पु॰ना International School

Shree Swaminarayan Gurukul, Zundal

Class -X

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SCIENCE

Class X

NCERT

SCIENCE

Textbook for Class X

INDEX

CHAPTER – 3
METALS AND NON-METALS

- About 118 elements are known today. There are more than 90 metals,22 non metals and a few metalloids.
- Sodium (Na), potassium (K), magnesium(Mg), aluminium(Al),calcium(Ca), Iron(Fe), Barium(Ba) are some metals.
- Oxygen(O), hydrogen(H), nitrogen(N), sulphur(S), hosphorus(P),fluorine(F), chlorine(Cl), bromine(Br), iodine(I) are some non-metals.

	Metals		Non-metals
1.	Generally solid except Hg(present in liquid form).	1.	Can be solid, liquid organs e.g., C is solid, Br (liq), H22(gas)
2.	Ductile, Malleable (drawn into wires) (beaten into sheets)	2.	Non-ductile, non-Malleable
3.	Sonorous (produces sound)	3.	Non-sonorous
4.	Lustrous (have natural shine)	4.	Non-lustrous except Iodine.
5.	High Melting Point except Ce and Ga	5.	Lower M.P. than metals.
6.	Generally good conductors of heat and electricity except Pb and Hg.	6.	Bad conductors of heat and electricity except Graphite (form of C)
7.	High density except Na and K	7.	Low densities except Diamond (form of C)
8.	Reactive	8.	Not very reactive.
9.	Ionic bonding is present,	9.	Covalent/Hydrogen bonding is present

- Metals form basic oxides e.g., Magnesium oxide(MgO), while non-metals form acidic oxides e.g., SO_2,CO_2 .
- Ag and Cu are best conductors of electricity.
- Metals and Non-metals can be distinguished on the basis of their physical and chemical properties.
- Some elements show the properties of both metals and non-metals and are called metalloids.

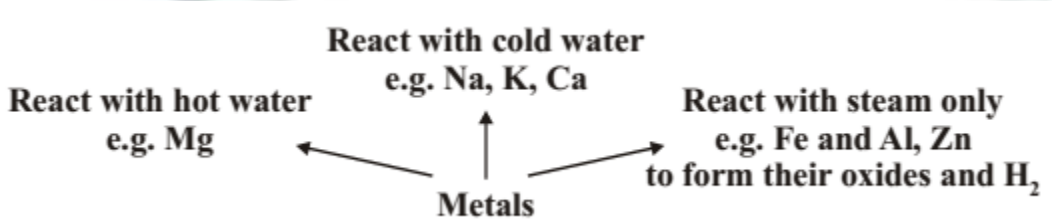
Chemical Properties of Metals Reaction with air : Different metals show different reactivities towards oxygen present in air. Metal+oxygen→Metal Oxide

- Some metals like Na and K are kept immersed in kerosene oil as they react vigorously with air and catch fire.
- Some metals like Mg, Al, Zn, Pb react slowly with air and form a protective layer.
- Mg can also burning air with a white dazzling light to form its oxide
- Fe and Cu don't burn in air but combine with oxygen to form oxide.Iron filings burn when sprinkled over flame.
- Metals like silver, platinum and gold don't burn or react with air.

e.g.. $2Na+1/2O_2 \rightarrow Na_2O$
$2Mg+O_2 \rightarrow 2MgO$
$2Cu+O_2 \rightarrow 2CuO$
$4Al+3O_2 \rightarrow 2Al_2O_3$

Usually metal oxides are basic in nature,but some metal oxides show both acidic and basic nature. Amphoteric Oxides :metal oxides which react with both acids as well as bases to form salt and water e.g. Al_2O_3,ZnO.Al_2O_3,ZnO.
eg.. $Al_2O_3+HCl \rightarrow AlCl_3+H_2O$
$Al_2O_3+NaOH \rightarrow NaAlO_3+H_2O$

REACTION WITH WATER : Metal oxides on reaction with water form alkalis.



$Na+HO_2 \rightarrow NaOH+H_2$

$K+HO_2 \rightarrow KOH+H_2$

$Ca+HO_2 \rightarrow Ca(OH)_2+H_2$

$Mg+H_2O \rightarrow Mg(OH)_2+H_2$

In case of Ca and Mg, the metal starts floating due to bubbles of hydrogen gas sticking to its surface.

