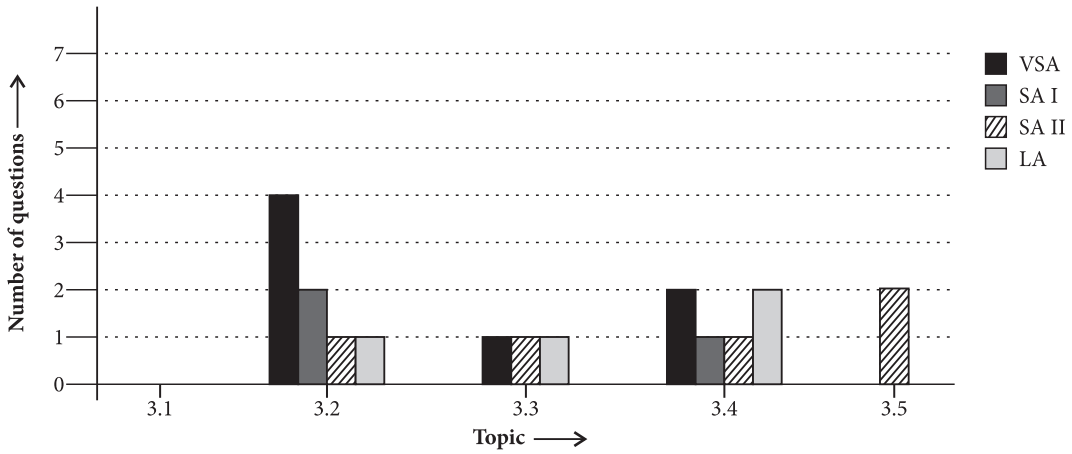
Chapter

3 Metals and Non-metals

Topicwise Analysis of 2010-2008 Years' CBSE Board Questions



- Maximum weightage is of *Chemical Properties of Metals and Occurrence of Metals.*
- Maximum VSA type questions were asked from *Chemical Properties of Metals.*
- Maximum SA I and SA II type questions were asked from *Chemical Properties of Metals and Corrosion respectively.*
- Maximum LA type questions were asked from *Occurrence of Metals.*

QUICK RECAP

- **Elements :** An element is a substance that is made entirely from one type of atoms.
  Examples : Hydrogen (H), Helium (He), Oxygen (O), etc.
  Based on their properties they are classified into two categories called metals and non-metals.
- **Metals :** Those elements which possess lustre when freshly cut, are malleable, ductile and good conductors of heat and electricity are known as *metals*. They may also be defined as those elements which lose electrons and form positive ions. Thus, metals are electropositive elements.
  Examples : Sodium (Na), Potassium (K), Calcium (Ca), etc.
- **Non-metals :** Those elements which do not possess lustre and are neither good conductors of heat and electricity nor malleable and ductile but are brittle, are known as *non-metals*. They may also be defined as elements which gain electrons and form negative ions. Thus,

non-metals are electronegative elements.
Examples : Hydrogen (H), Oxygen (O), Nitrogen (N), Chlorine (Cl), etc.

Physical properties of metals :

- Metals in their pure state have shining surface *i.e.*, possess metallic lustre.
- Metals are generally hard. The hardness varies from metal to metal. Stronger the metallic bond, harder is the metal.
- Metals are generally malleable. The ability of metals to be beaten into thin sheets is called *malleability*.
- Metals are generally ductile. The ability of metals to be drawn into wires is called *ductility*. Gold is the most ductile metal.
- Metals are good conductors of heat and possess high melting points. But some exceptions are there *e.g.*, lithium, sodium, potassium, caesium and gallium are metals with low melting points. Infact, gallium and caesium have so low melting points that they melt even on keeping them on the palm.
- Metals are good conductors of electricity. The order of electrical conductivity of some metals is found to be as follows :

$$\underset{\text{Silver}}{Ag} > \underset{\text{Copper}}{Cu} > \underset{\text{Gold}}{Au} > \underset{\text{Aluminium}}{Al} > \underset{\text{Tungsten}}{W} > \underset{\text{Mercury}}{Hg}$$

- Metals are sonorous *i.e.,* they produce sound by striking on hard surface.
- Metals have high density due to closely packed atoms. But lithium, sodium, potassium are metals with low densities.
- They have high tensile strength. Due to this property, iron is used in the construction of bridges, buildings, railway lines, etc.
- All metals are solids except mercury which is liquid.

