g) \rightarrow$

Answer : $CaO(s) + H_2O(g) \rightarrow Ca(OH)_2(aq)$ (hydrolysis reaction)

194) Complete the following chemical reactions and classify the above into (a) hydrolysis,(b) redox and (c) hydration reactions.

$AlCl_3(g) + H_2O(l) \rightarrow$

Answer :

$AlCl_3(g) + 6H_2O(l) \rightarrow [Al(OH_2)_6]^{3+}(aq) + 3Cl^-(aq)$ (Hydration reaction)

195) Complete the following chemical reactions and classify the above into (a) hydrolysis,(b) redox and (c) hydration reactions.

$Ca_3N_2(s) + H_2O(l) \rightarrow$

Answer :

$Ca_3N_2(s) + 6H_2O(l) \rightarrow 3Ca(OH)_2(aq) + 2NH_3(g)$ (Hydrolysis reaction)

196) Complete the following reactions.

$H_2(g) + M_mO_0(s) \xrightarrow{\Delta}$

Answer : $H_2(g) + M_mO_0(s) \xrightarrow{\Delta}$

197) Complete the following reactions.

$CO(g) + H_2(g) \xrightarrow{\Delta}$

Answer : $CO(g) + H_2(g) \xrightarrow[\Delta]{Catalyst} CH_3OH(l)$

198) Complete the following reactions.

$C_3H_8(g) + 3H_2O(g) \underset{Catalyst}{\xrightarrow{\Delta}}$

Answer : $C_3H_8(g) + 3H_2O(g) \xrightarrow{Ni,1270K} 3CO(g) + 7H_2(g)$

199) Complete the following reactions.

$Zn(s) + NaOH(aq) \xrightarrow{Heat}$

Answer : $Zn(s) + NaOH(aq) \xrightarrow{Heat} Na_2ZnO_2(aq) + H_2(g)$

200) Give ion electron equations for the following reactions.

Reduction of acidified potassium dichromate solution

Answer :

(iii) $K_2Cr_2O_7 + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3(O)$

$[H_2O + O \longrightarrow H_2O + O_2] \times 3$

$K_2Cr_2O_7 + 4H_2SO_4 + 3H_2O_2 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + 3O_2$

Or $Cr_2O_7^{2-} + 8H^+ + 3H_2O_2 \longrightarrow 2Cr^{3+} + 7H_2O + 3O_2$ [1]

201) Give ion electron equations for the following reactions.

Oxidation of sulphurous acid to sulphuric acid

Answer :

(iv) $H_2O_2 \longrightarrow H_2O + O$

$H_2SO_3 + O \longrightarrow H_2SO_4$

$H_2SO_3 + H_2O_2 \longrightarrow H_2SO_4 + H_2O$

Or $SO_3^{2-} + H_2O_2 \longrightarrow SO_4^{2-} + H_2O$

202) What do you understand by the terms:
(i) Hydrogen economy
(ii) hydrogenation
(iii) syngas
(iv) water-gas shift reaction
(v) fuel-cell?

Answer : (i) **Hydrogen economy:** The basic principle of hydrogen economy is the storage and transportation of energy in the form of liquid or gaseous dihydrogen.

(ii) **Hydrogenation:** Hydrogenation means addition of hydrogen across double and triple bonds in presence of catalyst to form saturated compounds.

$$\text{Vegetable oil} + H_2 \xrightarrow{Ni, 437K} \text{Vegetable Ghee}$$

(iii) **Syngas:** The mixture of CO and H_2 are called synthesis or syngas. It can be produced by the reaction of steam on hydrocarbon or coke at high temperature in the presence of nickel catalyst

$$CH_4(g) + H_2O(g) \xrightarrow[Ni]{1270K} CO(g) + 3H_2(g)$$

The process of producing syngas from coal is called 'Coal gasification'.

$$C(g) + H_2O(g) \xrightarrow[Ni]{1270K} CO(g) + H_2(g)$$

(iv) **Water-gas** the syngas can be increased by the action of CO of syngas mixture with steam in the presence of iron chromate as catalyst.

$$C(s) + H_2O(g) \xrightarrow[FeCrO_4]{673K} CO(g) + H_2(g)$$

This is called water-gas shift reaction.

(v) **Fuel-Cell:** It is a cell which converts chemical energy of fuel directly into electrical energy.

203) Can we use concentrated sulphuric acid and pure zinc in the preparation of dihydrogen?
Write the chemical reactions to show the amphoteric nature of water.
Why is hydrogen peroxide stored in wax-lined plastic coloured bottles?

Answer : (a) Conc. H_2SO_4 cannot be used because it acts as an oxidizing agent also and gets reduced to SO_2.

$Zn + 2H_2SO_4$ (Conc.) $\rightarrow znSO_4 + 2H_2O + SO_2$

Pure Zn is not used because it is non-porous and reaction will be slow. The impurities in Zn help in constitute of electrochemical couple and speed up reaction.

(b) water is amphoteric in nature and it behaves both as an acid as well as base. With acids stronger than itself (e.g., H_2S) it behaves as a base and with bases stronger than itself (e.g., NH_3) it acts as an acid.

(i) As a base: $H_2O(1) + H_2S(aq) \rightarrow H_3O(aq) + HS^-(aq)$

(ii) As an acid: $H_2O(1) + NH_3(aq) \rightarrow OH^-\{aq) + NH_4^+(aq)$

(c) The decomposition of H_2O_2 occurs readily in the presence of rough surface (acting as catalyst). It is also decomposed by exposure of light. Therefore, wax-lined smooth surface and coloured bottles retard the decomposition of H_2O_2.