3 Metals and Non-metals

Fastrack Revision

- Elements are mainly divided into two groups namely metals and non-metals, but there are certain elements which show properties of both metals as well as non-metals. These are known as **metalloids.**
- Elements which form positive ions by losing electrons are called metals.
- Metals are hard solid substances, malleable, ductile, sonorous and are good conductors of heat and electricity.
- Almost all the metals combine with oxygen (or air) to form metal oxides which are basic in nature.
- Sodium and potassium react so vigorously with oxygen that they catch fire if kept in the open. Hence, to prevent accidental fires, they are kept immersed in kerosene oil.
- Anodising is a process of forming a thick oxide layer on aluminium, which prevents the metal from corrosion.
- Most of the metal oxides are insoluble in water. But some of the metal oxides dissolve in water to form alkalis. Metal oxides which react with both acids as well as bases to produce salt and water are called **amphoteric oxides.** Aluminium oxide and zinc oxide are examples of amphoteric oxides.
- Metals react with water to produce respective metal hydroxides and hydrogen gas.

  Metal + Water ⟶ Metal oxide + Hydrogen

  Metal oxide + Water ⟶ Metal hydroxide
- Except a few less reactive metals (such as Cu, Hg, Ag, Pt, etc.), all metals react with dil. sulphuric acid and dil. hydrochloric acid to produce salt and hydrogen gas.
- Hydrogen gas is not evolved when a metal reacts with nitric acid because it is a strong oxidising agent.
- Reactive metal can displace a comparatively less reactive metal from its compounds in aqueous salt solution or in molten form.

  Metal A + Salt solution of B ⟶ Salt solution of A + Metal B
  (Metal A is more reactive than B)
- The reactivity series is a list of metals arranged in the order of their decreasing reactivity. The order of reactivity of metals is K > Na > Ca > Mg > Al > Zn > Fe > Pb > H > Cu > Ag > Au.

MNEMONICS

Concept: *How to remember reactivity series?*

Mnemonics: ***P****lease* ***S****end* ***C****ats* ***M****onkeys* ***A****nd* ***Z****ebras* ***I****n* ***L****ovely* ***H****appy* ***C****ages* ***M****ade of* ***S****ilver and* ***G****old.*

Interpretation:

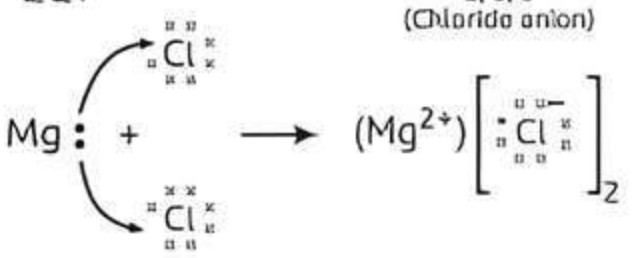
P – Potassium	*S – Sodium*	*C – Calcium*
M – Magnesium	*A – Aluminium*	*Z – Zinc*
I – Iron	*L – Lead*	*H – Hydrogen*
C – Copper	*M – Mercury*	*S – Silver*
G – Gold		

- **Non-metals** are those which form negative ions by gaining electrons.
- Non-metals occur in the form of solid, liquid or gas. They are non-malleable, non-ductile, non-sonorous in nature and are poor conductors of heat and electricity except graphite.
- Non-metals react with oxygen to form acidic oxides or neutral oxides.
- Non-metals do not usually react with water or steam but the non-metal oxides react with water to form acids.
- Non-metals do not react with dilute acids to release hydrogen gas.
- The compounds formed due to the transfer of electrons from a metal to a non-metal are known as **ionic compounds** or electrovalent compounds.

Formation of Magnesium Chloride:

$$\underset{2,8,2}{Mg} \longrightarrow \underset{\substack{2,8\\(\text{Magnesium cation})}}{Mg^{2+}} + 2e^-$$

$$\underset{2,8,7}{Cl} + e^- \longrightarrow \underset{\substack{2,8,8\\(\text{Chloride anion})}}{Cl^-}$$



Properties of Ionic Compounds:

- They are generally solid and hard because of the strong force of attraction between the positive and negative ions.
- They have high melting and boiling point.
- They are soluble in water but insoluble in solvents such as petrol etc.
- They do not conduct electricity in solid state but conduct electricity in molten state.

Occurrence of Metals:

- The naturally occurring compounds of the metals in the earth's crust are called **minerals.**
- Those minerals from which metals can be extracted conventionally and economically are called **ores**. The process of extraction of metals from their ores is called **metallurgy**.
- **Extraction of Metals:**

Position	Metal	Process and Example
Metals of low reactivity	Hg	**Heated in air:** $2HgS(s) + 3O_2(g) \xrightarrow{\text{Heat}} 2HgO(s) + 2SO_2(g)$ $2HgO(s) \xrightarrow{\text{Heat}} 2Hg(l) + O_2(g)$

	Cu	**Heated in air:** $2Cu_2S(s) + 3O_2(g) \xrightarrow{Heat} 2Cu_2O(s) + 2SO_2(g)$ $2Cu_2O(s) + Cu_2S(s) \xrightarrow{Heat} 6Cu(s) + SO\ (g)$
Metals of medium reactivity	Zn	**Roasting:** $2ZnS(s)\ \ 3O\ (g) \xrightarrow{Heat} 2ZnO(s) + 2SO_2(g)$ **Calcination:** $ZnCO_3(s) \xrightarrow{Heat} ZnO(s) + CO_2(g)$ **Reduction using carbon:** $ZnO(s) + C(s) \longrightarrow Zn(s) + CO(g)$
	Mn	**Reduction using aluminium:** $3MnO_2(s) + 4Al(s) \longrightarrow 3Mn(l) + 2Al_2O_3(s) + Heat$
	Fe	$Fe_2O_3(s) + 2Al(s) \longrightarrow 2Fe(l) + Al_2O_3(s) + Heat$
Metals of high reactivity	Na Mg Ca	**Electrolysis of their molten chlorides:** At cathode: $Na^+ + e^- \longrightarrow Na$ At anode: $2Cl^- \longrightarrow Cl_2 + 2e^-$
	Al	Electrolytic reduction of aluminium oxide
Metals at bottom of activity series	Au Pt Ag	Found in the free state.

The process of purification of the metal obtained after reduction is called refining of metals.

- **Electrolytic Refining:** In this process, impure metal is made the anode, thin strip of pure metal is made the cathode and a solution of metal salt is used as an electrolyte. On passing current through the electrolyte, pure metal gets deposited on the cathode and insoluble impurities settle at the bottom of the anode (known as anode mud).
- **Corrosion:** is the slow process of eating away of metals by the reaction of atmospheric air and moisture.
- **Rusting of Iron:** can be prevented by galvanising, by making alloys, painting, greasing or oiling and tin-plating or chromium-plating.
- The process of coating iron and steel objects with a thin layer of zinc is called galvanisation.
- An alloy is a homogeneous mixture of two or more metals or a metal and a non-metal *e.g.*, stainless steel (Iron + Nickel + Chromium), Brass (Copper + Zinc) etc. An amalgam is an alloy in which one of the metals is mercury.

Practice Exercise

Multiple Choice Questions

Q 1. Among the following, the metal with lowest density is: *(CBSE 2023)*

a. Lithium b. Lead
c. Magnesium d. Aluminium

Q 2. A cable manufacturing unit tested few elements on the basis of their physical properties.

Properties	W	X	Y	Z
Malleable	Yes	No	No	Yes
Ductile	Yes	No	No	Yes
Electrical Conductivity	Yes	Yes	Yes	No
Melting Point	High	Low	Low	High

Which of the above elements were discarded for usage by the company? *(CBSE SQP 2021 Term-1)*

a. *W, X, Y* b. *X, Y, Z* c. *W, X, Z* d. *Y, X, Z*

Q 3. An element with atomic number ..... will form a basic oxide. *(CBSE SQP 2023-24)*

a. 7 (2, 5) b. 17 (2, 8, 7)
c. 14 (2, 8, 4) d. 11 (2, 8, 1)

Q 4. The given table shows the reaction of a few elements with acids and bases to evolve Hydrogen gas. *(CBSE SQP 2021 Term-1)*

Element	Acid	Base
A.	✗	✗
B.	✓	✓
C.	✓	✗
D.	✓	✓

Which of these elements form amphoteric oxides?

a. *A* and *D* b. *B* and *D* c. *A* and *C* d. *B* and *C*

Q 5. Which of the following oxide(s) is/are soluble in water to form alkalies? *(CBSE 2021 Term-1)*

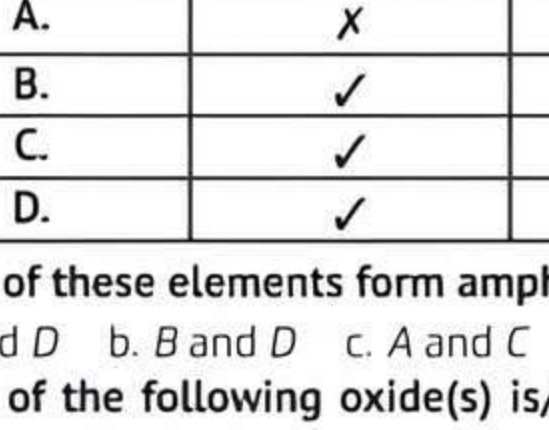
(i) Na_2O (ii) SO_2 (iii) K_2O (iv) NO_2

a. (I) and (III) b. Only (I)
c. (II) and (IV) d. Only (III)

Q 6. Which of the following oxide(s) of iron would be obtained on prolonged reaction of iron with steam? *(NCERT EXEMPLAR)*

a. FeO b. Fe_2O_3
c. Fe_3O_4 d. Fe_2O_3 and Fe_3O_4

Q 7.

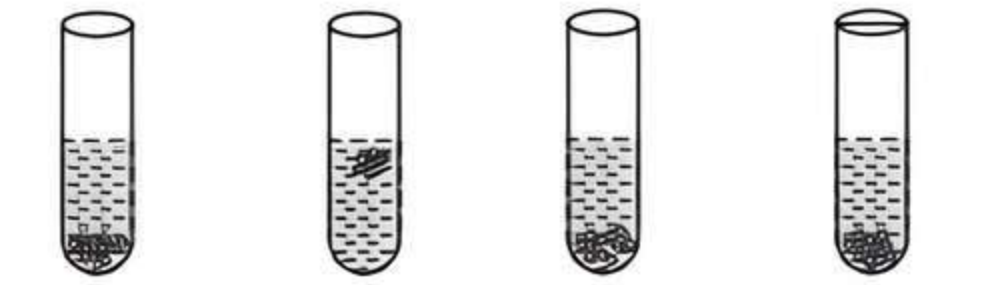


Which of the following two combinations are correct?