Physical properties of non-metals :

- Non-metals do not possess any lustre, but iodine is a non-metallic solid with lustre.
- They are soft and brittle. The only exception is diamond, an allotropic form of carbon, which is a non-metal but is the hardest substance known.
- They are neither malleable nor ductile.
- They are bad conductors of heat and electricity. Exception is graphite which is an allotropic form of carbon and is a non-metal but good conductor of electricity.
- They are non-sonorous, *i.e.,* they do not produce any sound when hit with a hard object.
- They have low melting and boiling points except diamond and graphite which have high melting points.
- They have low densities.
- They have low tensile strength *i.e.,* these are easily broken.
- They may be solids, liquids or gases at room temperature.
  - Carbon, sulphur, phosphorous and iodine are solid non-metals.
  - Bromine is a liquid non-metal.
  - Hydrogen, oxygen, nitrogen, chlorine, helium and neon are gaseous non-metals.

Chemical properties of metals :

- **Reaction with oxygen :** Almost all the metals react with oxygen or air to form metal oxides which are basic in nature.
  Metal + Oxygen $\longrightarrow$ Metal oxide
  - When copper is heated in air, it combines with oxygen to form copper (II) oxide which is a black in colour.
    $2Cu + O_2 \longrightarrow 2CuO$
  - Iron reacts with oxygen to give a mixture of FeO and Fe_2O_3.

$$3Fe + 2O_2 \xrightarrow{\text{Heat}} \underset{\substack{\text{Iron (II, III)}\\\text{oxide}}}{FeO.Fe_2O_3} \text{ or } \underset{\substack{\text{Ferrosoferric}\\\text{oxide}}}{Fe_3O_4}$$

- **Reaction with water :** Highly reactive metals such as sodium and potassium (placed at the top of the reactivity series) react violently even with cold water with formation of hydrogen gas and energy is released.
  $2K_{(s)} + 2H_2O_{(l)} \longrightarrow 2KOH_{(aq)} + H_{2(g)}$ + heat energy
  Calcium reacts with water less violently while magnesium reacts with water only on heating.
  $Ca_{(s)} + 2H_2O_{(l)} \longrightarrow Ca(OH)_{2(aq)} + H_{2(g)}$
  $Mg_{(s)} + 2H_2O_{(l)} \xrightarrow{\text{Heat}} Mg(OH)_{2(aq)} + H_{2(g)}$
- **Reaction with acids :** Metals placed above hydrogen in the reactivity series react with dilute acids such as HCl and H_2SO_4 to displace

hydrogen from acids forming corresponding metal salt with the evolution of hydrogen gas.

Metal + Acid(dil.) $\longrightarrow$ Metal salt + Hydrogen gas

$2Na_{(s)} + 2HCl(dil.) \longrightarrow 2NaCl_{(aq)} + H_{2(g)}$

$Mg_{(s)} + H_2SO_4(dil.) \longrightarrow MgSO_{4(aq)} + H_{2(g)}$

– Hydrogen gas is not evolved when a metal reacts with nitric acid because nitric acid is a strong oxidising agent.

– Gold and platinum are noble metals which do not react with any strong acid like HCl, HNO_3 and H_2SO_4, but these can be dissolved in aqua regia (a mixture of conc. HCl and conc. HNO_3 in the ratio of 3 : 1) due to the formation of nascent chlorine which reacts with these metals to form metal chlorides.

$\underbrace{3HCl + HNO_3}_{\text{Aqua regia}} \longrightarrow \underbrace{NOCl}_{\text{Nitrosyl chloride}} + 2H_2O + \underbrace{2Cl}_{\text{Nascent chlorine}}$

$Au + 3Cl \longrightarrow AuCl_3$; $Pt + 4Cl \longrightarrow PtCl_4$

Aqua regia is highly corrosive and fuming liquid.

