

STUDY OF FIRST GROUP ELEMENT- HYDROGEN SOLVED EXAMPLE

- Fill in the blank spaces with the appropriate word given within the brackets.
 - Most of the hydrogen occurs in the combined state in the form of _____ (water/minerals).
 - Hydrogen is not collected by the downward displacement of air, because it _____ (forms an explosive mixture/reacts) with air.
 - Arsine gas is an impurity present in hydrogen which can be removed by passing the gas through _____ (sodium hydroxide/silver nitrate) solution.
 - Hydrogen mixed with _____ (argon/helium) is used for filling weather observation balloons.

Ans. (a) water (b) explosive mixture (c) silver nitrate (d) helium

- Match the statements in Column A, with the statements in Column B.

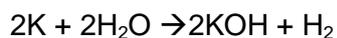
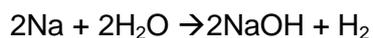
Column A	Column B
(a) The process by which vegetable oil changes into vanaspati ghee.	Water
(b) A liquid which turns anhydrous copper sulphate solution blue.	Calcium
(c) A metal which dissolves in water to form a milky white solution and hydrogen gas.	Hydrogenation

Ans. (a) Hydrogenation (b) Water (c) Calcium

- Statements given below are incorrect. Write the correct statements.
 - Hydrogen belongs to group IA and second period of the periodic table.
 - Most of the mass of the stars and our Sun consists of carbon.
 - Water gas is a mixture of equal volumes of hydrogen and water vapour.
 - During water gas shift reaction carbon monoxide is reduced to carbon dioxide.
- Ans. (a) Hydrogen belongs to group IA and **first** period of the periodic table.
 - Most of the mass of the stars and our Sun consists of **hydrogen**.
 - Water gas is a mixture of equal volumes of hydrogen and **carbon monoxide**.
 - During water gas shift reaction carbon monoxide is **oxidized** to carbon dioxide.
- Hydrogen can be prepared by the action of most reactive metals with cold water. Name three such metals and write fully balanced equations for their reaction with water.
 - Arrange the metals in 4(a) in increasing order of metal activity series.
 - Is it possible to collect hydrogen directly from the most reactive metals named by you? State a reason for your answer.

(d) Suggest a method for collecting hydrogen from the most reactive metal named by you.

Ans.(a) Metals which displace hydrogen from cold water are : (1) sodium (2) potassium (3) calcium.



(b) Ca, Na, K.

(c) It is not possible to collect hydrogen as the reaction between potassium and water is explosive in nature.

(d) The potassium metal is dissolved in mercury to form potassium amalgam. This in turn reduces the activity of the metal. When potassium amalgam is placed in a trough of water, it slowly releases hydrogen gas, which can be collected by the downward displacement of water.

5. Hydrogen can be collected from heated metals, when steam is passed over them. Name two such metals and write fully balanced equations in support of your answer.

Ans. Heated magnesium and iron displace hydrogen from steam.



6. Reaction with red hot iron gauze and steam is a reversible reaction.

However, when steam is passed over red hot iron gauze and the hydrogen evolved is collected over water, the reaction proceeds in the forward direction. Explain the observation.

Ans. The reaction becomes irreversible only, if the products of the reaction are not removed from the site of the reactants. In the present case, hydrogen (product) is removed from the site of the reaction, and hence, the reaction proceeds in the forward direction.

7. About 2 cm³ of water is boiled in a hard glass test-tube, so that steam comes out freely. Into this test-tube a burning magnesium ribbon is lowered.

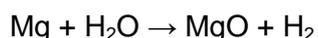
(a) State your observation and write a fully balanced equation for the chemical reaction.

(b) How will you test the gas formed in the above reaction?

(c) Why does the above reaction stop in a few moments?

Ans. (a) (1) The magnesium ribbon burns for a few moments and then goes off.

(2) A white powdery deposit covers the magnesium ribbon.



(b) When a burning splinter is brought near the test-tube the gas catches fire and explodes with characteristic pop sound.

(c) The reaction stops because, it is an endothermic reaction. As no heat is supplied from outside, therefore, it cannot sustain itself.

8. (a) Fill in the blank spaces and then balance the chemical equations given below.

