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

**Solution:**
Hydrogen is the first element in the periodic table. It has the electronic configuration 1s\(^1\). It is similar to alkali metal(ns\(^1\)) of group I. It shows resemblance with alkali metals of group I of the periodic table. Like alkali metals, Hydrogen forms compounds with halogens. It also collects at cathode during electrolysis of HCl or acidulated water. So it can be placed above the alkali metals in group I of the periodic table.

On the other hand Hydrogen can be placed in the Group 17 along with halogens, as it resembles them. Like halogens Hydrogen also collects at Anode when NaH is electrolysed. Like halogens it forms covalent bonds (H\(_2\), Cl\(_2\), Br\(_2\), etc) as well as ionic bonds (e.g. Na\(^+\)H\(^-\)). It forms hydride ion (H\(^-\)) by gaining one electron like halogens.

On the basis of its electronic configuration (1s\(^1\)) hydrogen is placed with other ns\(^1\) elements namely alkali metals in the group I as well as in group 17 of the periodic table. Thus the position of hydrogen in the periodic table is anomalous.

Hydrogen with so many unique characteristics is therefore best placed separately in the periodic table of elements.

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

**Solution:**
Three isotopes of hydrogen are known:

a. Protium (\(^1\)H).

b. Deuterium (\(^2\)H or D)

c. Tritium (\(^3\)H or T).

The mass ratio is 1.008123: 2.014: 3.01

3. Why does hydrogen occur in a diatomic form rather than in a monoatomic form under normal conditions?

**Solution:**
A molecule of hydrogen is formed by the combination of two atoms of hydrogen with one electron each present in 1s orbital. Thus two electrons are present in the hydrogen molecule and both will be accommodated in the molecular orbital of lowest energy. The bond order of H\(_2\) is +1. The positive value of bond order indicates that the H\(_2\) (diatomic) molecule is stable.

4. How can the production of dihydrogen obtained from ‘coal gasification’, be increased?
Solution:
The production of the dihydrogen can be increased by reacting carbon monoxide of syngas mixtures with steam in the presence of iron chromate as catalyst.

\[
\ce{C\text{(g)} + H_2O\text{(g)} &\rightarrow& CO\text{(g)} + H_2 \text{(g)}}
\]

Coal gasification

\[
\ce{CO\text{(g)} + H_2O\text{(g)} &\rightarrow& CO_2\text{(g)} + H_2 \text{(g)}}
\]

Water gas shift reaction

5. **Describe the bulk preparation of dihydrogen by electrolytic method. What is the role of an electrolyte in this process?**

Solution:
**Bulk preparation of dihydrogen by electrolytic method**

Dihydrogen of high degree of purity is prepared by the electrolysis of water in the presence of small amount of acid or base.

\[
\ce{2H_2O \text{ Electrolysis} &\rightarrow& 2H_2 \text{↑} + O_2 \text{↑}}
\]

However, dihydrogen is also produced as a by-product in many industrial processes such as manufacture of caustic soda by the electrolysis of sodium chloride solution. Here, the electrolyte used itself became the source of hydrogen. Pure water is not an electrolyte and is non-conductor of electricity. Hence electrolyte makes water a conductor of electricity.

6. **Complete the following reactions**

\[
(i) \ce{H_2g + M_mO_o (s) &\rightarrow& \text{(Δ)}}
\]

\[
(ii) \ce{CO (g) + H_2 (g) &\rightarrow& \text{(Δ Catalyst)}}
\]

Solution:
(i) \( n \ H_2(g) + M_{mO_n(s)} \rightarrow mM(s) + nH_2O(l) \)

(ii) \( CO \ (g) + 2 \ H_2 \ (g) \xrightarrow{\Delta} \text{Cr}_2O_3 \rightarrow CH_3CH \ (l) \)

(iii) \( C_3H_8(g) + 3H_2O (g) \xrightarrow{\Delta} \text{Catalyst} \rightarrow 3CO(g) + 7H_2 \ (g) \)

(iv) \( Zn (s) + 2 \ NaOH \ (aq) \xrightarrow{\text{Heat}} Na_2ZnO_2 + H_2 \)

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

**Solution:**
The H-H bond dissociation enthalpy is the highest for a single bond between two atoms of any element. This influences the chemical behaviour of dihydrogen. Hence the dissociation of dihydrogen into its atoms is nearly 0.081% around 2000 K which increases to 95.5% at 5000 K. Also, it is relatively inert at room temperature due to the high H-H bond enthalpy. Thus atomic hydrogen is produced at a high temperature in an electric arc or under ultraviolet radiations. Since its orbital is incomplete with 1s\(^2\) electronic configuration, it combines with almost all the elements. It takes part in reactions by

(i) Loss of the only electron to give \( H^+ \)

(ii) Gain of an electron to form \( H^- \) and

(iii) Sharing electron to form a single covalent bond.

