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Metals And Non-Metals

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Physical properties

Metal — Tendency to loose electron

Properties	Example	Exception
Mainly in solid state	Iron, zinc	Mercury
Lustrous	Al, Mg	—
Generally hard	Fe, Zn	K, Na, Li
Malleable	Au, Ag	—
Ductile	Au, Ag	—
Good conductor of heat and electricity	Silver, Copper	Lead and Mercury (heat)
Have high melting point	Iron	Gallium, Caesium
Sonorous	Mg,Fe,Al	—

Non-metal — Tendency to gain electron

Properties	Example	Exception
Solid, liquid, gaseous	O_2, H_2, C	Bromine —>liquid
Non - Lustrous	O_2, H_2, C	Iodine
Soft	I, O_2	Diamond
Non - Malleable	O_2, H_2	—
Non - Ductile	O_2, H_2	—
Bad conductor of heat and electricity	O_2, H_2, I	Graphite —> Electricity
Have mainly low melting point	O_2, H_2, I	Diamond
Non - Sonorous	—	—

Malleability: It is the property of metal that it can be beaten into thin Sheets.
Examples:- gold, copper, Iron

Ductility: It is the property of metal that it can be drawn into thin wires.
Example:- gold, copper

Activity 3.1

Observation: We see these metals look dull.
After rubbing with sandpaper all these materials shine.

Activity 3.2

Observation: Metals are hard and can not be cut easily. Only magnesium is easily cut. Aluminium require more effort while iron is very hard to be cut by a knife.

Explanation:
Atoms of a metal are strongly connected to its neighbour atoms by a strong attractional force. This makes them hard and difficult to be cut.

Inference/conclusion:
This experiment demonstrates metals have strong inter molecular force of attraction and are difficult to cut.

activity 3.7

Answer:

In activities from 3.1 to 3.6, we studied various properties of metals. They are:
1. Lusture 2. Hardness 3.Malleability 4. Ductility 5. Electric conductivity 6. Heat conductivity.

Metals generally carry all these properties except a few like mercury which is soft (liquid), Sodium and lithium which are not hard. Most non-metals have contrasting features with few exceptions like coal and graphite and diamond which are hard. Below table summaries the properties of some common non-metals.

chemical properties

Metal + oxygen → Metal oxide

Example: $2Cu + O_2 \rightarrow 2CuO$ (Black)

$4Al + 3O_2 \rightarrow 2Al_2O_3$

Amphoteric oxide:- The metal oxide which show both acidic as well as basic behaviour and react with both acids as wells as bases to produce salts and water.
Example:- Aluminium Oxide and Zinc Oxide

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

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

$ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$

$ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$

P.Y.Qs

Question: A metal M forms an oxide having the formula M_2O_3. It dissolves both in dilute sulphuric acid and dilute sodium hydroxide solution. Identify the metal equations for the reactions involved.

Answer: Metal is aluminium. Compound is amphoteric oxide.

$2Al(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3 + 3H_2(g)$

$2Al(s) + 2NaOH(aq) + 2H_2O(l) \rightarrow 2NaAlO_2 + 3H_2(g)$

*Sodium oxide and potassium Oxide dissolve in water to produce alkalis.

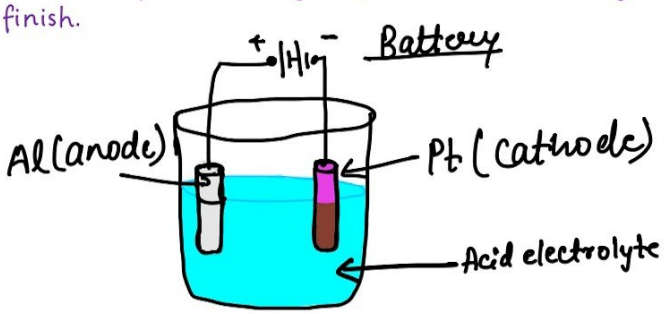
$Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$

$K_2O(s) + H_2O(l) \rightarrow 2KOH(aq)$

The metal such as sodium and potassium react so vigorously with oxygen that they catch fire if kept in open. Hence, to protect them and to prevent accidental fires they are kept immersed in kerosine oil.