- (i) $\text{Mg} + \text{_____} \rightarrow \text{MgCl}_2 + \text{_____}$
 (ii) $\text{_____} + \text{_____} \rightarrow \text{FeSO}_4 + \text{H}_2$
 (iii) $\text{Al} + \text{_____} \rightarrow \text{Al}_2(\text{SO}_4)_3 + \text{_____}$
 (iv) $\text{Zn} + \text{_____} \rightarrow \text{ZnCl}_2 + \text{_____}$.

(b) Why is nitric acid (dilute) not used for preparing hydrogen gas from metals.

Ans. (a)(i) $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$

(ii) $\text{Fe} + \text{H}_2\text{SO}_4 \rightarrow \text{FeSO}_4 + \text{H}_2$

(iii) $2\text{Al} + 3\text{H}_2\text{SO}_4 \rightarrow \text{Al}_2(\text{SO}_4)_3 + 3\text{H}_2$

(iv) $\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$

(b) Nitric acid is a powerful oxidising agent. Thus, the hydrogen evolved is oxidised by it and instead nitric oxide gas is liberated. Hence, dilute nitric acid cannot be used for preparing hydrogen from metals.

9. Write fully balanced chemical equations when the following metals in powder form are boiled with concentrated caustic soda.

(i) Aluminium (ii) Zinc (iii) Lead.

Ans. (i) $2\text{Al} + 2\text{NaOH} + 2\text{H}_2\text{O} \xrightarrow{\text{Boiling}} 2\text{NaAlO}_2 + 3\text{H}_2$

(ii) $\text{Zn} + 2\text{NaOH} \xrightarrow{\text{Boiling}} \text{Na}_2\text{ZnO}_2 + \text{H}_2$

(iii) $\text{Pb} + 2\text{NaOH} \xrightarrow{\text{Boiling}} \text{Na}_2\text{PbO}_2 + \text{H}_2$

10. (a) Name one metal which reacts explosively with water to liberate hydrogen gas.

(b) Name one metal which reacts very slowly with boiling water to liberate hydrogen gas.

(c) Name one metal which on heating reacts with steam at a moderate speed to liberate hydrogen.

(d) Name one metal which on heating reacts with steam, but the reaction is reversible.

(e) Name one metal which on heating does not react with steam.

(f) Name three metals which displace hydrogen from dilute sulphuric acid at a moderate rate.

(g) Name three metals which displace hydrogen from hot concentrated caustic soda solution.

Ans. (a) Sodium metal **(b)** Magnesium powder **(c)** Magnesium powder **(d)** Iron powder **(e)** Copper metal
(f) Magnesium, zinc and iron **(g)** Aluminium, zinc and lead

11. Why is granulated zinc and not pure zinc used for the preparation of hydrogen gas in the laboratory?

Ans. Granulated zinc always contain copper as an impurity. The copper acts as a catalyst and speeds up the rate of the reaction.

12. Why does the hydrogen gas collected by the action of zinc with dilute sulphuric acid have a faint fishy smell?

Ans. Granulated zinc contains traces of zinc phosphide. The zinc phosphide reacts with dilute sulphuric acid to liberate phosphine gas, which has a fishy smell. Thus, the hydrogen contaminated with phosphine gas has a faint fishy smell.

13. Why are the first few bubbles of hydrogen gas not collected, when the gas is prepared from zinc and dilute sulphuric acid in the laboratory?

Ans. The first few bubbles of hydrogen are always mixed with some amount of air present in the apparatus. This in turn forms an explosive mixture, which can explode, if a naked flame is brought near the gas jar. It is on account of this, that the first few bubbles of hydrogen are not collected.

14. Why is lighted candle or any other naked flame not brought near an apparatus producing hydrogen gas?

Ans. There is a possibility that hydrogen gas may be leaking from the apparatus. As this gas forms an explosive mixture which can explode with the naked flame, therefore no naked flame is brought near the apparatus.

15. (a) Name four impurities present in hydrogen gas collected by the action of dilute sulphuric acid on granulated zinc.

(b) Suggest a solution / chemical for the removal of impurities named in 15(a).

Ans. (a) Following are the impurities present in hydrogen gas.

- (i) Phosphine gas
- (ii) Hydrogen sulphide gas
- (iii) Sulphur dioxide gas
- (iv) Oxides of nitrogen.