	Metal	Gas Evolved
(I)	Copper	Yes
(ii)	Iron	Yes
(iii)	Magnesium	No
(iv)	Zinc	Yes

a. I and Iii b. I and Iv
c. ii and iii d. ii and iv

Q 8. The diagram shows the reaction between metal and dil. acid. *(CBSE SQP 2021 Term-1)*



What is the reason for different behaviour of Mg in test tube *B*?

a. Mg is lighter element than dil. HCl
b. Mg reacts with dil. HCl to produce H_2 gas which helps in floating
c. Mg reacts with dil. HCl to produce N_2 gas which helps in floating
d. Mg reacts with dil. HCl to produce CO_2 gas which helps in floating

Q 9. On adding dilute sulphuric acid to a test tube containing a metal '*X*', a colourless gas is produced when a burning match stick is brought near it. Which of the following correctly represents metal '*X*'? *(CBSE SQP 2023-24)*

a. Sodium b. Zinc
c. Copper d. Silver

Q 10. The colour of the solution observed after 30 minutes of placing zinc metal to copper sulphate solution is: *(CBSE SQP 2023-24)*

a. Blue b. Colourless
c. Dirty green d. Reddish Brown

Q 11. The pair(s) which will show displacement reaction is/are:

(i) NaCl solution and copper metal
(ii) $AgNO_3$ solution and copper metal
(iii) $Al_2(SO_4)_3$ solution and magnesium metal
(iv) $ZnSO_4$ solution and iron metal *(CBSE 2021 Term-1)*

a. Only (ii) b. (ii) and (iii)
c. (iii) and (iv) d. (i) and (ii)

Q 12. Which of the following are not ionic compounds? *(NCERT EXEMPLAR)*

(i) KCl **(ii) HCl**
(iii) CCl_4 **(iv) NaCl**

a. (i) and (ii) b. (ii) and (iii)
c. (iii) and (iv) d. (i) and (iii)

Q 13. The table shown below gives information about four substances: *A*, *B*, *C* and *D*.

Substance	Melting Point (K)	Electrical Conductivity	
		Solid	Liquid/Aqueous
A	295	Good	Good
B	1210	Poor	Good
C	1890	Poor	Good
D	1160	Poor	Poor

Identify Ionic compounds from the above given substances. *(CBSE SQP 2021 Term-1)*

a. *A*, *B* b. *B*, *C* c. *A*, *B*, *D* d. *A*, *C*, *D*

Q 14. Which one of the following structures correctly depicts the compound $CaCl_2$? *(CBSE 2021 Term-1)*

a. $Ca^{2+}\left[:\ddot{Cl}:\right]^{2-}$ b. $\left[:\ddot{Ca}:\right]^{2+}\left[:\ddot{Cl}:\right]_2$
c. $Ca^{2+}\left[:\ddot{Cl}:\right]^{-}_2$ d. $\left[:\ddot{Ca}:\right]^{0}\left[:\ddot{Cl}:\right]_2$

Q 15. Which one of the following correctly represents sodium oxide? *(CBSE SQP 2023-24)*

a. $Na^{+2}\,2\left[:\ddot{O}:\right]^{-2}$ b. $2Na^{+}\left[:\ddot{O}:\right]^{-2}$
c. $2Na^{+}\,2\left[:\ddot{O}:\right]^{-1}$ d. $Na^{+1}\left[:\ddot{O}:\right]^{-2}$

Q 16. An element '*M*' has 50% of the electrons filled in the 3rd shell as in the 2nd shell. The atomic number of '*M*' is: *(CBSE SQP 2023-24)*

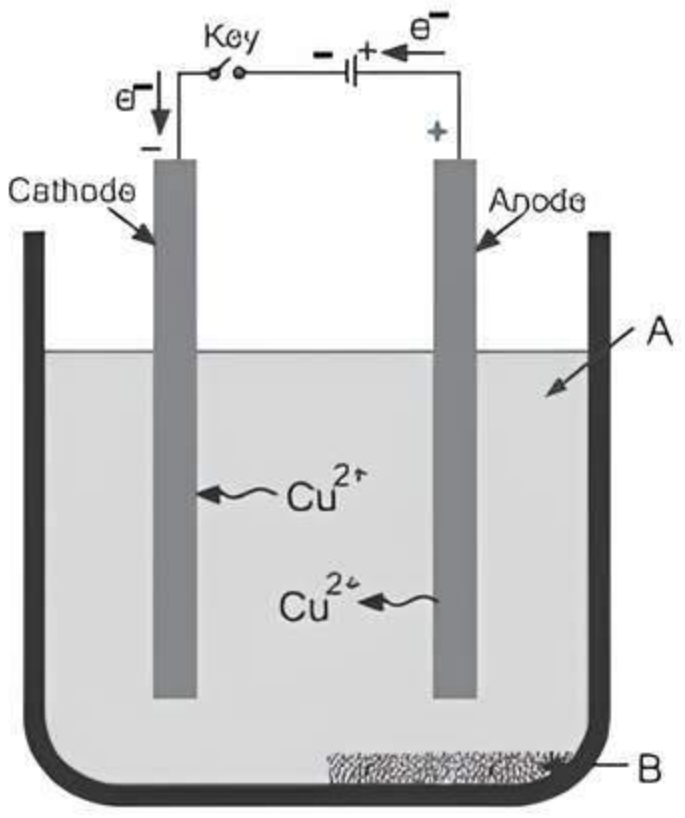
a. 10 b. 12 c. 14 d. 18

Q 17. Which of the following metals exist in their native state in nature? *(NCERT EXEMPLAR)*

(i) Ca (ii) Au (iii) Zn (iv) Ag

a. (i) and (ii) b. (ii) and (iii)
c. (ii) and (iv) d. (iii) and (iv)

Q 18. A diagram of refining impure metals is given below:



The statement which defines the system and its parts is:

a. this is an ideal setting of electrolytic refining of copper with *A* = acidified $CuSO_4$ solution and *B* = anode mud
b. this is an ideal setting of electrolytic refining of copper with *A* = manganese dioxide and *B* = anode mud

c. this is an ideal setting of thermite process with *A* = iron (III) oxide and *B* = impurities
d. this is showing a salt solution with A = graphite rod and B = impurities

Q 19. Galvanisation is a method of protecting iron from rusting by coating with a thin layer of: *(NCERT EXEMPLAR)*

a. gallium b. aluminium
c. zinc d. silver

Q 20. Match the alloys given in column (A) with their composition given in column (B).

	Column (A)		Column (B)
A.	Stainless steel	(i)	Pb + Sn
B.	Solder	(ii)	Cu + Zn
C.	Brass	(iii)	Cu + Sn
D.	Bronze	(iv)	Fe + Ni + Cr

a. *A*-(ii), *B*-(i), *C*-(iv), *D*-(iii) b. *A*-(iv), *B*-(i), *C*-(iii), *D*-(ii)
c. *A*-(iii), *B*-(iv), *C*-(i), *D*-(ii) d. *A*-(iv), *B*-(i), *C*-(ii), *D*-(iii)

Assertion & Reason Type Questions

Directions (Q. Nos. 21-30): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is a correct explanation of Assertion (A).
b. Both Assertion (A) and Reason (R) are true but Reason (R) is not a correct explanation of Assertion (A).
c. Assertion (A) is true but Reason (R) is false.
d. Assertion (A) is false but Reason (R) is true.

Q 21. Assertion (A): Metals are good conductors of heat.
Reason (R): Silver and copper are poor conductors of heat.

Q 22. Assertion (A): Aluminium oxide is an amphoteric oxide.
Reason (R): Anodising is a process of forming a thick oxide layer of aluminium.

Q 23. Assertion (A): Calcium floats in water.
Reason (R): Calcium reacts with water to form hydrogen gas and bubbles of H_2 gas stick to the calcium metal surface.

Q 24. Assertion (A): Zinc fails to evolve hydrogen gas on reacting with diL nitric acid.
Reason (R): DiLHNO_3 is an oxidising agent and zinc gives no when reacts with it.

Q 25. Assertion (A): Different metals have different reactivities with water and dilute acids.
Reason (R): Reactivity of a metal depends on its position in the reactivity series.

Q 26. Assertion (A): Ionic compounds have high melting and boiling points.
Reason (R): A large amount of energy is required to break the strong inter-ionic attraction in ionic compounds.

Q 27. Assertion (A): Metals low in the reactivity series are very unreactive. The oxides of these metals can be reduced to metals by heating alone.
Reason (R): Cinnabar when heated in air first gets converted into mercuric oxide which is then reduced to mercury on further heating.

Q 28. Assertion (A): The reaction of Fe_2O_3 with Al is known as thermite reaction. This is used to join railway tracks or cracked machine parts.
Reason (R): The reaction is highly exothermic.

Q 29. Assertion (A): Sodium, calcium and magnesium are obtained by the electrolysis of their molten oxides.
Reason (R): These metals have more affinity for oxygen than carbon. *(CBSE 2023)*

Q 30. Assertion (A): Pure gold, known as 24 carat gold, is not suitable for making jewellery.
Reason (R): Pure gold is very soft.

Answers

1. (a) Alkali metals (lithium, sodium) have low densities.

2. (b) *X* and *Y* are discarded because they are not malleable and ductile. *Z* is discarded because it does not conduct electricity.

3. (d) We know that metals form basic oxides and metals have 1, 2, or 3 valence electrons.
∴ 11 (2, 8, 1) (or Na) will form a basic oxide.

4. (b) Only elements *B* and *D* reacts with both acid and base. Thus, they are amphoteric oxides.

5. (a) (i) and (iii)

6. (c) $3Fe(s) + 4H_2O(g) \longrightarrow Fe_3O_4(s) + 4H_2(g)$

7. (d) Copper does not react with dilute HCL whereas Magnesium reacts rapidly with dilute HCl to give a salt and hydrogen gas.

8. (b) Mg reacts with diL HCl to produce H_2 gas which helps in floating.

9. (a) Sodium

10. (b) $Zn + \underset{\text{Blue}}{CuSO_4} \longrightarrow \underset{\text{Colourless}}{ZnSO_4} + Cu$

11. (b) $NaCl + Cu \longrightarrow$ No reaction
$2AgNO_3 + Cu \longrightarrow Cu(NO_3)_2 + 2\,Ag$
$Al_2(SO_4)_3 + 3Mg \longrightarrow 3MgSO_4 + 2Al$
$ZnSO_4 + Fe \longrightarrow$ No reaction

12. (b) HCl and CCl_4 are covalent compounds, where the compound is formed by mutual sharing of electrons.