Anodising: It is the process of forming a thick oxide layer of aluminium.

A clean aluminium article is made the anode and is electrolysed with dilute Sulphuric acid. The oxygen gas evolved at the anode react with aluminium to make a thicker protective layer of oxide. This Oxide layer can be dyed easily to give aluminium article an attractive finish.



Metal + water → Metal hydroxide + H_2

Cold water

$2K(S) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g) + heat$

$2Na(s) + 2H_2O(l) \rightarrow 2NaOH\ (aq) + H_2(g) + heat$

$Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$

Calcium start floating because the bubbles of hydrogen gas formed stick to the surface of the metal.

Hotwater

$Mg(s) + 2H_2O(l) \rightarrow Mg(OH)_2(aq) + H_2(g)$

Steam

$2Al(s) + 3H_2O(g) \rightarrow Al_2O_3(s) + 3H_2(g)$

$3Fe(s) + 4H_2O(g) \rightarrow Fe_3O_4(s) + 4H_2(g)$

Yaad karne ka Tarika

metal water se react karega to hydroxide banayega

$H_2O \rightarrow$ hydroxide

H और O से याद रखो

metal steam se react karega to oxide banayega

steam → metal oxide

मतलब air samjho यानी Oxygen से बनेगा

Metal + Dilute acid → Salt + Hydrogen

Example: $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

$2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$

$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

$Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$

Exception

Hydrogen gas not evolve when a metal react with nitric acid. This is because HNO_3 is strong Oxidising agent. It oxidised the H_2 produced water and itself get reduced to any of the nitrogen oxidise (N_2O, NO, NO_2)
But Mg and Mn react with very dilute HNO_3 to evolve H_2 gas.

$Mn(s) + 2HNO_3(aq) \rightarrow Mn(NO_3)_2(aq) + H_2(g)$

$Mg(s) + 2HNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + H_2(g)$

★ Aqua regia (royal water) is prepared mixture of a freshly concentrated HCl and concentrated HNO_3 in the ratio of 3:1. It is highly corrosive, fuming liquid. It is able to dissolve gold and platinum.
$3HCl + HNO_3 \rightarrow NaCl + 2H_2O + 2Cl$

activity 3.8

Observation: We get metal oxide by burning the metal in the presence of oxygen. Metal oxide reacts with water to give a base. It turns the red litmus paper blue.
Similarly, the burning of non-metal produces its oxide. The solution of oxides of non-metal with water turns the blue litmus paper into the red.

Explanation: Burning Magnesium ribbon

Magnesium burns in air to form its oxide.
$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$
Magnesium oxide reacts with water and forms Magnesium Hydroxide.

P.Y.Qs

Question: Write balanced equations for the reaction of
(a) Aluminium when heated in air. Write the name of the product.
(b) Iron with steam. Name the product obtained.
(c) Calcium with water. Why does calcium start floating in water?
Answer:
(a) $4Al + 3O_2 \rightarrow 2Al_2O_3$, Aluminium oxide
(b) $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$, Ferric Oxide
(c) $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$, because hydrogen sticks to calcium.

Question: What is observed after about 1 hour of adding the strips of copper and aluminium separately to ferrous sulphate solution filled in two beakers? Name the reaction if any change in colour is noticed. Also, write chemical equation for the reaction.
Answer:
$Cu(s) + FeSO_4(aq) \rightarrow$ No change will take place.
Copper is less reactive then $FeSO_4$, Cu cannot displace iron from ferrous sulphate solution
(i) No reaction will take place.
$2Al(s) + 3FeSO_4(aq) \rightarrow Al_2(SO_4)_3 + 3Fe(s)$. (Displacement reaction)
(ii) When Al is added to a $FeSO_2(aq)$ solution, the green colour of $FeSO_4(aq)$ disappears and the Fe is seen setting down as the reaction occurs Al being higher in reacting series displace the Fe in $FeSO_4$.