$Al+H_2O \rightarrow Al_2O_3+H_2$

$Fe+H_2O \rightarrow Fe_3O_4+H_2$

Inert metals like Au and Ag do not react with water.

Metal oxide+water→MetalHydroxide

Note: Try Balancing the above Chemical equations yourself

REACTION WITH ACIDS
Metal +dilute acid→→ Salt + Hydrogen gas

metals react with dilute hydrochloric acid and dilute sulphuric acid to form chlorides. $Fe+2HCL \rightarrow FeCl_2+H_2$

$Mg+2HCl \rightarrow MgCl_2+H_2$

$Zn+2HCl \rightarrow ZnCl_2+H_2$

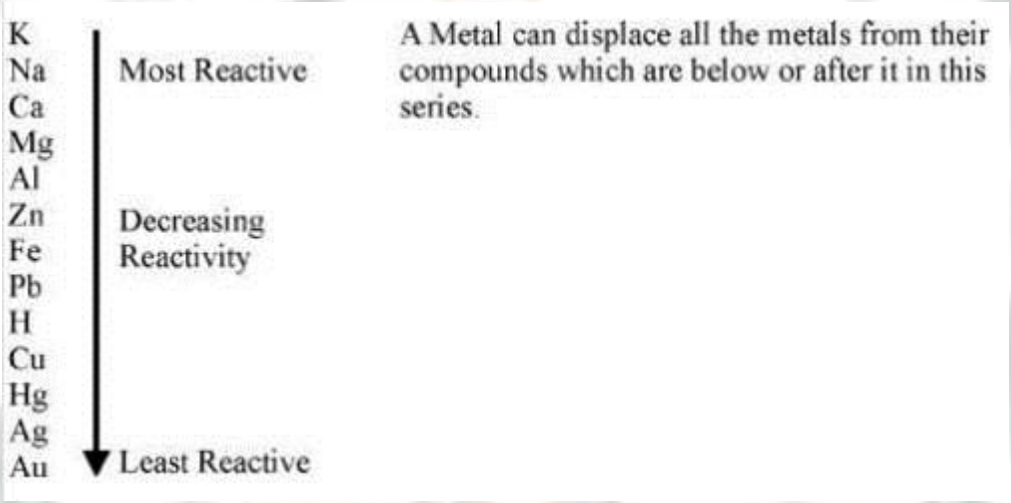
$2Al+6HCl \rightarrow 2AlCl_3+3H_2$

Note : Copper, mercury and silver don't react with dilute acids.

Hydrogen gas produced is oxidised to water. This happens because HNO_3HNO3is a strong oxidising agent when metals react with nitric acid(HNO_3).(HNO3). But Mg and Mn, react with very dilute nitric acid to evolve hydrogen gas. 4. Reaction of metals with other metal salts : MetalA+SaltsolutionofB→ SaltSolutionofA+MetalBMetalA+SaltsolutionofB→ SaltSolutionofA+MetalB

All metals are not equally reactive. Reactive metals can displace less reactive metals from their compounds in solution. This forms the basis of reactivity series of metals. Reactivity series is a list of metals arranged in order of their decreasing activities.

$Fe+CuSO_4 \rightarrow FeSO_4+Cu$ $Zn+CuSO_4 \rightarrow ZnSO_4+Cu$



REACTION OF NON-METALS :

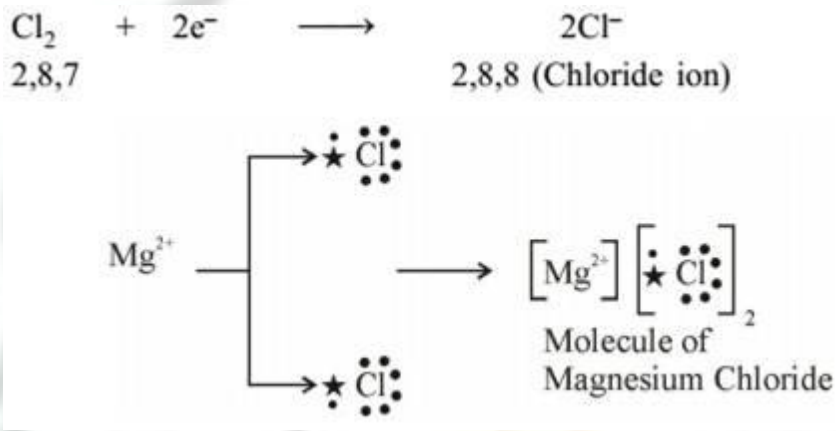
reaction with oxygen	non-metals form acidic oxides Eg:$C+O_2 \rightarrow CO_2$
reaction with water	non-metals do not react with water because they cannot release electrons.
reaction with dilute acids	no reaction
reaction with salt solutions	a more reactive non-metal will displace less reactive non-metal from its salt solution.
reaction with chlorine	chloride is formed. Eg;$H_2(g)+Cl_2 \rightarrow 2HCl$
reactions with hydrogen	hydrides are formed. $H_2 + S(l) \rightarrow H_2S$