13. (b) B, C

14. (c) $Ca^{2+}\left[:\underset{\cdot\cdot}{\overset{\cdot\cdot}{\underset{\cdot\cdot}{\overset{\cdot\cdot}{Cl}}}}:\right]^-_2$

15. (b) $2Na^+\left[:\overset{\cdot\cdot}{\underset{\cdot\cdot}{O}}:\right]^{2-}$

16. (c)

Atomic Number	Electronic Configuration		
	K	L	M
10	2	8	
12	2	8	2
14	2	8	4
18	2	8	8

Electrons filled in L (2^{nd}) shell = 8

50% of electrons filled in L shell $= \frac{50}{100} \times 8$

$= 4$

∴ Element M (atomic no = 14) has 50% of the electrons filled in the 3rd shell as in the 2nd shell.

17. (c) (ii) and (iv)

18. (a) this is an ideal setting of electrolytic refining of copper with A = acidified $CuSO_4$ solution and B = anode mud

19. (c) zinc

20. (d) A-(iv), B-(i), C-(ii), D-(iii)

21. (c) Reason (R) is false because silver and copper are best conductors of heat.

22. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not a correct explanation of Assertion (A).

23. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is a correct explanation of Assertion (A).

24. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is a correct explanation of Assertion (A).

25. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is a correct explanation of Assertion (A).

26. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is a correct explanation of Assertion (A).

27. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not a correct explanation of Assertion (A).

28. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is a correct explanation of Assertion (A).

29. (d) Assertion (A) is false because sodium, magnesium and calcium are obtained by the electrolysis of their molten chlorides.

30. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is a correct explanation of Assertion (A).

Case Study Based Questions ↘

Case Study 1

Metals are lustrous, malleable, ductile and are good conductors of heat and electricity. They are solids at room temperature, except mercury which is a liquid. Metals combine with oxygen to form basic oxides. Different metals have different reactivities with water and dilute acids. Non-metals have properties opposite to that of metals.

Read the above passage carefully and give the answer of the following questions:

Q 1. The ability of metals to be drawn into thin wire is known as:

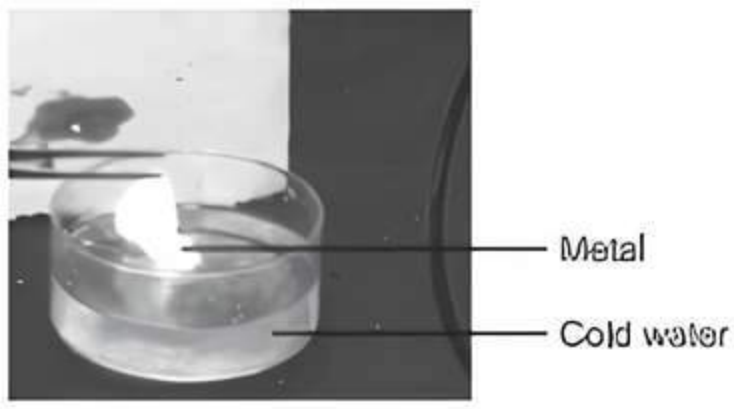
a. conductivity b. malleability
c. sonority d. ductility

Q 2. Which of the following metals do not react with oxygen even at high temperatures?

(i) Ag (ii) Al
(iii) Au (iv) Fe

a. (i) and (iv) b. (iii) and (iv)
c. (i) and (iii) d. (i) and (ii)

Q 3. Study the image below that shows the reaction of a metal with cold water.



Which of the following metal explains this event?

a. K b. Ca
c. Mg d. Fe

Q 4. Which among the following statements is incorrect for magnesium metal?

a. It burns in oxygen with a dazzling white flame
b. It reacts with cold water to form magnesium oxide and evolves hydrogen gas
c. Both a. and b.
d. It reacts with hot water to form magnesium hydroxide and evolves hydrogen gas

Q 5. Generally metals react with acids to give salt and hydrogen gas. Which of the following acids does not give hydrogen gas on reacting with metals (except Mn and Mg)?

a. H_2SO_4 b. HCl
c. HNO_3 d. All of these

Answers

1. (d) ductility
2. (c) (i) and (iii)
3. (a) K
4. (b) It reacts with cold water to form magnesium oxide and evolves hydrogen gas
5. (c) HNO_3

Case Study 2

A student, took four metals *P*, *Q*, *R* and *S* and carried out different experiments to study the properties of metals. Some of the observations were.

(i) All metals could not be cut with knife except metal *R*.

(ii) Metal *P* combined with oxygen to form an oxide M_2O_3 which reached with both acids and bases.

(iii) Reaction with water.

P — Did not react either with cold or hot water but reacted with steam

Q — Reacted with hot water and the metal started floating

R — Reacted violently with cold water

S — Did not react with water at all

Read the above passage carefully and give the answer of the following questions:

(CBSE 2021 Term-1)

Q 1. Out of the given metals, the one which needs to be stored under kerosene is:

a. *P* b. *R*

c. *S* d. *Q*

Q 2. Out of the given metals, the metal *Q* is:

a. Iron b. Zinc

c. Potassium d. Magnesium

Q 3. Metal which forms amphoteric oxides is:

a. *P* b. *Q* c. *R* d. *S*

Q 4. The increasing order of the reactivity of the four metals is:

a. $P < Q < R < S$ b. $S < R < Q < P$

c. $S < P < Q < R$ d. $P < R < Q < S$

Answers

1. (b) *R*
2. (d) magnesium
3. (a) *P*
4. (c) $S < P < Q < R$

Case Study 3

Study the given table and answer the following questions: A student took the samples of four metals *A*, *B*, *C* and *D* and added following solution one by one. The results obtained have been tabulated as follows:

Metal	Iron (II) sulphate	Copper (II) sulphate	Zinc sulphate	Silver nitrate
A	No reaction	Displacement	—	—
B	Displacement	—	No reaction	—
C	No reaction	No reaction	No reaction	Displacement
D	No reaction	No reaction	No reaction	No reaction

Read the above passage carefully and give the answer of the following questions:

Q 1. Which is the least reactive metal and why?

Q 2. Which is the most reactive metal and why?

Q 3. Arrange the metals *A*, *B*, *C* and *D* in order of increasing reactivity.

Q 4. Write the chemical formulae of product formed when *C* reacts with AgCl solution.

Q 5. What would be observed, if '*B*' is added to a solution of copper (II) sulphate and why?

Answers

1. *D* is the least reactive metal as it has not displaced any metal amongst the solutions.
2. *B* is the most reactive metal as it has displaced the most reactive metal amongst the solutions. *i.e.*, Fe of $FeSO_4$.
3. $D < C < A < B$
4. When C reacts with AgCl, Ag and CCl_2 are formed.
5. The blue colour of $CuSO_4$ solution fades away.

   If *B* is added to $CuSO_4$ solution, it will displace Cu because *B* has displaced Fe, so it can also displace Cu.

Case Study 4

The melting points and boiling points of some ionic compounds are given below:

Compound	Melting Point (K)	Boiling Point (K)
NaCl	1074	1686
LiCl	887	1600
$CaCl_2$	1045	1900
CaO	2850	3120
$MgCl_2$	981	1685

These compounds are termed ionic because they are formed by the transfer of electrons from a metal to a non-metal. The electron transfer in such compounds is controlled by the electronic configuration of the elements involved. Every element tends to attain a completely filled valence shell of its nearest noble gas or a stable octet.

Read the above passage carefully and give the answer of the following questions:

Q 1. Show the electron transfer in the formation of magnesium chloride.

Q 2. List two properties of ionic compounds other than their high melting and boiling points.

Q 3. While forming an ionic compound say sodium chloride how does sodium atom attain its stable configuration?

Or

Give reasons:

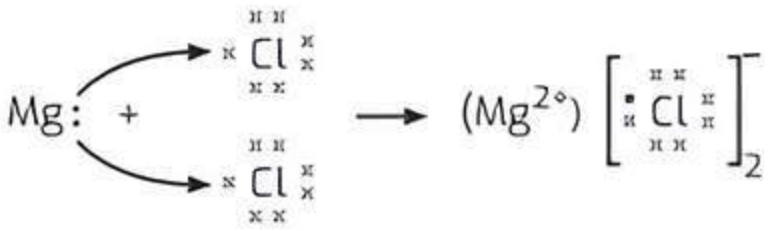
(i) Why do ionic compounds in the solid state not conduct electricity?

(ii) What happens at the cathode when electricity is passed through an aqueous solution of sodium chloride? *(CBSE 2023)*

Answers

1. $Mg \underset{2,8,2}{\dashrightarrow} Mg^{2+} \underset{2,8}{} + 2e^-$

   $Cl \underset{2,8,7}{} + e^- \longrightarrow Cl^- \underset{2,8,8}{}$



2. (a) Ionic compounds are solids, hard and brittle.
(b) They are soluble in water and insoluble in solvents such as petrol, kerosene etc.

3. (A) The atomic number of sodium is 11, so its electronic configuration is 2, 8, 1. Sodium atom has only 1 electron in its outermost shell. A stable arrangement has usually 8 electrons in its outermost shell. Hence, in order to attain stable configuration, sodium atom donates 1 e^- to chlorine.

$$\underset{2,8,1}{Na} \longrightarrow \underset{2,8}{Na^+} + e^-$$

Or

(B) (i) Ionic compounds in the solid state do not conduct electricity because movement of ions in the solid is not possible due to their rigid structure.

(ii) When electricity is passed through an aqueous solution of sodium chloride, sodium ions move towards cathode and get deposited there.

At cathode : $Na^+ + e^- \longrightarrow Na$.

Case Study 5

Different methods are used for extracting metals of different reactivity.

Metal	Method of extraction
K, Na, Ca, Mg, Al	Electrolysis of molten chloride or oxide
Zn, Fe, Pb, Cu	Reduction of oxide with carbon
Cu, Hg	Heating sulphide in air (Reduction by heat alone)
Ag, Au, Pt	Found in native state (as metals)

Based on the above table, answer the following questions:

Q 1. Why is carbon not used for reducing aluminium from aluminium oxide?

Q 2. Why sulphide and carbonate ores are converted into oxides?

Q 3. Name the ore of mercury. How mercury is extracted from its ore?

Q 4. What is thermite reaction?

Q 5. Write a balanced chemical equation for representing the chemical reaction between manganese dioxide and aluminium powder.

Answers

1. Because aluminium has more affinity for oxygen than carbon.
2. Because it is easier to obtain a metal from its oxide, as compared to its sulphides and carbonates.
3. Cinnabar (HgS) is an ore of mercury.