Question: (a) Design an activity to demonstrate the decomposition reaction of lead nitrate.
(b) Draw labelled diagram of the experimental set-up. List two main observations.
(c) Write balanced chemical equation for the reaction stating the physical state of the reactant and the products.

Answer: Activity to demonstrate the decomposition reaction of lead nitrate $Pb(NO_3)_2$

(a) (i) Take about 2g of lead nitrate powder in a boiling tube.

(ii) Hold the boiling tube with a pair of tongs and heat it over a flame, as shown in figure.

Two main observation:

- The emission of brown fumes of NO_2 after thermal decomposition of $Pb(NO_3)_2$
- The colourless compound $Pb(NO_3)_2$ forms a yellow compound PbO and brown fumes of NO_2 gas.

(c) $2Pb(NO_3)_2(s) \xrightarrow{Heat} 2PbO(s) + 4NO_2(g) + O_2(g)$

Lead Nitrate — Lead Oxide — Nitrogen dioxide — Oxygen gas

Metal A + Salt Solution of B → Salt Solution A + Metal B

Example: $Fe + CuSO_4 \rightarrow FeSO + Cu$

$Cu + FeSO_4 \rightarrow$ No changing

Ionic Compound

The compound formed by the transfer of e from a metal to a nonmetal are known as ionic compound electrovalent compound.

Properties of ionic compound

Physical nature: Ionic compounds are Solids and are somewhat hard because of the strong force of attraction between the positive and negative ion. These compounds are generally brittle and break into pieces when pressure is applied.

Melting and boiling points: Ionic compound have high melting and boiling points. This is because a considerable amount of energy is required to break the Strong Inter - ionic attraction.

Solubility: Electrovalent compounds are generally soluble in water and insoluble in solvents such as kerosene, petrol, etc.

conduction of electricity:

- A solution of an ionic compound in water contain ions, which move to the opposite electrode when electricity is passed through the solution.
- Ionic compounds in the Solid state do not conduct electricity because movement of ions in the solid is not possible due to there rigid Structure.
- Ionic Compound conduct electricity in the molten state. This is possible in the molten state since the electrostatics force of attraction between the oppositely charged ions are overcome due to the heat. Thus the ions more freely and conduct electricity.

Occurence of metal

- Few less reactive metals (like Cu, Ag, Au and Pt) are found in the 'free State' as metals (because of their low chemical activity.)
- When metal is found as free element, it is said to occur in 'native state'.
- Copper and silver metal occur in free state (native state) as well as in combine.
- The metals highly reactive like potassium, sodium, ca, Mg and aluminium they are found in nature as never free element.

- The metals middle in the reactivity Series (like Zn, Fe and Pb) are in the combined state.

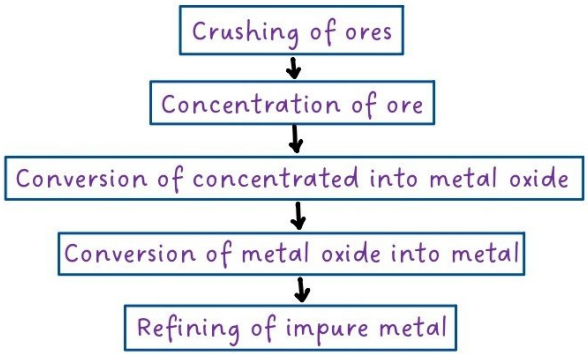
Minerals: The natural material in which the metals or their compound are found in earth.
Ores: Those minerals from which the metals can be extracted conveniently and profitable.

All the ores are mineral but all the mineral are not ores. The ores of many metals are oxides because oxygen in a very reactive element and are abundant on the earth.