▸ **Reaction with salt solutions :** More reactive metals can displace less reactive metals from the aqueous solutions of their salts. These reactions are known as *metal displacement reactions*. Generally,

Metal *A* + Salt solution of *B* $\longrightarrow$ Salt solution of *A* + Metal *B*

Examples :

$Zn_{(s)} + CuSO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + Cu_{(s)}$

$Fe_{(s)} + CuSO_{4(aq)} \longrightarrow FeSO_{4(aq)} + Cu_{(s)}$

Reactivity series : It is the series in which metals are arranged in the order of their decreasing reactivity as shown :

Potassium (K)	Most reactive
Sodium (Na)	
Calcium (Ca)	
Magnesium (Mg)	
Aluminium (Al)	
Zinc (Zn)	
Iron (Fe)	
Lead (Pb)	
[Hydrogen (H)]	
Copper (Cu)	
Mercury (Hg)	
Silver (Ag)	
Gold (Au)	Least reactive

Reactivity decreases

▸ **Characteristics of the reactivity series :**

– Metals are arranged in this series on the basis of the ease with which atoms of these metals give up their electrons to form ions.

– Higher the metal in the series, greater is its tendency to form ions in solution.

– Metals are placed in a decreasing order of reactivity, *i.e.,* the most reactive metals are placed at the top and as we move down, the reactivity of metals decreases.

– The series also shows which metal will displace the other in a solution. Metals placed above will displace the metals placed below in the series.

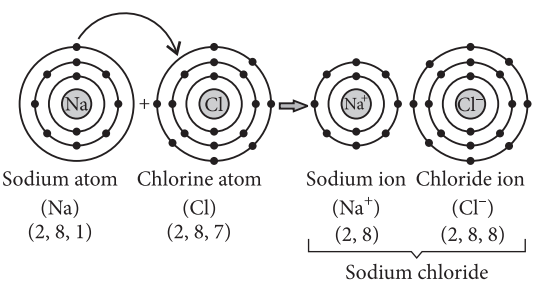
Ionic compounds : A chemical bond formed between two atoms by complete transfer of electrons from one atom to another so as to complete their octets and hence, acquire the stable nearest noble gas configuration, is called *ionic bond*. The compounds thus formed are known as *ionic compounds*.

▸ **Formation of ionic compounds :** During formation of ionic compounds, metal atom looses electrons and these electrons are accepted by non-metal atom. In this way, cations and anions are formed which are held together by ionic bonds.

This can be understood by taking an example of formation of sodium chloride.

$\underset{(2,8,1)}{\dot{N}a} + \underset{(2,8,7)}{:\dot{\underset{\cdot\cdot}{Cl}}:} \longrightarrow \underset{(2,8)}{[Na]^+} \underset{(2,8,8)}{[:\ddot{\underset{\cdot\cdot}{Cl}}:]^-}$ or NaCl

The transfer of electrons may be represented as:



Properties of ionic compounds :

▸ **Physical state :** Ionic compounds are generally solids and exist in the form of crystals as ions are bonded by strong attractive forces. These crystals differ in their shapes and lustre.

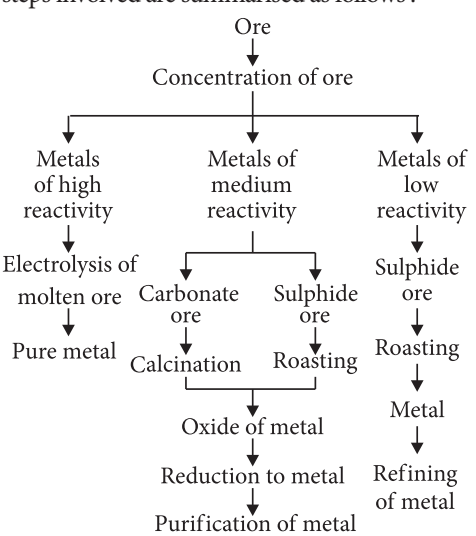
- **Melting and boiling points :** Their melting and boiling points are very high as they have strong forces of attraction.
- **Solubility :** Ionic compounds are generally soluble in water and insoluble in solvents such as kerosene, petrol, etc.
- **Electrical conductivity :** Ionic compounds conduct electricity in the aqueous solution as well as in the molten state but not in the solid state.

Occurrence of metals : The major source of metals (whether in the free state or in the combined state) is the earth's crust. Some metals are found in the sea water in the form of their soluble salts. Percentage of some metals in earth's crust is as follows :
Al(7%), Fe(4%), Ca(3%), Na(2.7%), K(2.5%), Mg(2%) and Ti(0.6%).