Extraction: $2HgS + 3O_2 \xrightarrow{Heat} 2HgO + 2SO_2$

$$2HgO \xrightarrow{Heat} 2Hg + O_2$$

4. Reduction of iron oxide to iron by aluminium is called thermite reaction.

$$Fe_2O_3 + 2Al \longrightarrow 2Fe + Al_2O_3 + Heat$$

5. $3MnO_2 + 4Al \longrightarrow 3Mn + 2Al_2O_3 + Heat$

Case Study 6

Two students decided to investigate the effect of water and air on iron object under identical experimental conditions. They measured the mass of each object before placing it partially immersed in 10 mL of water. After a few days, the object were removed, dried and their masses were measured. The table shows their results.

Student	Object	Mass of Object before Rusting (in g)	Mass of the coated object (in g)
A	Nail	3.0	3.15
B	Thin plate	6.0	6.33

Read the above passage carefully and give the answers of the following questions:

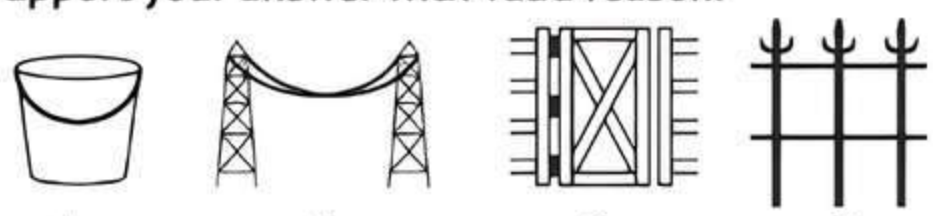
Q 1. What might be the reason for the varied observations of the two students?

Q 2. In another set up, the students coated iron nails with zinc metal and noted that, iron nails coated with zinc prevents rusting. They also observed that zinc initially acts as a physical barrier, but an extra advantage of using zinc is that it continues to prevent rusting even if the layer of zinc is damaged. Name this process of rust prevention and give any two other methods to prevent rusting.

Or

In which of the following applications of Iron, rusting will occur most?

Support your answer with valid reason.



A B C D

A - Iron Bucket electroplated with Zinc
B - Electricity cables having iron wires covered with aluminium
C - Iron hinges on a gate
D - Painted Iron fence *(CBSE SQP 2022-23)*

Answers

1. Rusting occurs in both *A* and *B* so there is an increase in mass.
As the surface area of B is more, so extent of rusting is also more.
2. Galvanisation is the process of applying zinc coating to iron to prevent rusting.
Two other methods to prevent rusting are:

(I) Greasing, (II) Painting, (III) Alloying, (Iv) Chromium plating. (Any two)

Or

C-iron hinges on a gate because Iron is in contact with both atmospheric oxygen and moisture.

Very Short Answer Type Questions ↘

Q 1. Give two examples each of the metals that are good conductors and poor conductors of heat respectively.

Ans. Silver and copper are good conductors of heat. Lead and mercury are poor conductors of heat.

Q 2. Which of the following metals will melt at body temperature?

Gallium, Magnesium, Caesium, Aluminium.

Ans. Gallium and caesium metals will melt at body temperature (37°C).

Q 3. Name a non-metal which is lustrous and a metal which is non-lustrous.

Ans. Iodine is a lustrous non-metal and lead is a non-lustrous metal.

Q 4. A non-metal X exists in two different forms Y and Z. Y is the hardest natural substance, whereas Z is a good conductor of electricity. Identify X, Y and Z.

(NCERT EXEMPLAR)

Ans. X is carbon, Y is diamond and Z is graphite.

Q 5. An element forms an oxide A_2O_3, which is acidic in nature. Identify A as a metal or non-metal.

Ans. Since the oxide is acidic in nature, therefore A will be a non-metal.

Q 6. Why sodium is kept immersed in kerosene oil?

Ans. Sodium is a very reactive element. It reacts so vigorously with oxygen that it catches fire easily if kept in the open. So, to protect sodium and to prevent accidental fires, it is kept immersed in kerosene oil.

Q 7. Why does calcium float in water?

Ans. Calcium reacts with water to produce hydrogen gas. Although, calcium is heavier than water, but due to the sticking of the H_2 gas bubbles on calcium metal surface, it starts floating.

Q 8. From amongst the metals sodium, calcium, aluminium, copper and magnesium, name the following:

(i) metal that reacts with hot water.

(ii) another metal which does not react even with steam.

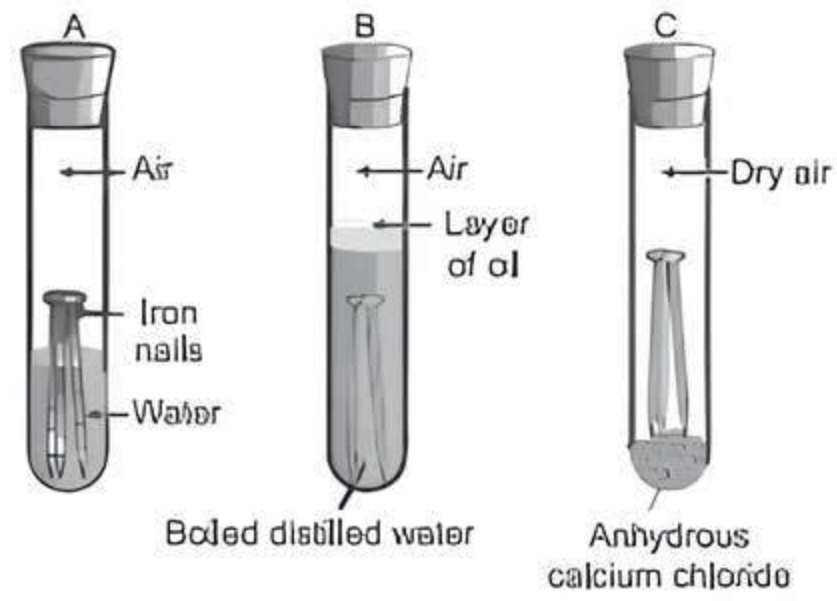
Ans. (i) Magnesium reacts with hot water.

(ii) Copper does not react even with steam.

Q 9. Why should the metal sulphides and carbonates be converted to metal oxides in the process of extraction of metal from them?

Ans. It is easier to obtain metal from its oxide, as compared to its sulphides and carbonates so metal sulphides and carbonates should be converted to metal oxides during extraction.

Q 10. In the arrangement shown below there are three test tubes marked *A*, *B* and *C*. Few clean iron nails are placed in these tubes. Water is poured in test tube *A*, boiled distilled water and 1 mL of oil are poured in test tube *B* and anhydrous calcium chloride is added in test tube *C*.



What are the two observations that can be observed after a few days from the given arrangement?

Ans. The two observations are:

(i) Iron nails rust in test tube *A* as the nails are exposed to both air and water.

(ii) Iron nails do not rust in test tubes B and C because the nails are not exposed to air in test tube *B* and not exposed to either air or water in test tube *C*.

Q 11. What are the constituents of solder alloy? Which property of solder makes it suitable for welding electrical wires?

Ans.

TiP

Make a list of alloys and learn the mixture of their metals along with their names.

Solder is an alloy of lead and tin. Low melting point of solder makes it suitable for welding electrical wires.

Short Answer Type-I Questions ↘

Q 1. Name one metal and one non-metal that exist in liquid state at room temperature. Also name two metals having melting point less than 310 K (37°C).

Ans. Mercury (metal) and Bromine (non-metal) exist in liquid state at room temperature.

Two metals with melting point less than 310 K are Gallium (Ga) and Caesium (Cs).

Q 2. What are amphoteric oxides? Give two examples of amphoteric oxides. *(NCERT EXERCISE)*

Ans. The metal oxides which react with both acids as well as bases to produce salts and water are known as amphoteric oxides.

Aluminium oxide and zinc oxide show both acidic as well as basic behaviour and are amphoteric oxides.

Q 3. *A* metal *A*, which is used in thermite process, when heated with oxygen gives an oxide *B*, which is amphoteric in nature. Identify *A* and *B*. Write down the reactions of oxide B with HCl and NaOH.

(NCERT EXEMPLAR)

Ans. '*A*' is aluminium and '*B*' is Al_2O_3.

$$Al_2O_3 + 6HCl \longrightarrow 2AlCl_3 + 3H_2O$$

$$Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$$

COMMON ERROR

Students often write unbalanced chemical equations.

Q 4. Keerti added dilute Hydrochloric acid to four metals and recorded her observations as shown in the table given below:

Metal	Gas Evolved
Copper	Yes
Iron	Yes
Magnesium	No
Zinc	Yes

Select the correct observation(s) and give chemical equation(s) of the reaction involved.

(CBSE SQP 2022-23)

Ans. We know that metals react with acids to give a salt and hydrogen gas. Also, copper does not react with dilute HCl.

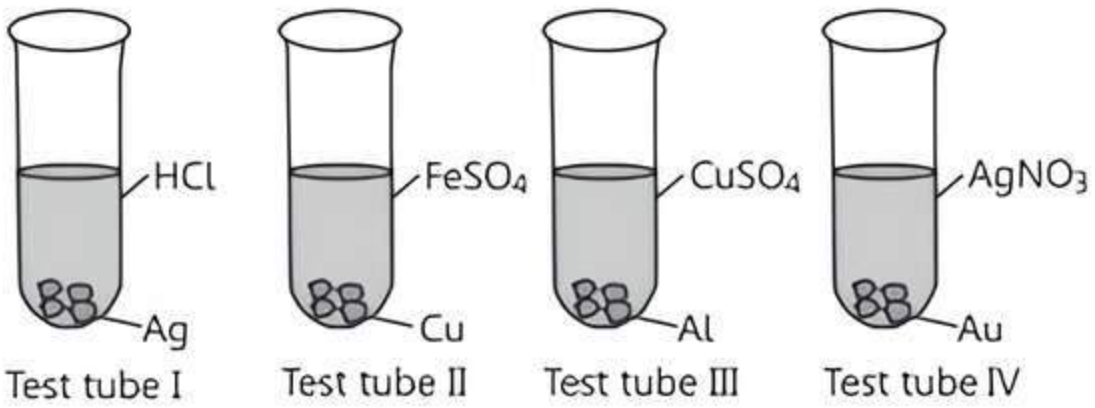
Therefore, observation (ii) and (iv) are correct.

Chemical Equations:

$Fe + 2HCl \longrightarrow FeCl_2 + H_2$

$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

Q 5. A student performs the following four experiments.