Metallurgy

The various process Involved in the extraction of metals from their ore and refining are known as metallurgy.

The major steps involved in the extraction of metal from its ore:-



Crushing of ores

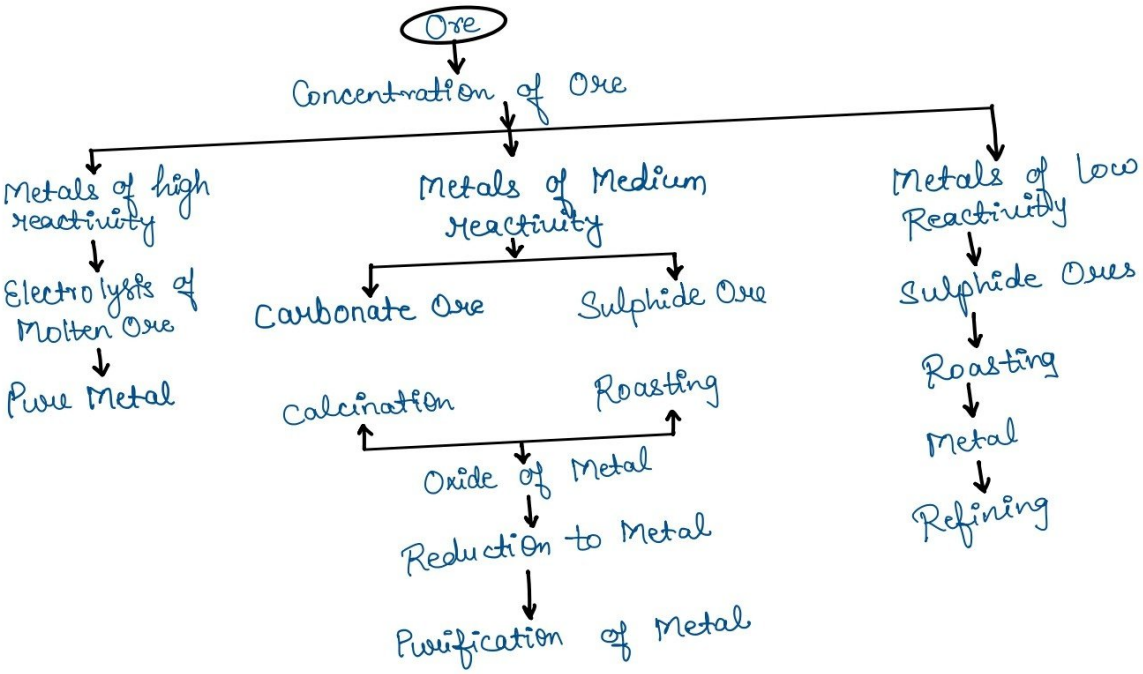
Crushing is the process of reducing the size of materials so that they can be further processed.

Concentration of ore

The Method of removing an impurities (gangue) like Sand, rock, earthy particle, limestone, mica etc. from its ore is referred as concentration of ores.

There are four physical methods involved in the concentration of ores

- Gravity separation
- Magnet separation
- Forth flotation
- Leaching or chemical method



- **Roasting:** It is the process of heating the substance in the presence of oxygen below its boiling point it is mainly used for sulphide ores.

- **Calcination:** It is the process of heating the substance in absence of oxygen below its melting point it is mainly for the carbonate ores.

Extracting metal Low in the activity series

The metal low in the activity series are extracted by simply heating I.e ore of mercury (Cinnabar HGS).

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

Copper found as Cu_2S in nature

$2Cu_2S + 3O_2(g) \xrightarrow{Heat} 2Cu_2O(s) + 2SO_2(g)$
$2Cu_2O + Cu_2S \xrightarrow{Heat} 6Cu(s) + SO_2(g)$

Extracting better in the middle of the activity series

Sulphide ores are converted by roasting and the carbonate ores are converted by calcination.