(b) Phosphine gas is removed by passing the gas through silver nitrate solution. Hydrogen sulphide gas is removed by passing the gas through lead nitrate solution. Sulphur dioxide gas and oxides of nitrogen are removed by passing the gas through caustic potash solution.

16. Answer the following questions regarding the manufacture of hydrogen by Bosch process.

(a) Name the raw materials required.

(b) Write fully balanced equation between the raw materials which result in the formation of hydrogen gas.

(c) Is the reaction in 16(b) exothermic or endothermic?

Ans. (a) Raw materials required are :

(i) coke (ii) air (iii) water.

(b) $C \text{ (red hot)} + H_2O \rightarrow CO + H_2$

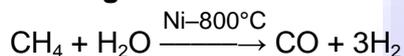
(c) Reaction is endothermic in nature.

17. Paragraph below describes the industrial preparation of hydrogen gas from methane. Fill in the blank spaces.

Methane gas is mixed with twice the volume of _____ at 170 °C and then compressed to _____ atmospheres _____. The mixture so formed is passed over heated _____ maintained at _____ when the following reaction takes place.



Ans. Methane gas is mixed with twice the volume of **super heated steam** at 170 °C and then compressed to **thirty atmospheres pressure**. The mixture so formed is passed over heated **nickel gauze** maintained at **800 °C**, when the following reaction takes place.



18. State four physical properties of hydrogen gas.

Ans. 1. It is a colourless, odourless and tasteless gas.

2. It is lighter than air, its V.D. being 1 and that of air being 14.4.

3. It is insoluble in water.

4. Under very high pressure and low temperature it liquefies.

19. State four uses of hydrogen gas.

Ans. 1. It is used in oxy-hydrogen flame for cutting and welding purposes.

2. It is used in the hydrogenation of vegetable oils.

3. It is used as a fuel in rockets.

4. It is used in the manufacture of ammonia.

20. What do you understand by the term "hydrogenation of vegetable oils"? Briefly explain how hydrogenation is carried out?

Ans. Addition of hydrogen atoms in the molecule of vegetable oils such that they solidify at room temperature is called hydrogenation of oils.

The deodourised and decolourised vegetable oils are mixed with finely divided nickel (catalyst) and heated to 200 °C. Hydrogen gas is slowly bubbled through the mixture when hydrogen atoms bind with the molecules of oil. The mixture is then filtered to remove nickel. On cooling, it changes to vanaspati ghee.

21. A, B, C, D, E and F are metals which can react as under:

(a) Metal A reacts violently with cold water to form a colourless solution and hydrogen gas.

(b) Metal B does not react even with steam or dilute sulphuric acid.

(c) Metal C does not react with steam, but silently reacts with dilute sulphuric acid.

(d) Metal D reacts vigorously with cold water to form turbid solution and hydrogen gas.

(e) Metal E rapidly reacts with steam to form hydrogen.

(f) Metal F reacts with steam to form hydrogen, but the reaction is reversible.

By carefully studying the above reactions, arrange the metals in the metal activity series, starting with the least reactive metal.

- Ans.** (a) Metal A may be sodium. (b) Metal B may be copper.
(c) Metal C may be tin. (d) Metal D may be calcium.
(e) Metal E may be magnesium. (f) Metal F may be iron.

Activity series : copper, tin, iron, magnesium, calcium, sodium or B,C,F,E,D,A.

- 22.** You are given a metal X which lies between sodium and calcium in the metal activity series. State in word equations what reaction takes place between :
(i) X and oxygen (ii) X and water (iii) X and hydrochloric acid?

- Ans.** (i) $X + \text{oxygen} \rightarrow X \text{ oxide}$.
(ii) $X + \text{water} \rightarrow X \text{ hydroxide} + \text{hydrogen}$.
(iii) $X + \text{hydrochloric acid} \rightarrow X \text{ chloride} + \text{hydrogen}$.

- 23.** Metal sodium decomposes water at ordinary temperature. The metal magnesium decomposes boiling water very slowly, but much quicker when in powdered form. Explain briefly why is this so?

Ans. Sodium is higher in the metal activity series as compared to magnesium. Thus, sodium reacts with cold water, whereas magnesium reacts only when heated or when steam is passed over it. The reaction is quicker, because powdered magnesium offers a large surface area to steam.

- 24.** When a piece of calcium metal is dropped into a beaker of cold water a vigorous reaction takes place and the metal gradually disappears and a white suspension is formed.