Test tube I Test tube II Test tube III Test tube IV

Based on the above experiments:

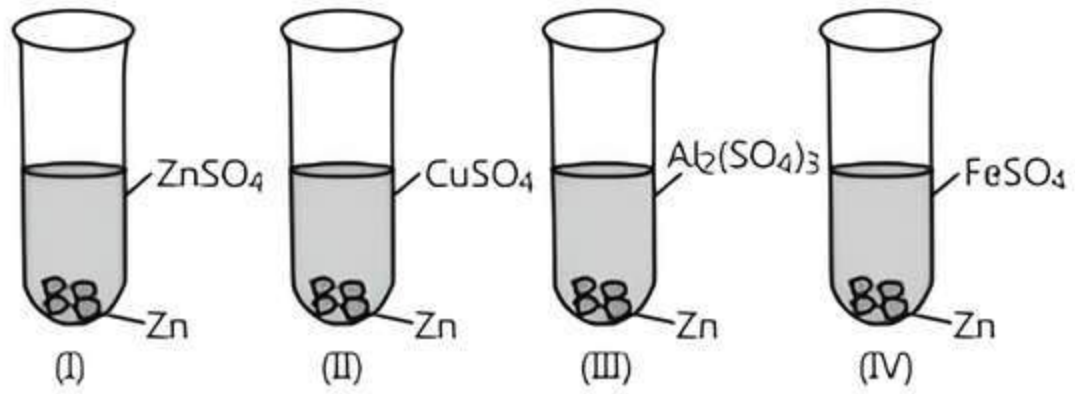
(i) In which test tube(s) no reaction occurred? Give reason.

(ii) Arrange the given metal samples in the increasing order of reactivity.

Ans. (i) Reaction does not occur in test tube I, II and IV because a less reactive metal cannot displace a more reactive metal from its compounds in solution form.

(ii) Au < Ag < Cu < Al is the increasing order of reactivity.

Q 6. Zinc granules were added to zinc sulphate, copper sulphate, aluminium sulphate and iron sulphate solutions as shown in the given test tubes:



(I) (II) (III) (IV)

Based on the given information:

(i) In which test tubes would you observe the deposition of metal on zinc? Give reason.

(ii) Arrange Zn, Cu, Al and Fe in the increasing order of reactivity.

Ans. (i) We would observe the deposition of metal on zinc in test tubes II and IV.

Reason: Displacement reactions take place in test tube II and IV because Zn is more reactive than Cu and Fe, leading to deposition of Cu and Fe respectively on zinc in test tube II and IV.

(ii) Cu < Fe < Zn < Al is the increasing order of reactivity.

Q 7. Show the formation of Na_2O by transfer of electrons.

Ans.

TiP

Learn the electronic configuration of metals and understand the concept of formation of ionic compounds.

$$Na \longrightarrow Na^+ + e^-$$

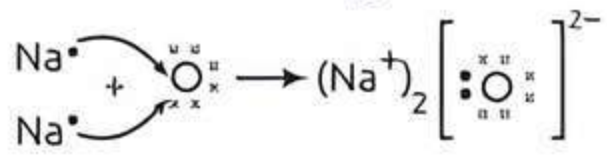
2, 8, 1 2, 8

Sodium cation

$$O + 2e^- \longrightarrow O^{2-}$$

2, 6 2, 8

Oxygen anion



Q 8. A metal that exists as a liquid at room temperature is obtained by heating its sulphide in the presence of air. Identify the metal and its ore and give the reaction involved. *(NCERT EXEMPLAR)*

Ans. Mercury is the only metal that exists as liquid at room temperature. Cinnabar (HgS) is an ore of mercury.

The reactions are as follows:

$$2HgS(s) + 3O_2(g) \xrightarrow{Heat} 2HgO(s) + 2SO_2(g)$$

$$2HgO(s) \xrightarrow{Heat} 2Hg(l) + O_2(g)$$

Q 9. The following reaction takes place when aluminium powder is heated with MnO_2:

$$3MnO_2(s) + 4Al(s) \dashrightarrow 3Mn(l) + 2Al_2O_3(l) + Heat$$

(I) Is aluminium getting reduced?

(ii) Is MnO_2 getting oxidised?

Ans. (i) No, because oxygen is added to aluminium, therefore, it is getting oxidised.

(ii) No, since manganese has lost oxygen therefore, it is getting reduced.

Q 10. Compound *X* and aluminium are used to join railway tracks.

(i) Identify the compound *X*.

(ii) Name the reaction.

(iii) Write down its reaction.

Ans. (i) The compound 'X' is iron (III) oxide (Fe_2O_3).

(ii) The reaction is known as thermite reaction.

(iii) $Fe_2O_3\,(s) + 2Al\,(s) \longrightarrow 2Fe\,(l) + Al_2O_3\,(s) + Heat$

TiP

Practice all the reactions used for obtaining metals of low, medium and high reactivity.

Q 11. During extraction of metals, electrolytic refining is used to obtain pure metals.

(i) Which material will be used as anode and cathode for refining of silver metal by this process?

(ii) Suggest a suitable electrolyte also.

(iii) In this electrolytic cell, where do we get pure silver after passing electric current?

Ans. (i) In electrolytic refining, impure silver is made the anode and a thin strip of pure silver is made the cathode.

(ii) A solution of silver salt (like $AgNO_3$) is used as an electrolyte.

(iii) Pure silver is deposited on the cathode in this electrolytic cell.

Short Answer Type-II Questions

Q 1. Write one example of each of the following:

(i) Most malleable metal and most ductile metal.

(ii) The best conductor of heat and the poorest conductor of heat.

(iii) A metal with highest melting point and a metal with lowest melting point. *(CBSE 2016)*

Ans. (i) Gold is the most malleable and the most ductile metal.

(ii) Silver is the best conductor and lead is the poorest conductor of heat.

(iii) Tungsten has the highest melting point and mercury has the lowest melting point.

Q 2. State three reasons for the following facts:

(i) Sulphur is a non-metal.

(ii) Magnesium is a metal.

One of these reasons must be supported with a chemical equation. *(CBSE 2015)*

Ans. (i) Sulphur is a Non-metal:

(a) It is a poor conductor of heat and electricity.

(b) It is neither malleable nor ductile.

(c) It forms acidic oxides.

$$S + O_2 \longrightarrow SO_2$$

$$SO_2 + H_2O \longrightarrow H_2SO_3 \text{ (Sulphurous acid)}$$

SO_2 is an acidic oxide.

(ii) Magnesium is a Metal:

(a) It is a good conductor of heat and electricity.

(b) It is malleable and ductile.

(c) It forms basic oxides.

$$2Mg + O_2 \longrightarrow 2MgO$$

$$MgO + H_2O \longrightarrow Mg(OH)_2$$

Magnesium hydroxide

MgO is basic in nature.

Q 3. Explain the following statements:

(i) Most metal oxides are insoluble in water but some of these dissolve in water. What are these oxides and their solutions in water called?

(ii) At ordinary temperature, the surface of metals such as magnesium, aluminium, zinc, etc. is covered with a thin layer. What is the composition of this layer? State its importance.

(iii) Some alkali metals can be cut with a knife. *(CBSE 2016)*

Ans. (i) These oxides are called basic oxides and solution of these metal oxides in water is called alkali. *e.g.*, NaOH (Sodium hydroxide).

(ii) This layer is called oxide layer. It makes the metal less reactive and prevents further oxidation. Due to this layer, the metal cannot get corroded and remains intact.

(iii) Some alkali metals can be cut with a knife because they are very soft and have low densities. *e.g.* Sodium, potassium, lithium etc.

Q 4. Of the three metals *X*, *Y* and *Z*. *X* reacts with cold water. *Y* with hot water and *Z* with steam only. Identify *X*, *Y* and *Z* and also arrange them in order of increasing reactivity.

Ans. Metals like potassium and sodium react with cold water. So, *X* is K or Na.

Magnesium reacts with cold water, so, *Y* is Mg. Metals like aluminium, iron and zinc reacts with steam. So, *Z* is Al, Fe or Zn.

Increasing order of Reactivity:

$$K > Na > Mg > Al > Zn > Fe$$

COMMON ERROR

Most students commit errors in writing the correct order of reactivity of metals.

Q 5. State which of the following chemical reactions will take place giving suitable reason for each.

(i) $Zn(s) + CuSO_4\,(aq)$ (ii) $Fe(s) + ZnSO_4(aq)$

(iii) $Zn(s) + FeSO_4(aq)$

Ans. (i) Reaction will take place because Zn is above Cu in the activity series and is more reactive than Cu.

$$Zn(s) + CuSO_4\,(aq) \longrightarrow Cu(s) + ZnSO_4\,(aq)$$

(ii) Reaction will not take place as Fe is below Zn in the activity series and cannot displace Zn from its solution.

(iii) Reaction will take place because Zn is more reactive than Fe.

$$Zn(s) + FeSO_4(aq) \longrightarrow Fe(s) + ZnSO_4(aq)$$

Q 6. An element 'M' with electronic configuration 2, 8, 3 combines separately with Cl^-, SO_4^{2-} anions. Write the chemical formulae of the compounds formed. Predict with the suitable reason the nature of the bond formed by element 'M' in general. How will the electrical conductivity of the compounds formed vary with respect to 'M'? *(CBSE SQP 2023-24)*

Ans.

Symbol/ Formula	M	Cl
Charge	+3	−1

Formula: MCl_3

Symbol/ Formula	M	SO_4
Charge	+3	−2

Formula: $M_2(SO_4)_3$

M in general forms ionic bond. It can acquire a stable electronic configuration of neon (2, 8) by losing its three valence electrons to form M^{3+} cation.
Compounds formed will conduct electricity in molten state but not in solid state in contrast to 'M'.

Q 7. (i) Show diagrammatically the electrons between the atoms in the formation of MgO. Write symbols of cation and anion present in MgO.
(ii) Name the solvent in which ionic compounds are generally soluble.
(iii) Why are aqueous solution of ionic compounds able to conduct electricity?

Ans. (i) $Mg: + :\ddot{O}: \longrightarrow (Mg^{2+})\left[:\ddot{O}:\right]^{2-}$

MgO contains Mg^{2+} as cation and O^{2-} as anion.
(ii) Ionic compounds are generally soluble in water.
(iii) This is because aqueous solution consists of ions which can move freely and are responsible for conduction of electricity.

TiP
Learn the properties of ionic compounds with proper justification.

Q 8. Suggest a method of reduction for the following metals during their metallurgical processes:
(i) Metal 'A' which is at one of the last, second or third position in the reactivity.
(ii) Metal 'B' which gives vigorous reaction even with water and air.
(iii) Metal 'C' which is kept in the middle of the activity series.

Ans. (i) 'A' can be obtained by just heating in air.
(ii) 'B' can be obtained by the method of electrolytic reduction.
(iii) 'C' can be reduced by using suitable reducing agents such as carbon, aluminium, etc.