$2ZnS(s) + 3O_2(g) \xrightarrow{Heat} 2ZnO(s) + 2SO_2(g)$ → Roasting
$ZnCO_3(s) \xrightarrow{Heat} ZnO(s) + CO_2(g)$ → Calcination

Metal oxides are reduced into metal by using suitable reducing agent like C, Coke, CO, H_2 and NH_3.

$ZnO(s) + C(s) \longrightarrow Zn(s) + CO(g)$ → reduction using carbon
$3MnO_2(s) + 4Al(s) \longrightarrow 3Mn(l) + 2Al_2O_3(s) + Heat$ → Sometimes, Some highly reactive metals are used as Reducing agent.

Thermite process is a process in which molten metal oxides are treated with aluminium powder. It is highly exothermic reaction. The molten metal obtained is used for welding of railway tracks or cracked machine parts.

$2Al + Fe_2O_3 \longrightarrow 2Fe + Al_2O_3 + Heat$
Aluminium + Haematite → Molten Iron + Aluminium Ore

Extracting metals towards the top of the activity series

These metal are obtained by electrolytic reduction.
I.e sodium, magnesium and calcium are obtained by the electrolysis of their molten chloride.

P.Y.Q

Question: Define alloys. List the properties of alloys that makes them useful over pure metals. Explain this fact with suitable examples.

Answer: Alloys are homogeneous mixture of two or more metals or a metal and a non-metal that cannot be separated into their components by physical methods.
(i) The electrical conductivity, and
(ii) Melting point of an alloy is less than that of pure metal. e.g.,
(a) Brass and bronze (an alloy of Cu) are not good conductors of electricity, whereas copper is used in making electrical circuit.
(b) Solder has a low melting point.

P.Y.Qs

Question: (a) What type of ores are calcined? Illustrate giving a suitable example.
(b) In what form the calcined ore is obtained and how it can be reduced? Give chemical equations of the reduction process involved for the example given by you.
(c) Name two metals used as reducing agents by displacing metals of lower reactivity from their compounds.

Answer: (a) Carbonate ores are calcined.

e.g $MCO_3 \xrightarrow{Heat} MO + CO_2$

(b) Calcined ore is obtained in oxide form. It can be reduced into metal by reduction process.

$2MO + C \longrightarrow 2M + CO_2$

(c) Na, Ca, Al, Mn (any two).

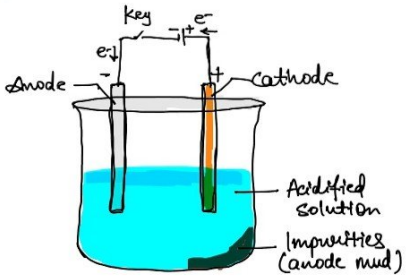
Refining

Refining is a process of converting impure metal into pure metal by different process depending on the nature of metals. It is the process of purification of metal.

Electrolytic refining

In this process, the impure metal is made the anode and a thin strip of pure metal is made the cathode.

On passing the current through the electrolyte, the pure metal from the anode dissolve into the electrolyte. An equivalent amount of pure metal from the electrolyte Is deposited on the cathode. The soluble impurities go into the solution, where insoluble impurities settle down at the bottom of the anode and are known as anode mud.



Corrosion

Slow eating of metals due to attack of atmospheric gases so as to convert the metal into its oxide, sulphide, or carbonate etc. is called corrosion.

Example: silver article become black
Copper become green
Iron become brown flaky substance (rust).

Prevention of corrosion

The corrosion of metal can be prevented by applying painting, oiling, greasing, galvanisation, chrome plating or making alloys.