- **Minerals and Ores :** The elementary state or the compounds, in the form of which the metals occur in nature are called *minerals*. The earthy, sandy and rocky impurities associated with the mineral are called *gangue* or *matrix*. Also, the mineral from which the metal can be extracted conveniently and economically is called an *ore*.

Extraction of metals : Getting a metal out of its ore is called *extraction of the metal*.

Metallurgy : Various steps involved in the extraction of a metal from its ore followed by refining of the metal is called '*metallurgy*'. The steps involved are summarised as follows :



The three major steps involved in the extraction of a metal from its ore are :
(i) concentration or enrichment of ore
(ii) conversion of concentrated ore into metal
(iii) refining of impure metal.

- **Concentration or enrichment of ore :** It is done by removing gangue. The methods for removing gangue are gravity separation, froth floatation process, electromagnetic separation and chemical separation.
- **Conversion of concentrated ore into metal :**
  - **Extraction of highly reactive metals :** The highly reactive metals like Na, Mg, Ca, etc. are extracted by electrolytic reduction of their molten chlorides or oxides. Electrolytic reduction is brought about by passing electric current through the molten state. Metal gets deposited at the cathode.
    At cathode : $Na^+ + e^- \longrightarrow Na$
    At anode : $2Cl^- \longrightarrow Cl_2 + 2e^-$
  - **Extraction of metals of medium reactivity :** The metals with moderate reactivity like zinc, iron, lead, copper, etc. are generally present as oxides, sulphides or carbonates. These sulphides and carbonates first need to get converted to oxides as it is easier to get metal from their oxides.
    This can be done by two processes :
    - **Roasting :** In this process, the sulphide ores are converted into oxides by heating strongly in presence of excess of air.
      $2ZnS_{(s)} + 3O_{2(g)} \xrightarrow{\text{Roasting}} 2ZnO_{(s)} + 2SO_{2(g)}$
      Zinc sulphide (Zinc blende ore)
    - **Calcination :** In this process, the carbonate ores are converted into oxides by heating strongly in the absence or limited supply of air.
      $ZnCO_{3(s)} \xrightarrow{\text{Heat}} 2ZnO_{(s)} + CO_{2(g)}$
      Zinc carbonate (Calamine ore)

    The metal oxides are then reduced to corresponding metals by using

reducing agents like carbon or by using displacement reactions with highly reactive metals such as aluminium, sodium, calcium, etc.

$$ZnO_{(s)} + C_{(s)} \xrightarrow{\text{Heat}} Zn_{(s)} + CO_{(g)}$$

$$3MnO_{2(s)} + 4Al_{(s)} \xrightarrow{\text{Heat}} 3Mn_{(l)} + 2Al_2O_{3(s)}$$

The reduction of metal oxides to metal using aluminium as the reducing agent is called *aluminothermy*. The reaction is highly exothermic. The heat evolved is so high that the metal is obtained in the molten state.

$$Fe_2O_{3(s)} + 2Al_{(s)} \xrightarrow{\text{Ignited}} 2Fe_{(l)} + Al_2O_{3(s)}$$

This reaction is known as *thermite reaction* and used for welding the broken parts of iron machinery, railway tracks, girders, etc.

– **Extraction of metals with low reactivity :** The oxides of these metals can be reduced to metals by heating alone.

$$\underset{\text{Mercury sulphide (Cinnabar ore)}}{2HgS_{(s)}} + 3O_{2(g)} \xrightarrow{\text{Heat}} 2HgO_{(s)} + 2SO_{2(g)}$$

$$2HgO_{(s)} \xrightarrow{\text{Heat}} 2Hg_{(l)} + O_{2(g)}$$

▸ **Refining of impure metal :** The process of purifying impure metals is called *refining of metals*. The most widely used method is electrolytic refining. In this process, the impure metal is made the anode and a thin strip of pure metal is made the cathode. A solution of the metal salt is used as an electrolyte. On passing the current through the electrolyte, the impure metal from the anode dissolves into the electrolyte and pure metal from the electrolyte is deposited on the cathode. The soluble impurities go into the solution, whereas, the insoluble impurities settle down at the bottom of the anode as such in the form of *anode mud*.