Q 9. With the help of suitable chemical equations, list the two main differences between roasting and calcination. How is metal reduced from the product obtained after roasting/calcination of the ore? Write the chemical equation for the reaction involved. *(CBSE 2023)*

Ans.

Basis of Difference	Roasting	Calcination
Use	This is used for sulphide ores.	This is used for carbonate ores.
Process	The ore is heated strongly in the presence of excess air.	The ore is heated strongly in limited air.
Chemical Equation	$2ZnS(s) + 3O_2(g) \xrightarrow{Heat} 2ZnO(s) + 2SO_2(g)$	$ZnCO_3(s) \xrightarrow{Heat} ZnO(s) + CO_2(g)$

The metal oxides obtained after roasting/calcination of the ore are reduced to the corresponding metal by using suitable reducing agents such as carbon.

Chemical equation:

$$ZnO(s) + C(s) \longrightarrow Zn(s) + CO(g)$$

Q 10. The given reaction shows one of the processes to extract the metals like Iron and Manganese.

$$MnO_2(s) + Al(s) \longrightarrow Mn(l) + Al_2O_3(s) + Heat$$

(i) Give reason why the above reaction is known as a thermite reaction.
(ii) Identify the substance oxidised and reduced in the above reaction.
(iii) Give a reason why aluminium is preferably used in thermite reactions. *(CBSE SQP 2023-24)*

Ans. (i) The given reaction is known as thermite reaction because the reaction is highly exothermic, in which a large amount of heat is evolved.
(ii) Al(s) is oxidised and $MnO_2(s)$ is reduced.
(iii) Aluminium is preferably used in thermite reactions as it is more reactive than manganese. Also, the oxides of manganese are not satisfactorily reduced by carbon.

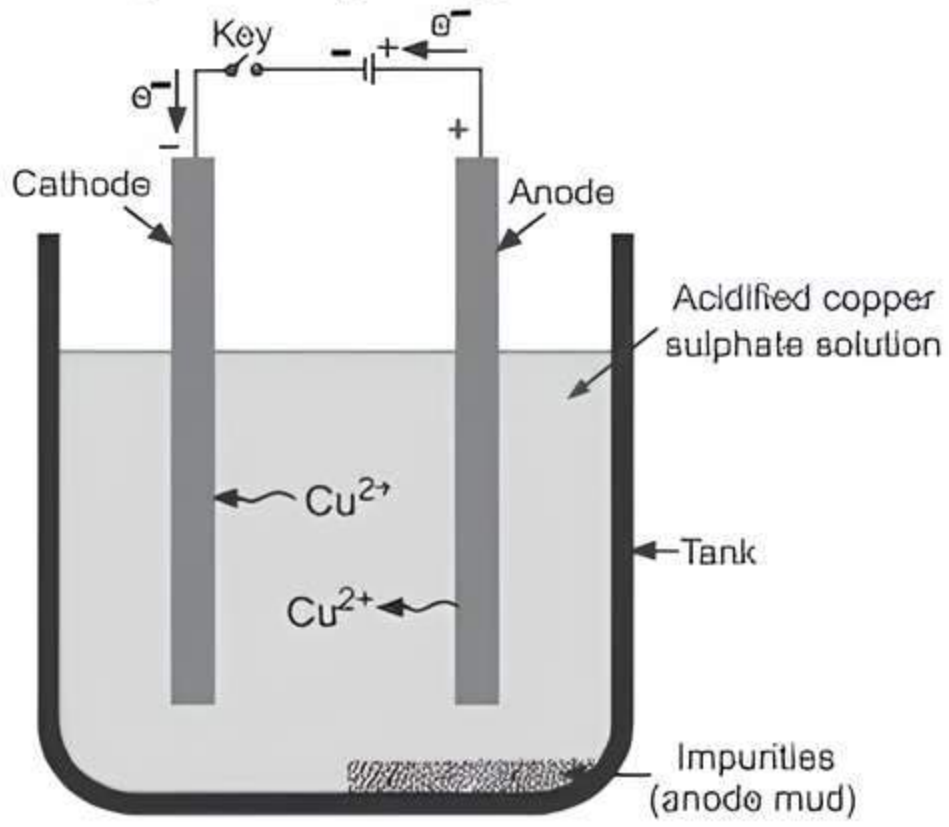
Q 11. A reddish-brown metal 'X', when heated in air, gives a black compound 'Y', which when heated in presence of H_2 gas gives 'X' back. 'X' is refined by the process of electrolysis; this refined form of 'X' is used in electrical wiring.
Identify 'X' and 'Y'. Draw a well-labelled diagram to represent the process of refining 'X'.
(CBSE SQP 2023-24)

Ans. $\underset{\text{Reddish-brown metal (X)}}{2Cu} + O_2 \xrightarrow{Heat} \underset{\text{Black Compound (Y)}}{2CuO}$

$\therefore$ X is copper metal
and Y is copper oxide

TiP
Practice drawing well-labelled diagram of electrolytic refining of copper.

Electrolytic Refining of Copper:



Reaction for Electrolytic Refining:

At cathode: $Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$

At anode: $Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$

Long Answer Type Questions

Q 1. (i) List in tabular form three chemical properties on the basis of which we can differentiate between a metal and a non-metal.

(ii) Give reasons for the following:

(a) Most metals conduct electricity well.

(b) The reaction of iron (III) oxide [Fe_2O_5] with heated aluminium is used to join cracked machine parts. *(CBSE 2019)*

Ans.

TiP

Learn and understand the difference between metals and non-metals on the basis of their physical and chemical properties.

(i) Difference between metals and non-metals on the basis of chemical properties are:

S. No.	Basis of Difference	Metal	Non-metal
1.	Nature	Metals are electropositive and form cations.	Non-metals are electronegative and form anions.
2.	Reaction with oxides	They react with oxygen to form basic oxides.	They react with oxygen to form acidic or neutral oxides.
3.	Reaction with dilute acids	They react with dilute acids to form a salt and evolve hydrogen gas.	They do not react with dilute acids as they are incapable to displace hydrogen.

(ii) (a) Metals are good conductors of electricity because they contain free electrons which can move easily through the metal and conduct electricity.

(b) It is a displacement reaction which is highly exothermic. The amount of heat evolved is so large that the metals are produced in the molten state and is thus used to join cracked machine parts.

Q 2. A metal '*M*' is stored under kerosene. It vigorously catches fire, if a small piece of this metal is kept open in air. Dissolution of this metal in water releases great amount of energy and the metal catches fire. The solution so formed turns red litmus blue.

(i) Name the metal '*M*'.

(ii) Write formula of the compound formed when this metal is exposed to air.

(iii) Why is metal '*M*' stored under kerosene?

(iv) If oxide of this metal is treated with hydrochloric acid, what would be the products?

(v) Write balanced equations for:

(a) Reaction of '*M*' with air.

(b) Reaction of '*M*' with water.

(c) Reaction of metal oxide with hydrochloric acid. *(CBSE 2020)*

Ans. (i) The metal 'M' is sodium (Na).

(ii) Formula of the compound formed is Na_2O.

(iii) Sodium reacts with oxygen so fast that it catches fire if kept open. So, it is always kept immersed in kerosene oil to prevent accidental fire.

(iv) Sodium oxide reacts with hydrochloric acid to produce sodium chloride and water.

(v) (a) Reaction with air: $4Na + O_2 \longrightarrow 2Na_2O$

(b) Reaction with water:

$$2Na(s) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g) + \text{Heat energy}$$

(c) Reaction of sodium oxide with HCl:

$$Na_2O(s) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(l)$$

Q 3. (i) By the transfer of electrons, illustrate the formation of bond in magnesium chloride and identify the ions present in this compound.

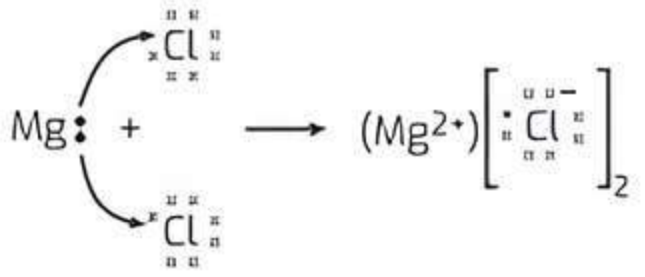
(ii) Ionic compounds are solids. Give reasons.

(iii) With the help of a labelled diagram show the experimental set up of action of steam on a metal. *(CBSE 2020)*

Ans. (i)

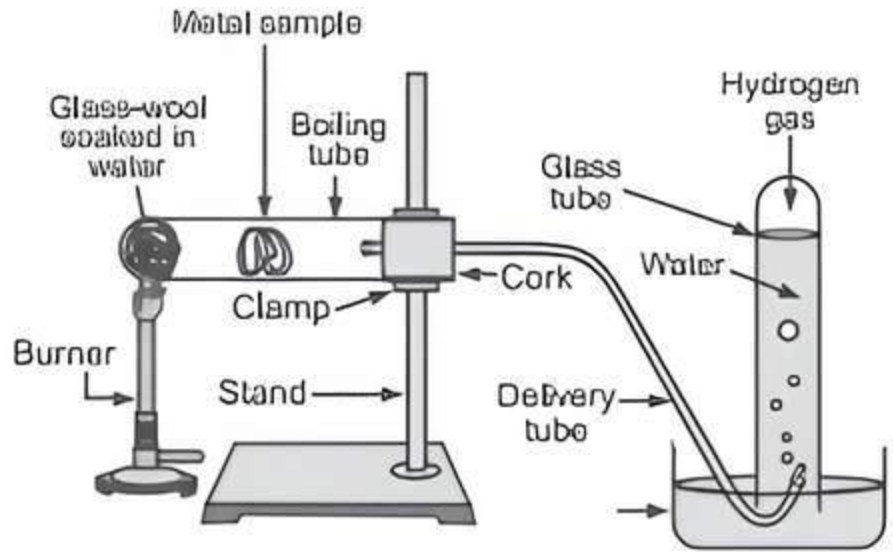
$$\underset{2.8.2}{Mg} \longrightarrow \underset{\substack{2.8. \\ \text{(Magnesium cation)}}}{Mg^{2+}} + 2e^-$$

$$\underset{2.8.7}{Cl} + e^- \longrightarrow \underset{\substack{2.8.8 \\ \text{(Chloride anion))}}}{Cl^-}$$



(ii) Ionic compounds are solids because of the strong force of attraction between the positive and negative ions.

(iii) Metals like aluminium, iron and zinc react with steam to form the metal oxide and hydrogen.