**Eg., Loss of Electrons**

\[ 2H_2(g) + O_2(g) \xrightarrow{970 \text{ K}} 2H_2O(g) \]

\[ 3H_2(g) + N_2(g) \xrightarrow{Fe/Mo \ 750 \text{ K}} 2NH_3(g) \]

**Gain of Electron**

\[ 2Na + H_2 \xrightarrow{525 \text{ K}} 2NaH \]

\[ Ca + H_2 \xrightarrow{525 \text{ K}} CaH_2 \]

**Sharing Electron**
8. What do you understand by (i) electron-deficient, (ii) electron-precise, and (iii) electron-rich compounds of hydrogen? Provide justification with suitable examples.

**Solution:**

**Electron-deficient, Electron-precise and Electron-rich compounds of Hydrogen**

Molecular hydrides can be classified according to the relative number of electrons and bonds in their Lewis structure into electron-deficient, electron-precise and electron-rich hydrides.

**Electron-deficient hydrides**

As the name suggests, these hydrides have very few electrons for writing its conventional Lewis structure.

For e.g., Diborane (B₂H₆) is an electron deficient molecule. It is having two 3 centred, 2-electron, B-H-B bonds.

![B₂H₆ Lewis Structure](image)

B ---- H ---- B => 3c - 2e bond

These compounds act as Lewis acids i.e., electron acceptors.

**Electron-Precise Hydrides**

They have the required no. of electrons to write their conventional Lewis structure. All elements of Group 14 form such compounds (e.g., CH₄) which are tetrahedral in geometry.

![CH₄ Lewis Structure](image)

**Electron-rich Hydrides**

They have excess electrons which are present as lone pairs. Elements of group 15-17 form such compounds.
Likewise $H_2O$ has 2 lone pairs and HF has 3 lone pairs. They will 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. This leads to the association of molecules.

**9. What characteristics do you expect from an electron-deficient hydride with respect to its structure and chemical reactions?**

**Solution:**
Electron deficient hydrides have too less electrons for writing their conventional Lewis structure. $B_2H_6$ is common example. Due to less number of electrons, they are very good electron acceptors and act as Lewis acids.

**10. Do you expect the carbon hydrides of the type $(C_nH_{2n+2})$ to act as ‘Lewis’ acid or base? Justify your answer.**

**Solution:**
They are saturated hydrocarbons and cannot act as Lewis acid or Lewis bases.

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

**Solution:**
Alkali metals do not form non-stoichiometric hydrides. They have more tendencies to form ionic hydrides.

**12. How do you expect the metallic hydrides to be useful for hydrogen storage? Explain.**

**Solution:**
Some of the metals in d-block and f-block elements like palladium (Pd) and platinum (Pt) can accommodate a very large volume of hydrogen and therefore, can be its storage media. This property has high potential for H$_2$ storage.

**13. How does the atomic hydrogen or oxy-hydrogen torch function for cutting and welding purposes? Explain.**

**Solution:**
Atomic hydrogen and oxy-hydrogen torches find use for cutting and welding purposes. Atomic hydrogen atoms (produced by the dissociation of dihydrogen with the help of an electric arc) are allowed to recombine on the surface to be welded to generate the temperature of 4000 K.

**14. Among NH$_3$, H$_2$O and HF, which would you expect to have highest magnitude of hydrogen bonding and why?**
**Solution:**
Highest magnitude of hydrogen bonding exist in H - F because of highest electro negativity and smallest size of fluorine (F).

### 15. Saline hydrides are known to react with water violently producing fire. Can CO₂ a well known fire extinguisher, be used in this case? Explain

**Solution:**
Saline hydrides are known to react with water violently producing fire. The reaction is

\[
\text{NaH (s) + H}_2\text{O(aq)} \rightarrow \text{NaOH (aq) + H}_2(g)
\]

Only sand can be used to extinguish the fire. Carbon di oxide cannot be used because it gets reduced by the hot metal hydride.