- **Galvanisation or galvanization (or galvanizing as it is most commonly called) is the process of applying a protective zinc coating to iron or steel, to prevent rusting.**

- **An alloy is a homogeneous mixture of two or more metals, or a metal and then non metal.**
  Example: jwellery –> silver/ copper and gold
  Amalgam –> alloy of mercury
  Brass –> Cu and Zn
  Bronze –> Cu and Sn
  Alloy of lead and tin (Pb and Sn) has a low melting and is used for welding electrical wires together.

P.Y.Q

Question: (a) Give reason for the following
(1) Ionic compounds have high melting and boiling points.
(ii) Ionic compounds are soluble in water.
(in) Ionic compounds conduct electricity in molten state.
(b) Show the formation of MgO by transfer of electrons.

Answer: (a) (i) Ionic compounds have high melting and boiling points. It is because of strong force of attraction between oppositely charged ions, therefore high energy is required to break the metallic bonds between ions.
(ii) Ionic compounds are soluble in water because they form ions in aqueous solutions.
(iii) Ionic compounds conduct electricity in molten state and in aqueous solution because ions carry current. The movement of ions takes place towards oppositely charged electrode in electric field.
(b) Formation of MgO:

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

$O + 2e^- \rightarrow O^{2-}\ (2,8)$

$Mg: + \ddot{O}: \rightarrow [Mg^{2+}][:\ddot{O}:]^{2-}$ or MgO

MgO has Mg^{2+} and O^{2-} ions

P.Y.Qs

Question: (i) Explain the steps for extraction of copper from its sulphide ore. Write the balanced equations involved in the process.
(ii) What is meant by refining of metals? Draw a diagram of electrolytic refining of copper and name the substances used as cathode, anode and the electrolyte.

Answer: (i) Copper is extracted from its sulphide ore (Cu_2S) by just heating in the air.

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

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

(ii) Removal of impurities from the metals after their reduction.

Anode : impure copper

Cathode : pure copper

Electrolyte : acidified $CuSO_4$

activity 3.9

Observation

Not all metals burn easily. Copper and aluminium take time to burn.

Flame colour

Sodium: yellow

Magnesium: white

Aluminium: silver white

Copper: Blue flame

Solubility

Highly reactive metals like sodium and potassium reacts with water and form soluble hydroxide. But most other metals are not so reactive. So they are not soluble in water.

Only some metal oxides that from metal hydroxide with water, are soluble in water. Else they are insoluble.

Beryllium and magnesium are exceptions as they are slightly soluble in Water.

Metal oxide + $H_2O(l)$ –> Metal Hydroxide

Inference/ Conclusion

Metals on the heating burn to produce its oxides. During this process, they produce characteristic flames.

activity 3.11

Observation

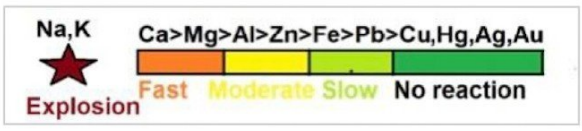
Metals react with dilute hydrochloric acid and form metal chlorides with the evolution of hydrogen gas.

Metal(s) + HCl(aq) –> Metal Chloride(aq) + $H_2(g)$

$Ca(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2(g)$

Order of reactivity:

Ca>Mg>Al>Zn>Fe>Pb>Cu



Reaction of metals with dilute hydrochloric acid

Temperature during the reaction:

Experiment done at room temperature (25°C).

Calcium: 40°C

Zinc: 34°C

Iron: 30°C

Copper: 25°C

Inference/conclusion

Metals react with acids to form their salt. The process is exothermic and hydrogen gas is also produced.

activity 3.12

Observation

More reactive metals displace with metals from other salt solution and form corresponding salts.
e.g. Iron in a copper sulphate solution.

Explanation

Iron is more reactive than copper. It displaces copper from copper sulphate and forms ferrous sulphate. Copper sulphate solution is blue while ferrous sulphate is green. So the solution turns green from blue.

$Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$
Note: The diplacement depend on reactivity series. A metal can displace a salt if the metal is higher in reactivity series.

activity 3.13

Observation

Salts of acids and bases are Hard; brittle; have a high melting point; soluble in water; insoluble in non-polar solvents likekerosene, benzene; conducts electricity.

Explanation

Molecules of salt are closed together by the strong lonic bond between anions and cations. This strong attraction gives a salt hard appearance, high melting and boiling point.
In water and other polar solvents, they form strong ionic bonds, so they are soluble in water. Non-polar solvents like organic solvents and kerosene do have polar bonds. A salt molecule, therefore, does not mix with such solvents. As a result, it sinks to the bottom.
In solution form molecules of salts are in ionic form. They move freely in the solution; therefore they conduct electricity.

activity 3.14

Observation

Nails in test tube A got rusted in a few days. Nails in test tube B and C did not get rust.

Inference

It shows water and air both are necessary to form rust.

Explanation

Oxidation of iron metal with oxygen require high temperature. The other alternative is to use the hydration energy of water. The outer layer of iron nail reacts with oxygen in the presence of water to form its oxide.
$4Fe(s) + 6H_2O(l) + 3O_2(g) \rightarrow 2Fe_2O_3.3H_2O$

Outer layer now scrapes off and give way to oxygen and moisture to the inner layer of iron. The process goes on until all iron convert into its oxide.
In the test tube, B oil prevents oxygen from dissolving in water. In the test tube C, calcium chloride acts as an absorbent and absorbs moisture present in it. So, Iron does not form rust in these test tubes.

Examplar

Question: 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
(b) HCl
(c) HNO_3
(d) All of these
Answer: (c) HNO_3

Question: Reaction between X and Y, forms compound Z. X loses electron and Y gains electron. Which of the following properties is not shown by Z?
(a) Has high melting point
(b) Has low melting point
(c) Conducts electricity in molten state
(d) Occurs as solid
Answer: (b) Has low melting point

Question: Which of the following can undergo a chemical reaction?
(a) $MgSO_4$ + Fe
(b) $ZnSO_4$ + Fe
(c) $MgSO_4$ + Pb
(d) $CuSO_4$ + Fe
Answer: (d) $CuSO_4$ + Fe

Question: Which one of the following properties is not generally exhibited by ionic compounds?
(a) Solubility in water
(b) Electrical conductivity in solid state
(c) High melting and boiling points
(d) Electrical conductivity in molten state
Answer: (b) Electrical conductivity in solid state

Question: Why should the metal sulphides and carbonates be converted to metal oxides in the process of extraction of metal from them?
Answer: Metal sulphide and carbonates are converted to metal oxides in the process of extraction of metal from them because metals can be obtained easier in oxide form than its sulphide or carbonate form.

Question: What are the constituents of solder alloy? Which property of solder makes it suitable for welding electrical wires?
Answer: Solder alloy is made of Lead and aluminium. Its low melting point makes it suitable for welding electrical wires.

Question: What happens when
(a) ZnCO is heated in the absence of oxygen?
(b) a mixture of Cu O and Cu S is heated?
Answer: (a) When $ZnCO_3$ is heated in the absence of oxygen Zinc Oxide and Carbon-di-oxide are liberated.

$$ZnCO_3 \longrightarrow ZnO + CO_2$$

(b) When a mixture of Cu_2O and Cu_2S is heated we get pure copper

$$2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2$$

Question: An element A burns with golden flame in air. It reacts with another element B, atomic number 17 to give a product C. An aqueous solution of product C on electrolysis gives a compound D and liberates hydrogen. Identify A, B, C and D. Also write down the equations for the reactions involved.
Answer:
Element A is 17 Sodium because it will burn with golden flame in air.
Element B is Chlorine for its atomic number is 17.
Product C is Sodium Chloride

$$2Na + Cl_2 \longrightarrow 2NaCl$$

Product D is Sodium hydroxide

$$2NaCl + 2H_2O \longrightarrow 2NaOH + Cl_2 + H_2$$