Action of Steam on a Metal

COMMON ERROR

Students draw incorrect diagram and they label some irrelevant parts.

Q 4. (i) Write electron dot structures of Ca (At. no. 20) and O (At. no. 8).
(ii) Show the formation of calcium oxide by transfer of electrons.
(iii) Name the ions present in this compound.
(iv) List four important characteristics of this compound. *(CBSE 2020)*

Ans. Electronic configuration of Ca = 2. 8. 8. 2 and O = 2. 6

(I) Electron dot structures:

Ca : $\quad$ $\ddot{\underset{\cdot\cdot}{O}}$:

(ii) Ca + $\ddot{\underset{\cdot\cdot}{O}}$: $\longrightarrow$ $[Ca^{2+}]$ $[\ddot{\underset{\cdot\cdot}{O}}:^{2-}]$

(iii) Ions present in this compound are calcium ions (Ca^{2+}) and oxygen ions (O^{2-}).

(iv) Four important characteristics of CaO are:
(a) It is solid and hard.
(b) It has high melting and boiling points.
(c) It is soluble in water.
(d) It conducts electricity in molten state.

Q 5. Explain the following:
(i) Sodium chloride is an ionic compound which does not conduct electricity in solid state whereas it does conduct electricity in molten state as well as in aqueous solution.
(ii) Reactivity of aluminium decreases if it is dipped in nitric acid.
(iii) Metals like calcium and magnesium are never found in their free state in nature.
(iv) The formation of calcium chloride with the help of electron dot structure. (At. numbers : Ca = 20; Cl = 17)
(v) Carbon cannot reduce the oxides of Na or Mg.
(CBSE 2019)

Ans. (I) Sodium chloride is an ionic compound formed by ions of sodium (Na^+) and chlorine (Cl^-). In solid state, ions are fixed in position so no free electrons are available to conduct electricity. Whereas in molten state and aqueous solution of sodium chloride, free electrons are available to conduct electricity.

(II) When aluminium is dipped in nitric acid, a layer of aluminium oxide is formed because nitric acid is a strong oxidising agent. The layer of aluminium oxide prevents further reaction of aluminium due to which the reactivity of aluminium decreases.

(iii) Because these metals are highly reactive and readily react with atmospheric oxygen and other gases.

(iv) Element Z — E. C
Ca – 20 — 2 8 8 2
Cl – 17 — 2 8 7

Ca + $\ddot{\underset{\cdot\cdot}{Cl}}$ $\longrightarrow$ (Ca^{2+}) $\left[\ddot{\underset{\cdot\cdot}{Cl}}^{-}\right]_2$

or Ca^{2+} $2Cl^-$ or $CaCl_2$

(v) Carbon cannot reduce the oxides of Na or Mg because these metals have more affinity for oxygen than carbon.

Q 6. Write balanced chemical equations to explain what happens, when:
(i) Mercuric oxide is heated.
(ii) Mixture of cuprous oxide and cuprous sulphide is heated.
(iii) Aluminium is reacted with manganese dioxide.
(iv) Ferric oxide is reduced with aluminium.
(v) Zinc carbonate undergoes calcination.
(CBSE 2020)

Ans. (i) $2HgO\,(s) \xrightarrow{Heat} 2Hg\,(l) + O_2\,(g)$
Mercuric oxide → Mercury metal

(ii) $2Cu_2O\,(s) + Cu_2S\,(s) \xrightarrow{Heat} 6Cu\,(s) + SO_2\,(g)$
Cuprous oxide; Cuprous sulphide → Copper metal; Sulphur dioxide

(iii) $3MnO_2\,(s) + 4Al\,(s) \longrightarrow 3Mn\,(l) + 2Al_2O_3\,(s) + Heat$
Manganese dioxide; Aluminium powder → Manganese metal; Aluminium oxide

(iv) $Fe_2O_3\,(s) + 2Al\,(s) \longrightarrow 2Fe\,(l) + Al_2O_3\,(s) + Heat$
Ferric oxide; Aluminium powder → Iron metal (Molten); Aluminium oxide

(v) $ZnCO_3\,(s) \xrightarrow[Heat]{Calcination} ZnO\,(s) + CO_2\,(g)$
Zinc carbonate → Zinc oxide; Carbon dioxide

Q 7. (i) Write the steps involved in the extraction of pure metals in the middle of the activity series from their carbonate ores.
(ii) How is copper extracted from its sulphide ore? Explain the various steps supported by chemical equations. Draw labelled diagram for the electrolytic refining of copper. *(CBSE 2018)*

Ans. (I) The different steps involved in the extraction of pure metal in the middle of the activity series from their carbonate ores are:

(a) Calcination: The carbonate ores are changed into oxides by heating strongly in limited air.

(b) Reduction: The metal oxides are then reduced to corresponding metals by using suitable reducing agents.

(c) Purification: The impure metals thus obtained are purified by electrolytic refining.

(II) The sulphide ores are first converted into oxides by heating strongly in the presence of excess air which is known as roasting.

$$2Cu_2S\,(s) + 3O_2\,(g) \xrightarrow{\text{Heat}} 2Cu_2O\,(s) + 2SO_2\,(g)$$

The obtained oxide reacts with remaining Cu_2S to give copper metal.

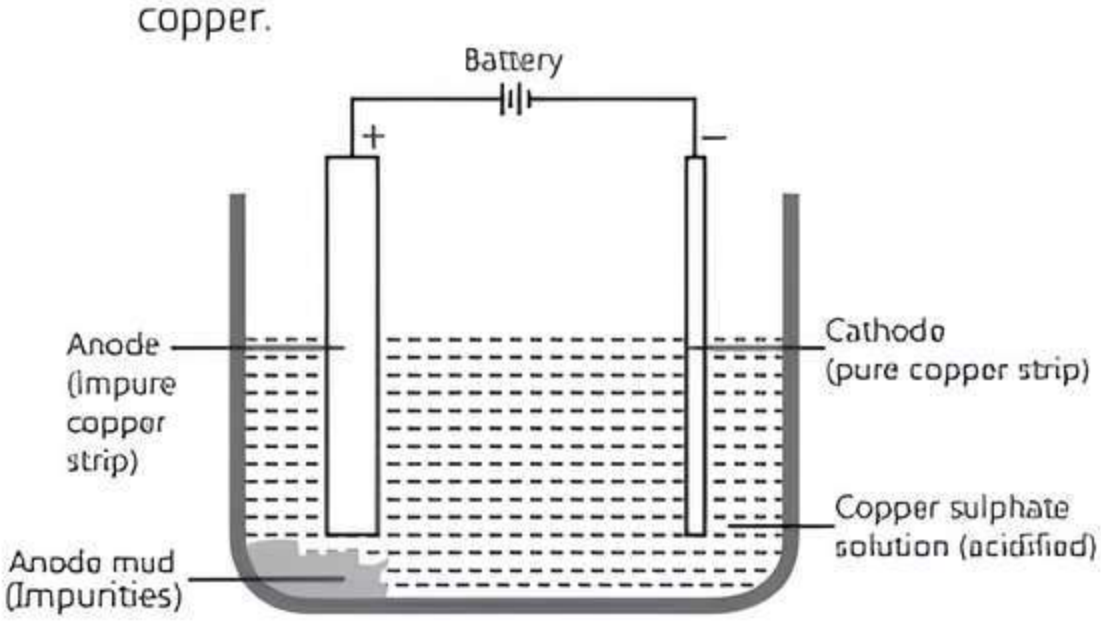
$$2Cu_2O\,(s) + Cu_2S\,(s) \xrightarrow{\text{Heat}} 6Cu\,(s) + SO_2\,(g)$$

This reaction is known as auto-reduction. The obtained metal is then purified by electrolytic refining.

TiP

Understanding and making points of each technique used to extract metals is the best way to avoid mistakes and confusions.

Labelled diagram to show electrolytic refining of copper.



Q 8. (i) Write chemical equations for the following reactions:

(a) Calcium metal reacts with water.

(b) Cinnabar is heated in the presence of air.

(c) Manganese dioxide is heated with aluminium powder.

(ii) What are alloys? List two properties of alloys.

(CBSE 2019)

Ans. (i) (a)

$$\underset{\text{Calcium}}{Ca\,(s)} + \underset{\substack{\text{Water}\\(\text{cold})}}{2H_2O(l)} \longrightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_2(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$$

(b) $\underset{\text{Cinnabar}}{2HgS(s)} + 3O_2(g) \longrightarrow \underset{\text{Mercury (II) oxide}}{2HgO\,(s)} + 2SO_2(g)$

(c) $\underset{\substack{\text{Manganese}\\\text{dioxide}}}{3MnO_2(s)} + \underset{\substack{\text{Aluminium}\\\text{powder}}}{4Al(s)} \longrightarrow \underset{\text{Manganese}}{3Mn(l)} + \underset{\substack{\text{Aluminium}\\\text{oxide}}}{2Al_2O_3(s)}$

(ii) Alloys are the homogeneous mixture of two or more metals or a metal and a non-metal.

Two properties of alloys are:

(a) They are stronger than the metal from which they are made.

(b) They are more resistant to corrosion.

Q 9. What is meant by rusting? With labelled diagrams, describe an activity to find out the conditions under which iron rusts.

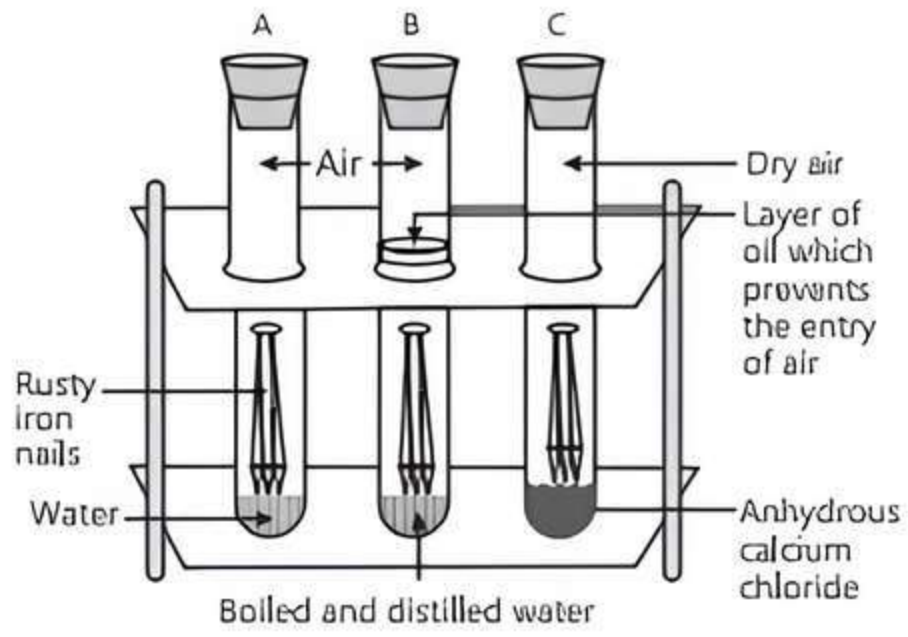
Ans. Rusting: The process in which iron reacts with oxygen in the presence of moisture to form a reddish-brown coating of hydrated ferric oxide ($Fe_2O_3.x\ H_2O$) is called rusting.