### 16. Compare the structures of \( \text{H}_2\text{O} \) and \( \text{H}_2\text{O}_2 \).

**Solution:**

**Structure of \( \text{H}_2\text{O} \) molecule**
Water in the gaseous form is a bent molecule with a HOH bond angle of 104.5° and OH bond length of 95.7 pm. It is polar in nature.

![Structure of \( \text{H}_2\text{O} \) molecule](image)

**Structure of \( \text{H}_2\text{O}_2 \) molecule**

It has a non-planar structure. In gaseous phase, the dihedral angle (115.5°) is reduced to 90.2° in the solid state due to hydrogen bonding. The two oxygen atoms are joined by a single electron pair bond.

17. What do you understand by the term ‘auto-protolysis’ of water? What is its significance?

**Solution:**

**Auto-protolysis of Water**

The term auto-protolysis of water means self-ionisation of water. It takes place as follows:

\[ \text{H}_2\text{O}(l) + \text{H}_2\text{O}(l) \rightleftharpoons \text{H}_3\text{O}^+_{(aq)} + \text{OH}^-_{(aq)} \]

This property of water is used to explain the amphoteric nature of water.

18. Consider the reaction of water with \( \text{F}_2 \) and suggest, in terms of oxidation and reduction, which species are oxidised/reduced.

**Solution:**

**Reaction of \( \text{H}_2\text{O} \) with \( \text{F}_2 \)**

With Fluorine, water is oxidized to \( \text{O}_2 \).

\[ 2\text{F}_2(g) + 2\text{H}_2\text{O}(l) \rightarrow 4\text{H}^+_{(aq)} + 4\text{F}^-_{(aq)} + \text{O}_2(g) \]

Oxidation state of \( \text{F}_2 \) in the reactant side is 0 (zero). Oxidation state of \( \text{F}_2 \) in the product side is -1.

\( \therefore \) Each Fluorine atom has accepted 1\( e^- \). Hence Fluorine is said to undergo reduction. Whereas electrons are lost by \( H \) in \( \text{H}_2\text{O} \) (each \( H \) atom –1\( e^- \)) to form \( \text{H}^+ \) ion. Hence \( \text{H}_2\text{O} \) undergoes oxidation to form \( \text{H}^+ \) and \( \text{O}_2 \).

19. Complete the following equations

\( \text{PbS} \text{ (s)} + \text{H}_2\text{O}_2 \text{ (aq)} \rightarrow \)

\( \text{MnO}_4^- \text{ (aq)} + \text{H}_2\text{O}_2 \text{ (aq)} \rightarrow \)

\( \text{CaO}(s) + \text{H}_2\text{O} \text{ (g)} \rightarrow \)

\( \text{AlCl}_3(g) + 3\text{H}_2\text{O}(l) \rightarrow \)

\( \text{Ca}_3\text{N}_2(s) + \text{H}_2\text{O} \text{ (l)} \rightarrow \)
Solution:
(i) PbS(s) + 4H₂O₂(aq) → PbSO₄ + 4H₂O
   (white)

(ii) MnO₄⁻ (aq) + H₂O₂ (aq) → 2Mn²⁺(aq) + 5 O₂(g) + 8H₂O(l)

(iii) CaO(s) + H₂O (g) → Ca (OH)₂ (s)

(iv) AlCl₃(g) + 3H₂O(l) → Al(OH)₃ (aq) + 3HCl(aq)

(v) Ca₃N₂(s) + H₂O (l) → 3 Ca(OH)₂(s) + 2NH₃ (g)

20. Describe the structure of the common form of ice.

Solution:
In the normal hexagonal ice, each oxygen atom is tetrahedrally surrounded by four other oxygen atoms, i.e. there is a hydrogen atom between each pair of oxygen atoms. This gives ice an open cage like structure, as shown in Fig.

![Ice Structure](https://example.com/ice_structure.png)

From the figure, it is clear that each oxygen is surrounded by four hydrogen atoms, two by strong covalent bonds (shown by solid lines) and two by weak hydrogen bonds (shown by dotted lines). Since the H-bonds are longer (177 pm) than covalent bonds(95.7 pm), the molecules of water are not closely packed in the crystal lattice.

21. What causes the temporary and permanent hardness of water?

Solution:
Temporary and Permanent Hardness of Water
Temporary hardness in water is due to the presence of calcium and magnesium bicarbonates. [i. e., Ca(HCO₃)₂ and Mg(HCO₃)₂]

Permanent hardness in water is due to the presence of soluble salts of calcium and magnesium. i. e., sulphates and chlorides of calcium and magnesium.
22. Discuss the principle and method of softening of hard water by synthetic ion-exchange resins.