Corrosion : The process of slowly eating up of metals due to their conversion into oxides, carbonates, sulphides, sulphates, etc. by the action of atmospheric gases and moisture is called '*corrosion*'. In general, more reactive the metal, more easily it gets corrode. Metals like potassium, magnesium, aluminium, zinc, iron, etc. undergo corrosion easily while noble metals like gold and platinum do not get corroded easily. Corrosion of iron is known as *rusting* which causes a big loss to the economy of the country.

▸ **Prevention of corrosion :** Rusting of iron can be prevented by painting, oiling, greasing, galvanising, chrome plating, anodising or making alloys.

– A thin layer of tin metal or chromium metal is deposited on iron objects by electroplating to prevent rusting.

– Galvanisation is a method of protecting iron from rusting by coating them with a thin layer of zinc.

– **Alloying :** An alloy is a homogeneous mixture of two or more metals or a metal and a non-metal. *e.g.*,
stainless steel (Fe + Cr + Ni),
brass (Cu + Zn), bronze (Cu + Sn), etc.

Previous Years' CBSE Board Questions

3.2 Chemical Properties of Metals

VSA (1 mark)

1. What changes in the colour of iron nails and copper sulphate solution do you observe after keeping the iron nails dipped in copper sulphate solution for about 30 minutes? *(Delhi 2010)*

2. Which gas is generally liberated when a dilute solution of hydrochloric acid reacts with an active metal? *(Foreign 2009)*

3. Arrange the following metals in a decreasing order of activity :
Na, K, Cu, Ag *(Foreign 2009)*

4. From amongst the metals sodium, calcium, aluminium, copper and magnesium, name the metal
(i) which reacts with water only on boiling and
(ii) another which does not react even with steam. *(Delhi 2008)*

SA I (2 marks)

5. Name two metals which react violently with cold water. Write any three observations you would make when such a metal is dropped into water. How would you identify the gas evolved, if any, during the reaction? *(AI 2008)*

6. (a) Name a metal for each case :
(i) It does not react with cold as well as hot water but reacts with steam.
(ii) It does not react with any physical state of water.
(b) When calcium metal is added to water the gas evolved does not catch fire but the same gas evolved on adding sodium metal to water catches fire. Why is it so? *(AI 2008)*

SA II (3 marks)

7. (a) What are amphoteric oxides? Choose the amphoteric oxides from amongst the following oxides :
Na_2O, ZnO, Al_2O_3, CO_2, H_2O
(b) Why is it that non-metals do not displace hydrogen from dilute acids? *(AI 2008)*

LA (5 marks)

8. Give reason why
(i) metals are good conductors, whereas non-metals are bad conductors of electricity.
(ii) metals replace hydrogen from acids whereas non-metals do not.
(iii) an iron knife dipped in a blue copper sulphate solution turns the blue solution light green.
(iv) sodium is kept under kerosene.
(v) carbon cannot reduce the oxides of sodium or aluminium. *(Foreign 2010)*

3.3 How do Metals and Non-metals React?

VSA (1 mark)

9. Give reason for the following observation : ionic compounds in general have high melting and boiling points. *(1/5, Foreign 2009)*

SA II (3 marks)

10. (a) Show the formation of Na_2O by the transfer of electrons between the combining atoms.
(b) Why are ionic compounds usually hard?
(c) How is it that ionic compounds in the solid state do not conduct electricity and they do so when in molten state? *(Delhi 2008)*

LA (5 marks)

11. Write the names and symbols of two most reactive metals belonging to group I of the periodic table. Explain by drawing electronic structure how either one of the two metals reacts with a halogen. With which name is the bond formed between these elements known and what is the class of the compound

so formed known? State any four physical properties of such compounds. *(Delhi 2010)*

3.4 Occurrence of Metals

VSA (1 mark)

12. Name a reducing agent that may be used to obtain manganese from manganese dioxide. *(Delhi 2009)*

13. Give reason for the following observation : highly reactive metals cannot be obtained from their oxides by heating them with carbon. *(1/5, Foreign 2009)*

SA I (2 marks)

14. Explain how the following metals are obtained from their compounds by the reduction process :

(i) Metal *M* which is in the middle of the reactivity series.

(ii) Metal *N* which is high up in the reactivity series.