Reaction between Metals and Non-Metals

- Reactivity of elements can be understood as a tendency to attain a completely filled valence shell.
- Atom of metals can lose electrons from valence shells to form cations(+ve ions).
- Atom of non-metals gain electrons in valence shell to form anions (–ve ions).

- Oppositely charged ions attract each other and are held by strong electrostatic forces of attraction forming ionic compounds.

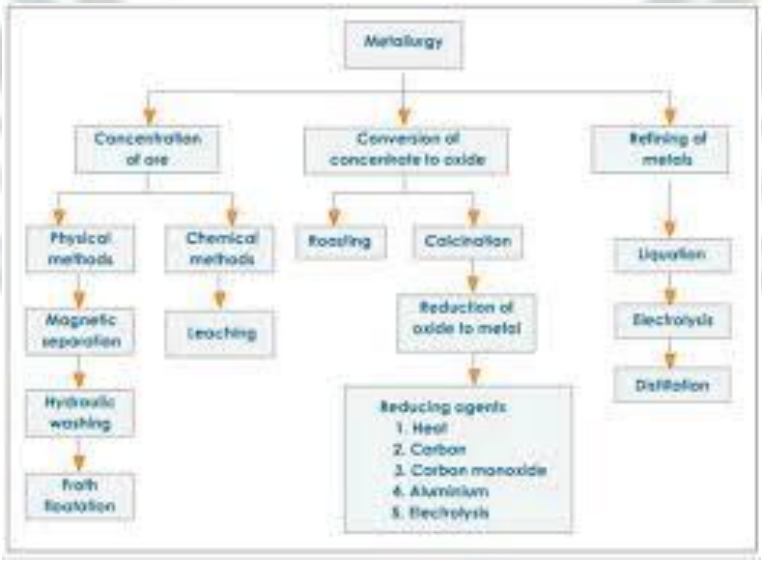
Formation of $MgCl_2$ $Mg \rightarrow Mg^{2+} + 2e^-$ 2,8, 22,8 (Magnesium ion)



Properties of Ionic Compounds

- Are solid and mostly brittle.
- Have high melting and boiling points. More energy is required to break the strong inter-ionic attraction.
- Generally soluble in water and insoluble in kerosene, petrol.
- Conduct electricity in solution and in molten state. In both cases, free ions are formed and conduct electricity.

Occurrence of Metals Minerals : Elements or compounds occurring naturally are minerals.
ORES : Mineral from which metal can be profitably extracted is an ore. For example, sulphide ore, oxide ore, carbonate ore.



- Metals at the bottom of activity series like gold, platinum, silver, copper generally occur in free state. But copper and silver also occur as sulphide and oxide ores.
- Metals of medium reactivity (Zn, Fe, Pb etc.) occur mainly as oxides,sulphides or carbonates.
- Metals of high reactivity (K, Na, Ca, Mg and Al) are very reactive and are thus found in combined state.