**Solution:**

**Synthetic resins method:** Nowadays hard water is softened by using synthetic cation exchangers. This method is more efficient than zeolite process. Cation exchange resins contain large organic molecule with -SO₃H group and are water insoluble. Ion exchange resin (RSO₃H) is changed to RNA by treating it with NaCl. The resin exchange Na⁺ ions with Ca²⁺ and Mg²⁺ ions present in hard water to make the water soft. Here R is resin anion.

\[ 2RNa(s) + M⁺(aq) \rightarrow R₂M(s) + 2Na⁺(aq) \]

The resin can be regenerated by adding aqueous NaCl solution.

Pure de-mineralised (de-ionized) water free from all soluble mineral salts is obtained by passing water successively through a cation exchange (in the H⁺ form) and an anion-exchange (in the OH⁻ form) resins:

\[ 2RH(s) + M⁺(aq) \rightleftharpoons MR₂(s) + 2H⁺(aq) \]

In this cation exchange process, H⁺ exchanges for Na⁺, Ca⁺⁺, Mg⁺⁺ and other cations present in water. This process results in proton release and thus makes the water acidic. In the anion exchange process:

\[ R₂NH₃(s) + H₂O(l) \rightleftharpoons R₂NH₄⁺, OH⁻(s) \]

\[ R₂NH₄⁺, OH⁻(s) + X⁻(aq) \rightleftharpoons R₂NH₂⁺, X⁻(s) + OH⁻(aq) \]

OH⁻ exchanges for anions like Cl⁻, HCO₃⁻, SO₄²⁻ etc., present in water OH⁻ ions, thus, liberated neutralize the H⁺ ions set free in the cation exchange.

\[ H⁺(aq) + OH⁻(aq) \rightarrow H₂O(l) \]

The exhausted cation and anion exchange resin beds are regenerated by treatment with dilute acid and alkali solutions respectively.

23. Write the chemical reactions to show the amphoteric nature of water.

**Solution:**

Water acts both as an acid and a base and is said to be amphoteric in nature.

According to Lowry Bronsted concept, it can act as an acid by losing a proton and as a base by accepting a proton, for example:
\[ \text{HCl} + \text{H}_2\text{O} \, \xrightleftharpoons{\text{base}} \, \text{Cl}^- + \text{H}_3\text{O}^+ \]

\[ \text{NH}_3 + \text{H}_2\text{O} \, \xrightleftharpoons{\text{acid}} \, \text{NH}_4^+ + \text{OH}^- \]

However, water is neutral towards litmus and its \( P_{\text{H}} \) is 7.

The auto - protolysis of water is represented by

\[ \text{H}_2\text{O}(\text{l}) + \text{H}_2\text{O}(\text{l}) \, \xrightleftharpoons{} \, \text{H}_3\text{O}^+(\text{aq}) + \text{OH}^-(\text{aq}) \]

\[ \text{acid 1} \quad \text{Base 2} \quad \text{acid 2} \quad \text{Base 1} \]

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

**Solution:**
Hydrogen peroxide acts as an oxidising agent as well as a reducing agent:

a) As an oxidizing agent (in neutral medium)

i) \[ \text{H}_2\text{O}_2 \rightarrow \text{H}_2\text{O} + \text{O} \]

\[ \text{H}_2\text{S} + \text{O} \rightarrow \text{S} + \text{H}_2\text{O} \]

\[ \text{H}_2\text{S} + \text{H}_2\text{O}_2 \rightarrow \text{S} + \text{H}_2\text{O} \]

ii) in acidic medium

\[ 2\text{FeSO}_4(\text{aq}) + \text{H}_2\text{SO}_4(\text{aq}) + \text{H}_2\text{O}_2(\text{aq}) \rightarrow \text{Fe}_2(\text{SO}_4)_3(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) \]

\[ \text{PbS}(s) + 4\text{H}_2\text{O}_2(\text{aq}) \rightarrow \text{PbSO}_4(s) + 4\text{H}_2\text{O}(\text{l}) \]

iii) in alkaline medium

\[ \text{H}_2\text{O}_2 + \text{OH}^- + 2\text{e}^- \rightarrow 3\text{OH}^- \]

\[ \text{MnSO}_4 + \text{H}_2\text{O}_2 + 2\text{NaOH} \rightarrow \text{MnO}_2 + \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O} \]

b) Reducing nature: (in acidic medium):

\[ 2\text{KMnO}_4 + 3\text{H}_2\text{SO}_4 + 5\text{H}_2\text{O}_2 \rightarrow \text{K}_2\text{SO}_4 + 2\text{MnSO}_4 + 8\text{H}_2\text{O} + 5\text{O}_2 \]

\[ \text{HOCl} + \text{H}_2\text{O}_2 \rightarrow \text{H}_3\text{O}^+ + \text{Cl}^- + \text{O}_2 \]