Give one example of each type. *(AI 2009)*

SA II (3 marks)

15. No chemical reaction takes place when granules of a solid, *A*, are mixed with the powder of another solid, *B*. However when the mixture is heated, a reaction takes place between its components. One of the products, *C*, is a metal and settles down in the molten state while the other product, *D*, floats over it. It was observed that the reaction is highly exothermic.

(i) Based on the given information make an assumption about *A* and *B* and write a chemical equation for the chemical reaction indicating the conditions of reaction, physical state of reactants and products and thermal status of reaction.

(ii) Mention any two types of reactions under which above chemical reaction can be classified. *(Delhi 2010)*

LA (5 marks)

16. What is meant by refining of metals? Name the most widely used method of refining impure metals produced by various reduction processes. Describe with the help of a labelled diagram how this method may be used for refining of copper. *(Delhi 2010)*

17. (a) Distinguish between 'roasting' and 'calcination'. Which of these two is used for sulphide ores and why?

(b) Write a chemical equation to illustrate the use of aluminium for joining cracked railway lines.

(c) Name the anode, the cathode and the electrolyte used in the electrolytic refining of impure copper. *(AI 2009)*

3.5 Corrosion

SA II (3 marks)

18. What is meant by 'rusting'? With labelled diagrams describe an activity to find out the conditions under which iron rusts. *(Delhi 2009)*

19. Give reason for the following observation : Copper vessels get a green coat when left exposed to air in rainy season. *(Foreign 2009)*

Detailed Solutions

1. As iron (Fe) is more reactive than copper (Cu) so, iron displaces copper from its salt solution. Thus, blue coloured $CuSO_4$ gets converted into pale green coloured $FeSO_4$ after keeping iron nails in $CuSO_4$ solution.

$$\underset{\text{Blue}}{CuSO_4} + Fe \longrightarrow \underset{\text{Pale green}}{FeSO_4} + Cu$$

2. Generally, hydrogen gas is liberated when dilute solution of hydrochloric acid reacts with active metals.

3. The decreasing order of activity is
$K > Na > Cu > Ag$

4. (i) Aluminium is the metal which reacts with water only on boiling (*i.e.*, it reacts with steam).
(ii) Copper metal does not react even with steam due to its low reactivity.

5. Sodium and potassium react with cold water violently.
When these metals are dropped into water then following changes are observed :
(i) Bubbles come out of water due to the evolution of a gas.
(ii) This gas catches fire immediately.
(iii) The beaker becomes hot as the reaction is highly exothermic.
When a burning matchstick is brought near this gas (hydrogen) then it burns explosively with a 'pop' sound.

6. (a) (i) Iron metal does not react with cold as well as hot water but it reacts with steam.

$$3Fe_{(s)} + 4H_2O_{(g)} \longrightarrow Fe_3O_{4(s)} + 4H_{2(g)}\uparrow$$

(ii) Gold does not react with cold water, hot water and not even with steam.
(b) When calcium metal is added to water the hydrogen gas evolved, does not catch fire because the reaction of calcium with water is less violent and the heat evolved is not sufficient for the hydrogen gas to catch fire. But the same gas evolved on adding sodium metal to water, catches fire because the reaction is very violent and highly exothermic and the heat evolved is sufficient for hydrogen gas to catch fire.

7. (a) Those oxides which react with both acids as well as bases to produce salts and water are called amphoteric oxides.
Among the given oxides, Al_2O_3 and ZnO are amphoteric in nature.
(b) Non-metals do not displace hydrogen from dilute acids because non-metals do not provide electrons to change H^+ ions into hydrogen gas.

8. (i) Metals are good conductors of electricity because they have free electrons or ions while non-metals do not contain free electrons or ions.
(ii) When a metal (which is more electropositive than hydrogen) is placed in an acid solution, it loses electrons. These electrons are gained by H^+ ions to produce hydrogen gas.
e.g.,

$$H_2SO_4 \longrightarrow 2H^+ + SO_4^{2-}$$

Loss of e^- by zinc : $Zn \longrightarrow Zn^{2+} + 2e^-$

Gain of e^- by H^+ : $2H^+ + 2e^- \longrightarrow H_2$

Overall reaction : $Zn + 2H^+ \longrightarrow Zn^{2+} + H_2$

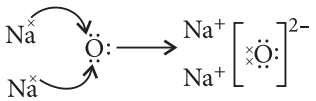
Non-metals do not have tendency to lose electrons.
(iii) As iron is more reactive than copper so, iron will displace copper from copper sulphate solution.