GANGUE : the commercially valueless materiallike soil,sand, etc. in which ore is found.called gangue. The gangue is removed from the ore. Various Methods to remove gangue:
1.GRAVITY SEPARATION 2.FROTH FLOATATION 3.MAGNETIC SEPARATION

METALLURGY : Step-wise process of obtaining metal from its ore.
I. *Enrichment of ore
II. *Obtaining metal from enriched ore.
III. *Refining of impure metal to obtain pure metal.
Enrichment of Ores : It is the process of the removal of impurities such as soil, sand etc. from the ore prior to extraction of the metal. Different separation techniques are used based on physical or chemical properties of ore. Extracting Metals from the Enriched Ore

Metal	Name of ore	Chemical name of main mineral in ore	Formula
sodium	rock salt	sodium chloride	$NaCl$
calcium	limestone	calcium carbonate	$CaCO_3$
magnesium	magnesite	magnesium carbonate	$MgCO_3$
aluminium	bauxite	aluminium oxide	Al_2O_3
zinc	zinc blende	zinc sulphide	ZnS
iron	haematite magnetite	iron(III) oxide black iron oxide (iron(II), (III) oxide)	Fe_2O_3 Fe_3O_4
tin	cassiterite	tin(IV) oxide	SnO_2
lead	galena	lead(II) sulphide	PbS
copper	copper pyrite or chalcopyrite	mixture of copper(II) sulphide and iron sulphide	$CuFeS_2$ ($Cu_2S + FeS$)
mercury	cinnabar	mercury(II) sulphide	HgS

Main minerals of metal ores

Extracting Metals Low in the Activity Series : By heating the ores in air at high temperature.

e.g.*Mercury from cinnabar

$2HgS+3O2 \xrightarrow{Heat} 2HgO+2SO2$

$2HgO \xrightarrow{Heat} 2Hg+O2$

e.g. *Copper from copper sulphide $Cu2S+3O2 \xrightarrow{Heat} 2Cu2O2SO2$

$2Cu2S+Cu2S \xrightarrow{Heat} 6Cu+SO2$

Extracting Metals in the Middle of Activity Series : *Metals are easier to obtain from oxide ores, thus, sulphide and carbonate ores are converted into oxides.

*Metal ore heated strongly in excess of air (**Roasting)**

e.g.. $2ZnS+3O2- \xrightarrow{Heat} 2ZnO+2SO2$

Metal ore heated strongly in limited or no supply of air (Calcination)

e.g.. $ZnSO3- \xrightarrow{Heat} ZnO+CO2$

Reduction of Metal Oxide :

USING COKE : Coke as a reducing agent.

$ZnO+C \xrightarrow{Heat} Zn+CO$

USING DISPLACEMENT REACTION : highly reactive metal like Na, Ca and Al are used to displace metals of lower reactivity from their compounds. These displacement reactions are highly exothermic.

$MnO2+4Al \xrightarrow{Heat} 3Mn+2Al2O3+heat$

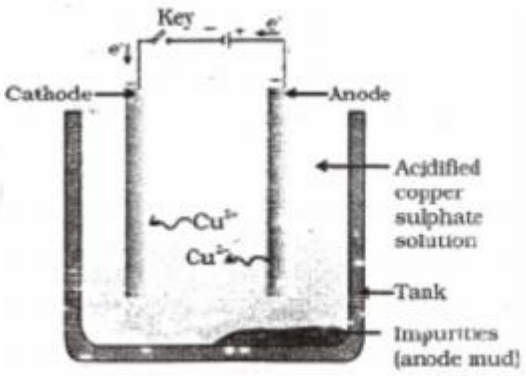
$Fe2O3+2Al \xrightarrow{Heat} 2Fe+Al2O3+heat$

Thermite Reaction : Reduction of a metal oxide to form metal by using Al powder as a reducing agent. This process is used to join broken pieces of heavy iron objects or welding. Extracting Metals at the Top of Activity Series

- These metals have more affinity for oxygen than carbon so they cannot be obtained from their compounds by reducing with carbon.
- So are obtained by electrolytic reduction. e.g.Sodium is obtained by electrolysis of its molten chloride $NaCl \rightarrow Na++Cl-$

As electricity is passed through the solution metal gets deposited at cathode and non-metal at anode. At cathode : e.g. $Na++e- \rightarrow Na$ At anode : $2Cl- \rightarrow Cl2+2e-$

III. Refining of Metals Impurities present in the obtained metal can be removed by electrolytic refining. Copper is obtained using this method. Following are present inside the electrolytic tank. Anode – slab of *impure* copper Cathode– slab of **pure** copper Solution – aqueous solution of copper sulphate with some dilute sulphuric acid From anode copper ions are released in the solution and equivalent amount of copper from solution is deposited at cathode. Insoluble impurities containing silver and gold gets deposited at the bottom of anode as anode mud.