- (i) Write down an equation for the reaction.
(ii) Why does the solution become cloudy?
(iii) On filtering a clear solution is obtained. What is the name of the clear solution?
(iv) What happens when carbon dioxide is passed through the clear solution?

- Ans.** (i) $\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2 + \text{H}_2$
(ii) The solution becomes cloudy on account of the formation of calcium hydroxide which is sparingly soluble in water.
(iii) The clear solution is commonly called limewater.
(iv) The clear solution turns milky due to the formation of insoluble calcium carbonate.

- 25. (a)** Arrange the following metals in the order in which they appear in the activity series. Copper, calcium, aluminium, iron, magnesium, lead, sodium and zinc. Put down the most reactive metal first and the least reactive metal last.

(b) P, Q, R are the coded letters for three metals in the activity series given in 25 (a) above. The metal P reacts violently with cold water and its hydroxide is not decomposed by heat. Metal Q has no reaction with water, but its hydroxide decomposes on slight warming giving a powder. Metal R reacts vigorously with cold dilute hydrochloric acid, but hardly at all with cold water. If steam is passed over white hot solid R, another white solid A is formed and a colourless gas B is set free.

- (i) Which metals in the list are P, Q, R?
- (ii) If A and B are codes for solid A and gas B, identify them.
- (iii) State what would be your observations and write chemical equations when nitrates of P and Q are heated strongly.
- (iv) Amongst the hydroxides of P and Q, state which is soluble and which is insoluble?

Ans. (a) Sodium, calcium, magnesium, aluminium, zinc, iron, lead and copper.

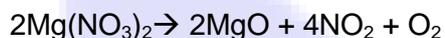
(b) (i) P may be sodium. Q may be magnesium. R may be zinc.

(ii) Solid A may be zinc oxide and gas B hydrogen.

(iii) The nitrate of P (sodium nitrate) on heating will melt to form sodium nitrite and oxygen gas.



The nitrate of Q (magnesium nitrate) on heating will decompose to give a white residue of magnesium oxide, nitrogen dioxide gas and oxygen gas.



(iv) The hydroxide P is soluble.

The hydroxide Q is insoluble.

26. From the metals sodium, copper, magnesium, iron and zinc select the metal in each case :

(a) Which does not dissolve in dilute hydrochloric acid?

(b) Which can form 2+ and 3+ ions?

(c) Whose hydroxide is soluble in acids and alkalis?

(d) Which does not react readily with cold water, but reacts with steam when burning?

Ans.(a) Copper does not dissolve in dilute hydrochloric acid.

(b) Iron can form 2+ and 3+ ions.

(c) Zinc metal forms hydroxide, which is soluble in acids and alkalis.

(d) Magnesium does not readily react with cold water, but reacts with steam.

27. **(a)** P, Q and R are metals. Q liberates hydrogen from cold water, whereas P and R do not.

R displaces P from an aqueous solution of one of its salts. Place P, Q and R in the order of decreasing activity.

(b) If QCl is the formula of a chloride :

(1) What is the formula of its sulphate?

(2) What is the effect of heat on the hydroxide of Q?

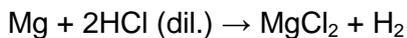
Ans. (a) Q, R and P.

(b) (1) Formula for sulphate is Q_2SO_4 . (2) The hydroxide of Q is stable and does not decompose on heating.

28. Using the terms “Violent”, “Slow” and “No reaction”, describe how does (i) water (ii) dilute hydrochloric acid react with (1) magnesium (2) copper (3) sodium. Write chemical equations for the reactions and hence arrange the above metals in the order of the activity series.

Ans. (1)(i) Water and magnesium have no reaction.

(ii) The reaction of dilute hydrochloric acid with magnesium is violent.



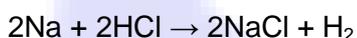
(2) (i) Copper has no reaction with water.

(ii) Dilute hydrochloric acid has no reaction with copper.

(3) (i) Sodium reacts with water violently.



(ii) Sodium reacts with dilute hydrochloric acid violently.



Activity series : sodium, magnesium, copper.

29. An important step in the manufacture of hydrogen takes place when a mixture of hydrogen and carbon monoxide with steam is passed over iron (III) oxide heated to 500 oC.



the products of the reaction are then passed into water under high pressure.