$$Fe + \underset{\text{Blue}}{CuSO_4} \longrightarrow \underset{\text{Pale green}}{FeSO_4} + Cu$$

Thus, blue coloured copper sulphate gets converted into light green iron sulphate.
(iv) Sodium catches fire vigorously on reaction with oxygen at room temperature if kept in open. Therefore, sodium is kept under kerosene.
(v) Carbon cannot reduce the oxides of sodium or aluminium because sodium and aluminium are placed at the top of the reactivity series and are highly reactive. They have more affinity for oxygen than carbon.

9. Due to strong forces of attraction, the ions are bound to each other very firmly. As a result, the electrovalent or ionic solids have high melting and boiling points.

10. (a) The formation of Na_2O can be represented as :

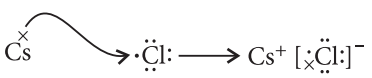


(b) Ionic compounds are usually hard due to strong forces of attraction between oppositely charged ions.

(c) Ionic compounds in the solid state do not conduct electricity because movement of ions in solid state is not possible due to the rigid structure. But they conduct electricity in the molten state as the electrostatic forces of attraction between oppositely charged ions are overcome by heat and ions become free to move.

11. Rubidium (Rb) and Caesium (Cs) are the two most reactive metals belonging to group-I of the periodic table.

Caesium (Cs) reacts with halogen say chlorine (Cl) to form caesium chloride as follows :



This bond formed by complete transfer of electrons between two elements is called ionic bond and the compound so formed is known as ionic compound.

Physical properties of ionic compounds are :

(i) **Physical nature :** Ionic compounds are solids and are somewhat hard because of the strong forces of attraction between the positive and negative ions.

(ii) **Melting and boiling points :** Ionic compounds have high melting and boiling points. This is because a considerable amount of energy is required to break the strong inter-ionic forces of attraction.

(iii) **Solubility :** They are soluble in water and insoluble in solvents such as kerosene, petrol, etc.

(iv) **Conduction of electricity :** A solution of an ionic compound in water contains ions which move to the opposite electrodes when electricity is passed through the solution. They conduct electricity in molten state as well as in aqueous solution but not in solid state because movement of ions in the solid state is not possible due to their rigid structures.

12. Aluminium reduces manganese dioxide (MnO_2) to manganese (Mn). The reaction is highly exothermic.

$$3MnO_{2(s)} + 4Al_{(s)} \xrightarrow{\text{heat}} 3Mn_{(l)} + 2Al_2O_{3(s)}$$

13. The oxides of the most reactive metals such as sodium, potassium, magnesium, aluminium, etc. cannot be reduced by reducing agents such as carbon or aluminium. This is because these metals have more affinity for oxygen than carbon or aluminium hence, cannot be reduced by common reducing agents.

14. (i) Those metals (*M*) which have moderate reactivity such as zinc, lead, iron, copper, etc. are obtained by the reduction of their oxides by reducing agents such as carbon or aluminium.

e.g.,

$$\underset{\text{Lead oxide}}{PbO} + C \xrightarrow{\Delta} \underset{\text{Lead}}{Pb} + CO$$

$$\underset{\text{Ferric oxide}}{Fe_2O_{3(s)}} + 2Al_{(s)} \xrightarrow{\text{heat}} \underset{\text{Iron}}{2Fe_{(l)}} + Al_2O_{3(s)}$$

(ii) Those metals (*N*) which are high up in the reactivity series are extracted by electrolytic reduction method.

e.g., sodium is obtained by the electrolysis of its molten chloride. The sodium metal is deposited at the cathode, whereas chlorine is liberated at the anode.

$$\text{At cathode : } Na^+ + e^- \longrightarrow Na$$
$$\text{At anode : } 2Cl^- \longrightarrow Cl_2 + 2e^-$$

15. From the given information it is clear that *A* is Fe_2O_3 and *B* is Al.

(i) When *A* (Fe_2O_3) and *B* (Al) are heated then *C* (Fe) metal is formed which settles down in the molten state while *D* (Al_2O_3) floats over it. This reaction is exothermic in nature.