Corrosion Metals are attacked by substances in surroundings like moisture and acids. Silver - it reacts with sulphur in air to our form silver sulphide and articles become black. Copper - reacts with moist carbon dioxide in air and gains a green coat of copper carbonate. Iron- acquires a coating of a brown flaky substance called rust. Both air and moisture are necessary for rusting of iron. Rust is hydrated Iron (III) oxide i.e. $Fe_2O_3.xH_2O$

Prevention of Corrosion Rusting of iron is prevented by painting, oiling, greasing, galvanizing, chrome plating, anodising and making alloys.

In galvanization, iron or steel is coated with a layer of zinc because oxide thus formed is impervious to air and moisture thus protects further layers from corrosion.

Alloys: These are homogeneous mixture of metals with metals or non-metals. Adding small amount of carbon makes iron hard and strong.

Some examples of alloys are following ;
1. Steel : Hard Iron and carbon.Used for construction of roads, railways, other infrastructure, appliances

2. Stainless steel :Hard Rust Free Iron, nickel and chromium. Used in utensils.

3. Brass :Low electrical conductivity Copper and zinc.used for decoration for its bright gold-like appearance and in locks,gears ,plumbing and electrical appliances.

4. Bronze: than pure metal Copper and tin. used to make coins, springs, turbines and blades.

5. Solder : Low MP, used to weld wires Lead and tin. used to create a permanent bond between metal work pieces

6. Amalgam :Used by dentists. Mercury and any other metal

In text Exercise :-

Page No. 40

1. Give an example of metal which
(i) is a liquid at room temperature.
(ii) can be easily cut with knife.
(iii) is best conductor of heat.
(iv) is poor conductor of heat.
Ans. (i) Mercury **(ii)** Sodium **(iii)** Silver **(iv)** Lead

2. Explain the meaning of malleable and ductile.
Ans. A substance that can be beaten into thin sheets is said to be malleable. For example, iron, copper etc.
A substance that can be drawn into wires is called ductile. For example, gold, silver etc.

Page No. 46

1. Why is sodium kept immersed in kerosene oil?
Ans. Sodium reacts so vigorously with oxygen that it catches fire when kept in the opens. Hence, to protect accidental fires, it is kept immersed in kerosene oil.

2. Write equation for the reaction of
(i) Iron with steam
(ii) Calcium and potassium with water
Ans.
(i) $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$
(ii) $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$
$2K + 2H_2O \rightarrow 2KOH + H_2$

3. Samples of four metals A, B, C and D were taken and added to the 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

Use the table given above to answer the f0llowing questions about metals A,B,C and D.
(i) Which is the most reactive metal?
(ii) What would you observe if B is added to a solution of Copper(II) sulphate?
(iii) Arrange the metals A, B,C and D in order of decreasing reactivity.
Ans. (i) B is the most reactive metal
(ii) If B is added to a solution of copper (II) sulphate, displacement reaction will take place. Blue colour of copper sulphate will fade and red –brown copper will settle down.
(iii) The decreasing order of reactivity is:

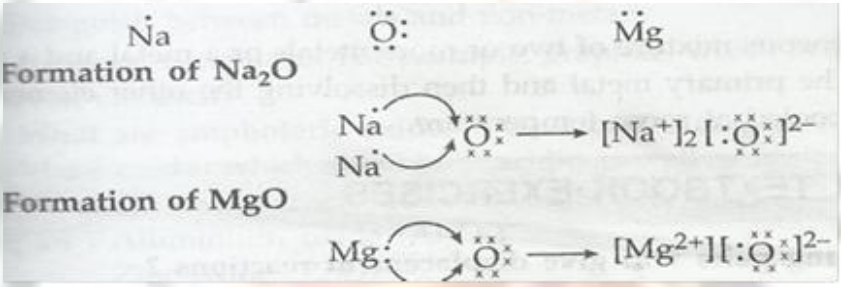
B> A> C >D

4. Which gas is produced when dilute hydrochloric acid is added to reactive metal?
Ans. Hydrogen gas is produced when dilute hydrochloric acid is added to a reactive metal.