(a) State briefly how a suitable mixture of hydrogen and carbon monoxide can be obtained? Give an equation for the reaction.

(b) What is the purpose of iron (III) oxide in this process?

(c) Why is it not necessary to heat iron (III) oxide further, once the reaction starts?

(d) What do double arrows indicate?

(e) How can hydrogen be obtained from the mixture of products?

Ans. (a) When superheated steam is passed through white hot coke, an endothermic reaction takes place with the formation of water gas.



(b) Iron (III) oxide acts as a catalyst in the water gas shift reaction when carbon monoxide is oxidised to carbon dioxide.

(c) The reaction is exothermic in nature. Thus, once started, no heating is required.

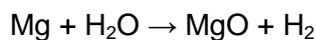
(d) It indicates that the reaction is reversible.

(e) The mixture is compressed to 30 atmospheric pressure and passed through water, when carbon dioxide dissolves to form carbonic acid, but hydrogen bubbles out.

30. (a) A metal in the powdered form reacts very slowly with boiling water, but decomposes steam. Name the metal and write balanced equation for the reaction.

(b) Metals A and B, liberate hydrogen from dilute hydrochloric acid, but C does not. Metal B is displaced from a solution of one of its salt by metal A, but not by metal C. Arrange the metals in the order of the activity series, with the most active metal first.

Ans. (a) The metal may be magnesium.



(b) A, B and C.

31. (a) When steam is passed over red hot iron, magnetic oxide of iron and hydrogen are obtained. The reaction between red hot iron and steam is called a “reversible reaction”. What is meant by this statement?

(b) When hydrogen burns in air, water is formed. Give two chemical tests to prove that water is formed.

(c) How can you obtain hydrogen from sodium hydroxide (Not by electrolysis)?

Ans. (a) It means that the products formed, if not removed will react back to form iron and steam.

(b) Water turns anhydrous copper sulphate blue. Water turns anhydrous cobalt chloride pink.

(c) Boil sodium hydroxide solution with zinc powder. It forms sodium zincate with the liberation of hydrogen. $2\text{NaOH} + \text{Zn} \rightarrow \text{Na}_2\text{ZnO}_2 + \text{H}_2$

32. There are two jars of hydrogen. One burns quietly, whereas other explodes with a pop sound. Explain the observation.

Ans. The jar which burns quietly contains pure hydrogen as the air from outside mixes slowly and does not form an explosive mixture. The jar in which hydrogen catches fire with a pop sound contains a mixture of hydrogen and air. As it is an explosive mixture, it suddenly catches fire, producing a loud explosion.

33. Thin strips of metals A, B and C are known to be magnesium, copper and iron respectively.

(a) Write down what you would observe in each case, when the metals are treated as follows :

(i) When each metal is heated in air.

(ii) When each metal is treated with dil. HCl and warmed if necessary.

(iii) When each metal is added to aqueous solution of zinc sulphate.

(b) Arrange the metals A, B and C in the decreasing order of activity series.

Ans. (a) (i) (1) The strip A will catch fire and burn with a dazzling white flame to form a white ash of magnesium oxide. (2) Strip B will be coated with a black coating of copper (II) oxide and the flame shows a non persistent green colour. (3) Strip C will glow and get covered with brown ferric oxide.

(ii) (1) The strip A will react briskly to form magnesium chloride solution and liberate hydrogen gas. (2) The strip B will show no reaction with HCl.

(3) The strip C will react slowly to form light green solution of iron (II) chloride, with the liberation of hydrogen gas.

(iii) (1) The strip A dissolves in the precipitate of zinc sulphate.

(2) The strip B will not show any reaction.

(3) The strip C will not show any reaction.

(b) A, C and B.

34. From the knowledge of the activity series name a metal :

(a) Which readily reacts with cold water giving hydrogen gas?

(b) Which displaces hydrogen from dil. sulphuric acid?

(c) Whose hydroxide is a strong base?

(d) Which displaces iron from iron (III) oxide?

Ans. **(a)** Sodium metal **(b)** Zinc metal **(c)** Sodium metal **(d)** Aluminium metal

35. Though hydrogen is lighter than air, it is not collected by the downward displacement of air. Why?

Ans. It is because, hydrogen forms an explosive mixture with air. Thus, in order to exclude air, it is collected over water.