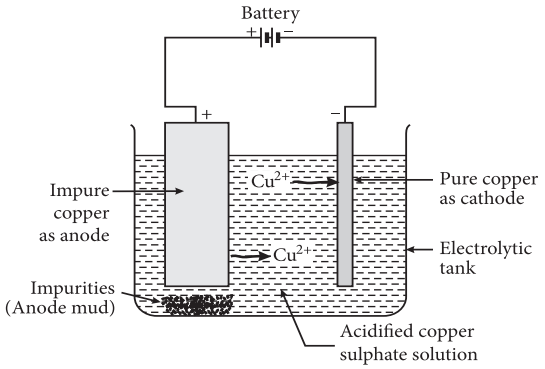
$$Fe_2O_{3(s)} + 2Al_{(s)} \xrightarrow{\text{heat}} 2Fe_{(l)} + Al_2O_{3(s)}$$

(ii) This reaction can be classified under displacement reaction and redox reaction.

16. The process of purifying the impure (crude) metal is called refining of metals.

The most widely used method of refining impure metals produced by various reduction processes is electrolytic refining.

In electrolytic refining, a thick block of impure metal acts as anode. It is connected to the positive terminal of the battery. A thin sheet of pure metal acts as cathode. It is connected to the negative terminal of the battery. An aqueous solution of a suitable salt of the metal is used as the electrolyte. On passing current through the electrolyte, pure metal gets deposited on the cathode and the impure metal of the anode dissolves into the elctrolyte. The impurities either dissolve in the solution or settle down at the bottom of the anode as anode mud.



Experimental set up for the electrolytic refining of copper

17. (a) The process of heating an ore (generally a sulphide ore) strongly below its melting point in the presence of an excess of air is called roasting.
Calcination is the process of heating an ore (generally a carbonate ore) strongly in the absence of air or very limited supply of air.
Roasting process is used for sulphide ores because sulphur gets oxidised to SO_2 which can be easily removed leaving behind the metal oxide.
(b) Aluminium displaces iron from iron oxide on heating.

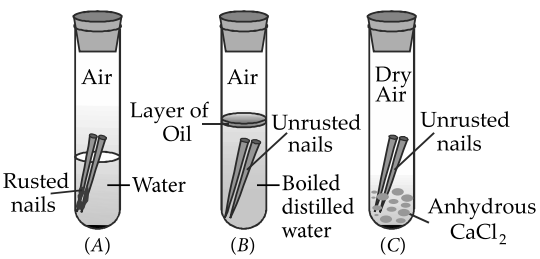
$$Fe_2O_{3(s)} + 2Al_{(s)} \xrightarrow{\text{heat}} Al_2O_{3(s)} + 2Fe_{(l)} + \text{Heat}$$

This reaction produces lots of heat which results in the melting of railway track lines. After cooling, iron again forms a hard solid and hence, cracked railway lines can be joined.

(c) For electrolytic refining of impure copper, impure copper is used as anode, pure copper is used as cathode and copper sulphate solution is used as the electrolyte.

18. Iron when exposed to moist air for a long time acquires a coating of a brown flaky substance known as rust and this process is called rusting. Following activity can be performed to find out the conditions under which iron rusts :
Materials required : Iron nails, distilled water, turpentine oil, anhydrous calcium chloride.
Procedure :

1. Take three test tubes and put one clean nail in each of them. Label them as *A*, *B* and *C*.
2. Pour some water in test tube *A*. In test tube *B*, pour some boiled distilled water along with some turpentine oil. In test tube *C*, add some anhydrous calcium chloride.
3. Leave these test tubes undisturbed for a few days.



Observations : Only in test tube *A*, iron nails get rusted since the nails in this test tube are exposed to both air and water.
Conclusion : Both air and water are required for rusting of iron.

19. Copper vessels get a green coat when left exposed to air in rainy season due to the formation of $CuCO_3 \cdot Cu(OH)_2$.

$$2Cu_{(s)} + \underbrace{H_2O_{(l)} + CO_{2(g)} + O_{2(g)}}_{\text{From moist air}} \longrightarrow \underbrace{Cu(OH)_2 \cdot CuCO_3}_{\text{Basic copper carbonate (Green)}}$$