In alkaline medium:

\[ 2\text{Fe}^{3+} + \text{H}_2\text{O}_2 + 2\text{OH}^- \rightarrow 2\text{Fe}^{2+} + 2\text{H}_2\text{O} + \text{O}_2 \]

\[ 2\text{KMnO}_4 + 3\text{H}_2\text{O}_2 \rightarrow 2\text{MnO}_2 + 3\text{O}_2 + 2\text{H}_2\text{O} + 2\text{KOH} \]

25. What is meant by 'demineralised' water and how can it be obtained?

**Solution:**

**Demineralised Water**
Water free from salts and minerals is called as demineralised or demi water. This process is commonly done by ion exchange method.
Deionization entails removal of electrically charged (ionized) dissolved substances by binding them to positively or negatively charged sites on a resin as the water passes through a column packed with this resin. This process is called ion exchange.

26. Describe the usefulness of water in biosphere and biological systems.

Solution:
Usefulness of water in the Biosphere and Biological Systems

Water Cycle
1. The continuous movement of water from the earth to the atmosphere and back to the earth.
2. The sun provides energy for the water cycle, also known as hydrologic cycle.
3. The water cycle occurs in four overlapping spheres.
Water Cycle Spheres
1. Hydrosphere
2. Atmosphere
3. Biosphere
4. Lithosphere

Hydrosphere
Water moves from the earth to the atmosphere through the processes of evaporation and transpiration.

Atmosphere
Air that holds moisture until it falls as precipitation.

Biosphere
Includes all plant and animal life which are consumers of water.

Lithosphere
Land where water falls as precipitation. Water is necessary for all living beings including aquatic organisms. Even the bacteria or fungi will grow in the presence of moisture. In comparison to other liquids, water has a higher specific heat, thermal conductivity, surface tension, dipole moment and dielectric constant, etc. These properties allow water to play a key role in the biosphere. Water is an intercellular medium for all living things. The ionization of water influences cellular activity.

27. What properties of water make it useful as a solvent? What types of compound can it (i) dissolve, and (ii) hydrolyse?

Solution:
The attractive forces between the water molecules are known as hydrogen bonds. These bonds arise due to the polar nature of the water molecule. There is separation of charge across the molecule, and these charges allow water molecules to interact with each other. Hydrogen bonds can form between
other molecules and water, and between several molecules themselves. Due to its polar properties, water is an excellent solvent.

1. Crystalline salts completely dissociate.

2. Neutral organics with polar functional groups.

3. Amphiphilic compounds form micelles, monolayers and bilayers.

4. Even covalent compounds like alcohols and carbohydrates dissolve in water.

**Hydrolysis**

Compounds that can undergo hydrolysis are amides, esters and halo alkanes.

\[
\begin{align*}
\text{Amide} & : R - C\equiv N - R' \\
\text{Ester} & : R - C\equiv O - R' \\
\text{Haloalkane} & : R - Br
\end{align*}
\]

In the overall process of hydrolysis, a bond in an organic compound is broken, and an O-H bond in a water molecule also breaks. Then, from the water molecule, an O-H group adds to one part from the organic molecule and an H atom to the other.

\[
\text{RCONH}_2 + H_2O \rightarrow \text{RCOOH} + \text{NH}_3
\]

(Primary Amine)

\[
\text{R - CONH - R' + H}_2\text{O} \rightarrow \text{RCOOH} + \text{R'NH}_2
\]

(Secondary Amine)

\[
\text{RCOO}R' + H_2O \rightarrow \text{RCOOH} + \text{ROH}
\]

(Ester)

\[
\text{R - Br + H}_2O \rightarrow \text{ROH} + H^+ + Br^- \\
R \rightarrow \text{Alkyl group}
\]

![28. Knowing the properties of H2O and D2O, do you think that D2O can be used for drinking purposes?](Image)

**Solution:**

Chemically heavy water is deuterium oxide (D2O). Like ordinary water it is odourless and tasteless liquid.