Activity:

(i) Take three boiling tubes A, B and C.

(ii) Pour some water in test tube A. Put iron nails in it and cork it.

(iii) Pour boiled distilled water in test tube B and put iron nails in it. Add 1 mL of oil in it so that oil floats over water to prevent the air from entering in.



(iv) Take some more iron nails in test tube C and put some anhydrous calcium chloride in it and tighten a cork on it.

(v) Leave all the three test tubes for a day and then observe the changes.

Observation: Iron nails get rusted in test tube A because both air and water are present in it. Iron nails do not get rusted in test tube B because there is water but no air. In test tube C, rusting will not take place because there is neither air nor water.

Conclusion: Iron gets rusted in the presence of air and water.

Q 10. (i) Define corrosion.

(ii) What is corrosion of iron called?

(iii) How will you recognise the corrosion of sliver?

(iv) Why corrosion of iron is a serious problem?

(v) How can we prevent corrosion of iron?

(CBSE 2016)

Ans. (i) Corrosion is a slow process of eating away of metals by the reaction of atmospheric air and moisture.

(ii) Corrosion of iron is called rusting.

COMMON ERROR

Students start explaining rusting of iron, instead of just naming the process.

(iii) Corrosion of silver can be recognised by the appearance of black layer on its surface due to the formation of Ag_2S.

(iv) Corrosion of iron makes the metal weak as well as brittle which is a serious problem.

(v) Corrosion of iron can be prevented by oiling, painting, greasing, galvanisation, chrome plating or alloying.

Chapter Test

Multiple Choice Questions

Q 1. Observe the given reactions and answer the question that follows:

$$\underset{(1,8,7)}{Na} \longrightarrow \underset{(2,8)}{Na^+} + e^-$$

$$\underset{(2,8,7)}{Cl} + e^- \longrightarrow \underset{(2,8,8)}{Cl^-}$$

$$\underset{(2,8,2)}{Mg} \longrightarrow \underset{(2,8)}{Mg^{2+}} + 2e^-$$

Which of the following are correct representations for the ionic compounds formed of these ions?

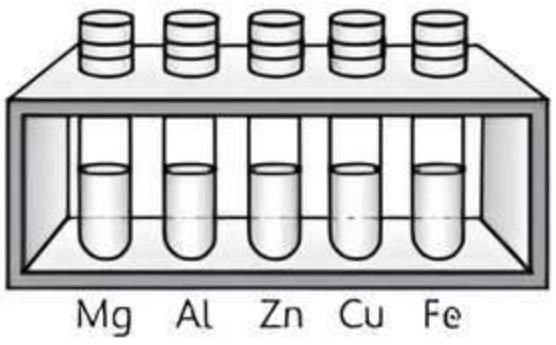
a. $(Na^+)\left[:\ddot{\underset{\cdot\cdot}{Cl}}:\right]^-$, $(Mg^{2+})\left[:\ddot{\underset{\cdot\cdot}{Cl}}:\right]_2^-$

b. $(Na^+)\left[:\ddot{\underset{\cdot\cdot}{Cl}}:\right]^-$, $(Mg^{2+})\left[:\ddot{\underset{\cdot\cdot}{Cl}}:\right]_2^-$

c. $(Na^+)\left[:\ddot{\underset{\cdot\cdot}{Cl}}:\right]^-$, $(Mg^{2+})\left[:\ddot{\underset{\cdot\cdot}{Cl}}:\right]_2^-$

d. $(Na^+)\left[:\ddot{\underset{\cdot\cdot}{Cl}}:\right]^-$, $(Mg^{2+})\left[:\ddot{\underset{\cdot\cdot}{Cl}}:\right]_2^-$

Q 2. Clean small pieces of magnesium, zinc, aluminium, iron and copper by rubbing them with a piece of sand paper. Take them in separate test tubes. Add about 10 mL of dilute hydrochloric acid to each of them.



Identify the correct statement(s).

(i) The rate of evolution of hydrogen gas bubbles is not same in all the test tubes.

(ii) The rate of formation of bubbles is the fastest in the case of magnesium.

(iii) The reactivity decreases in the order:

Mg > Zn > Al > Fe > Cu

(iv) In the case of copper, no bubbles are seen and the temperature also remains unchanged. This shows that copper does not react with dilute HCl.

a. (ii) and (iv) b. (iii) and (iv)

c. Only (iii) d. (i), (ii) and (iv)

Q 3. What happens when calcium is treated with water?

(i) It does not react with water.

(ii) It reacts violently with water.

(iii) It reacts less violently with water.

(iv) Bubbles of H_2 gas formed stick to the surface of calcium.

a. (i) and (iv) b. (ii) and (iii)

c. (i) and (ii) d. (iii) and (iv)

Q 4. The electrical conductivity and melting point of an alloy is:

a. less than that of pure metal

b. more than that of pure metal

c. equal to that of pure metal

d. electrical conductivity is less and melting point is more than that of pure metal.

Assertion and Reason Type Questions

Directions (Q. Nos. 5-6): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is a correct explanation of Assertion (A).

b. Both Assertion (A) and Reason (R) are true but Reason (R) is not a correct explanation of Assertion (A).

c. Assertion (A) is true but Reason (R) is false.

d. Assertion (A) is false but Reason (R) is true.

Q 5. Assertion (A): MgO exists in liquid state.

Reason (R): The electrostatic forces of attraction between Mg^{2+} and O^{2-} ions constitute ionic bond.

Q 6. Assertion (A): Zinc is used in the galvanisation of iron.

Reason (R): Its coating on iron articles increases their life by protecting iron from rusting.

Case Study Based Question

Q 7. The chemical properties of metals are mostly linked with the electron releasing tendency of their atoms. Greater the tendency, more will be the reactivity of the metal. They react with oxygen, water, acids, etc. Since they can lose electrons, they act as reducing agents. Some reactions of metals are given as:

Metal + Oxygen $\longrightarrow$ Metal oxide

Metal + Water ⟶ Metal hydroxide + Hydrogen

Metal + Acid (dilute) ⟶ Metal salt + Hydrogen

Metal X + Salt solution of metal Y ⟶ Salt solution of Metal X + Metal Y (Displacement reaction)

Read the above passage carefully and give the answer of the following questions:

(i) Metals such as ..... and ..... react so vigorously that they catch fire if kept in the open. Hence, to protect them and to prevent accidental fires, they are kept immersed in.....

a. phosphorus, magnesium, water
b. sodium, potassium, kerosene oil
c. sodium, potassium, water
d. tin, lead, alcohol

(ii) Which of the following pairs will give displacement reaction?

a. NaCl solution and copper metal
b. $MgCl_2$ solution and aluminium metal
c. $FeSO_4$ solution and silver metal
d. $AgNO_3$ solution and copper metal

(iii) There are four metals *K, L, M* and *N*. Identify them by using the hints given below.

***K* forms basic oxide.**

***L* forms amphoteric oxide.**

Oxide of *M* dissolves in water to form alkali.

N does not react with water at all.

a. $K \rightarrow Zn$, $L \rightarrow Al$, $M \rightarrow Na$, $N \rightarrow Fe$
b. $K \rightarrow Fe$, $L \rightarrow Na$, $M \rightarrow K$, $N \rightarrow Zn$
c. $K \rightarrow K$, $L \rightarrow Cu$, $M \rightarrow Pb$, $N \rightarrow Na$
d. $K \rightarrow Cu$, $L \rightarrow Zn$, $M \rightarrow K$, $N \rightarrow Pb$

(iv) Food cans are coated with tin and not with zinc because:

a. zinc is costlier than tin
b. zinc has a higher melting point than tin
c. zinc is more reactive than tin
d. zinc is less reactive than tin

Very Short Answer Type Questions

Q 8. Name two metals which react with dilute HNO_3 to evolve H_2 gas.

Q 9. Make a distinction between metals and non-metals with respect to the nature of their oxide.

Short Answer Type-I Questions

Q 10. Differentiate between roasting and calcination. Give examples.

Q 11. (i) In electrolytic refining of impure copper metal, what are used as cathode and anode?

(ii) Show the formation of KCl from potassium and chlorine atoms.

Q 12. Name two metals that start floating after sometime when immersed in water and explain why they do so.

Short Answer Type-II Questions

Q 13. State the conditions under which the following metals react with water. Write chemical equation for its reaction with each: (a) Na (b) Mg (c) Fe

Q 14. (i) Write the electron dot structure of calcium (20) and sulphur (16).

(ii) Show the formation of CaS by transfer of electrons.

(iii) State two physical properties of CaS.

Q 15. Distinguish between the following:

(i) Electrolytic reduction and electrolytic refining
(ii) Minerals and ores
(iii) Alloys and amalgams.

Long Answer Type Questions

Q 16. Sample pieces of five metals, *A, B, C, D* and *E* are added to the tabulated solutions separately. The results observed are shown in the table given below:

Metal	Solution				
	$FeSO_4$	$CuSO_4$	$ZnSO_4$	$AgNO_3$	$Al_2(SO_4)_3$
A	No change	×	×	A coating on metal	No change
B	Grey deposit	Brown coating	No change	A coating on metal	No change
C	No change	No change	No change	No change	No change
D	No change	–	No change	A coating on metal	No change
E	–	Brown coating	New coating	New coating	No change

Based on the observations recorded in the table answer the following questions:

(i) Which is the most reactive metal?
(ii) Which is the least reactive metal?
(iii) What would be observed if metal *D* was added to a solution of copper(II) sulphate?
(iv) What would be observed if metal *E* was added to a solution of iron(II) sulphate?
(v) Arrange the metals *A, B, C, D* and *E* in order of decreasing reactivity.

Q 17. Give reasons for the following:

(i) Sodium hydroxide solution cannot be kept in aluminium containers.
(ii) Silver metal does not combine easily with oxygen but silver jewellery tarnishes after some time.
(iii) Sodium is obtained by the electrolysis of its molten chloride and not from its aqueous solution.
(iv) Aluminium reacts with dilute HCl slowly in the beginning.
(v) Hydrogen is not a metal but has been assigned a place in the reactivity series of metals.