The slower rate of D+ compared to H+ in reactions involved in enzymatic catalysis. Due to this the D2O is toxic in nature.

![29. What is the difference between hydrolysis and hydration?](Image)

**Solution:**

<table>
<thead>
<tr>
<th>Hydrolysis</th>
<th>Hydration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
30. How can saline hydrides remove traces of water from organic compounds?

Solution:
Ionic hydrides are frequently used to remove traces of water from organic compounds, because they give H\(^+\) ion which is a strong Bronsted base which reacts with water from organic compound.

\[
\begin{align*}
\text{NaH} & \quad \rightarrow \quad \text{Na}^+ + \text{H}^- \\
\text{H}^- + \text{H}_2\text{O} & \quad \rightarrow \quad \text{H}_2 + \text{OH}^- \\
\text{Base} & \quad \rightarrow \quad \text{Na}^+ + \text{OH}^- \rightarrow \text{NaOH}
\end{align*}
\]

31. Do you expect different products in solution when aluminium (III) chloride and potassium chloride are treated separately with i) normal water, ii) acidified water and alkaline water?

Solution:

i) Aluminium (III) chloride dissociates in water to give \(\text{Al}^3+ (\text{aq})\) and \(\text{Cl}^- (\text{aq})\) due to high heat of hydration. The weak base formed ionises freely in the solution and therefore the free hydronium ions makes the solution acidic.

ii) KCl dissociates into potassium and chloride ions. Since neither \(\text{K}^+\) nor \(\text{Cl}^-\) ions chemically react with water, the concentrations of \(\text{H}^+\) and \(\text{OH}^-\) in the solution remains equal and the solution remains neutral.

32. How does \(\text{H}_2\text{O}_2\) behave as a bleaching agent?

Solution:

\(\text{H}_2\text{O}_2\) as a Bleaching Agent

\(\text{H}_2\text{O}_2\) has strong oxidizing properties and is therefore a powerful bleaching agent. It is commonly used (in very low concentrations of the range 5%) to bleach human hair, textiles, paper pulp, leather, oils, fats, etc. Hence it is called as peroxide blonde (or) Bottle Blonde.

The positive aspects of \(\text{H}_2\text{O}_2\) include the fact that it is environmentally friendly decomposes to \(\text{O}_2\) and...
H₂O), colourless and non-corrosive.

For e. g., 2H₂O₂ → 2H₂O + O₂

PbS(s) + 4H₂O₂(aq) → PbSO₄(s) + 4H₂O(l)

When dyeing with vat and sulphide dyestuffs, H₂O₂ is applied as an oxidizing agent.

**Advantages of peroxide bleaching**
1. Provides high bleaching effect
2. Reasonable costs
3. Maintains fibre quality.
4. Produces bleaching as well as cleaning effect.
5. Corrosion does not occur for stainless steels.

### 33. What do you understand by the terms

(i) **hydrogen economy**

(ii) **hydrogenation**

(iii) ‘syngas’

(iv) **water-gas shift reaction fuel-cell**?

**Solution:**

(i) Utilisation of liquid Hydrogen as an alternative source of energy as a fuel is known as Hydrogen economy. Hydrogen economy technology involves production, transportation and storage of liquid Hydrogen in bulk quantities. Liquid Hydrogen fuel is clean fuel and easily transported.

(ii) Hydrogenation is a chemical reaction in which Hydrogen is passed through polyunsaturated oils in the presence of a catalyst like Nickel when edible fat (Dalda) is obtained due to addition of Hydrogen atoms across the double bonds (unsaturation) of unsaturated acids.

(iii) The syngas is the mixtures of CO and H₂. The process of producing syngas from coal is called coal gasification.

(iv) Water gas shift reaction: When steam is passed over red hot coke at high temperature.

\[
C(s) + H₂O(g) \xrightarrow{1270 \text{ K}} CO(g) + H₂(g)
\]

The CO is converted to CO₂ by passing it with steam over an iron oxide or cobalt oxide catalyst at 673 K when more Hydrogen is generated.

\[
CO + H₂O \xrightarrow{673 \text{ K}} \text{FeO} \rightarrow CO₂ + H₂
\]
This reaction is called the water gas shift reaction. By this process more hydrogen gas is prepared. This method is used for the production of 77% of industrial hydrogen.

Fuel cell is a device to convert chemical energy of fuel into electrical energy. Dihydrogen is used in fuel cells for the generation of electric power.