5. What would you observe when zinc is added to a solution of iron(II) sulphate? Write the chemical reaction that takes place.
Ans. As zinc is more reactive than iron, displacement reaction will take place

$$Zn + FeSO_4 \rightarrow ZnSO_4 + Fe$$

Page No. 49
1. (i) Write the electro-dot structures for sodium, oxygen, and magnesium.
(ii) Show the formation of Na_2O and MgO by the transfer of electrons.
(iii) What are the ions present in these compounds?
Ans. (i) Electron-dot structure for sodium, oxygen and magnesium are
(ii)



(iii) Ions present in Na_2O are Na^+ and O^{2-}
Ions present in MgO are Mg^{2+} and O^{2-}

2. Why do ionic compounds have high melting points?
Ans. There are strong forces of attraction between oppositely charged ions in ionic compounds. Considerable amount of energy is required to break strong inter-ionic force of attraction. Therefore, they have high melting points.

Page No. 53

1. Define the following terms:
(i) Minerals
(ii) Ores and
(iii) Gangue
Ans. (i) Minerals- the element or compounds which occur naturally in the earth crest are known as minerals.
(ii) Ores- Minerals from which metal can be extracted profitably and easily are called ores.
(iii) Gangue- Impurities such as soil and sand which are present in the minerals are called gangue.

2. Name two metals which are found in nature in the free state.
Ans. Gold and Platinum

3. What chemical process is used for obtaining a metal from its oxide?
Ans. A metal is obtained from its oxide by the process of reduction.

Page No. 55
1. Metallic oxide of zinc, magnesium and copper were heated with following metals:

Metal	Zinc	Magnesium	copper
Zinc oxide			
Magnesium oxide			
Copper oxide			

In which case will you find displacement reactions taking place?
Ans. Based on the activity series of metals, the displacement reactions will take place as below:

Metal	Zinc	Magnesium	copper
Zinc oxide	No reaction	Displacement	No reaction
Magnesium oxide	No reaction	No reaction	No reaction
Copper oxide	Displacement	Displacement	No reaction

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2. Which metals do not corrode easily?
Ans. Metals which are placed at the bottom of activity series like silver, gold, platinum do not corrode easily.

3. What are alloys?
Ans. An alloy is homogenous mixture of two or more metals or metal and non-metal. It is obtained by first melting primary metal and then dissolving the other element in it in definite proportion.

TEXTBOOK EXERCISES:-

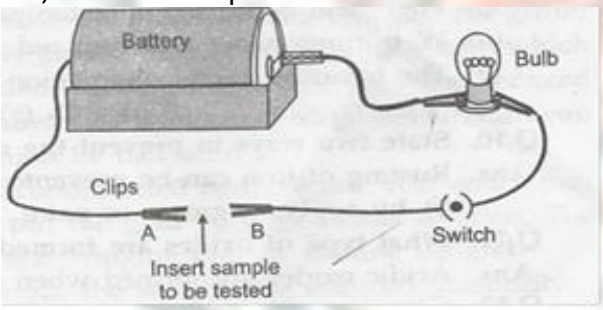
1. Which of the following pairs will give displacement reactions?
(a) NaCl solution and copper metal
(b) $MgCl_2$ solution and aluminum
(c) $FeSO_4$ solution and silver metal
(d) $AgNO_3$ solution and copper
Ans. (d) $AgNO_3$ solution and copper

2. Which of the following method is suitable for preventing an iron fry pan from rusting?
(a) Applying grease
(b) applying paint
(c) Applying coating of zinc
(d) All of the above
Ans. (c) Applying coating of zinc

3. An element reacts with oxygen to give a compound with a high melting point. This compound is also soluble in water. The element is likely to be
(a) Calcium
(b) Carbon
(c) Silicon
(d) Iron
Ans. (a) Calcium

4. Food cans are coated with tin and not zinc because
(a) Zinc is costlier than tin
(b) Zinc has higher melting point
(c) Zinc is more reactive than tin
(d) Zinc is less reactive than tin
Ans. (c) Zinc is more reactive than tin

5. You are given a hammer, a battery, a bulb, wires and switch.
(a) How could you use them to distinguish between samples of metals and non-metals?
(b) Asses the usefulness of these tests in distinguishing between metals and non-metals?
Ans. (a) Place the sample on an iron block. Strike with hammer. If the sample takes the shape of a sheet, it is a metal. If it breaks into pieces, it is a non-metal.
Set up the arrangement by using a bulb, a battery, wires and switch. Insert the samples of metals and non-metals in the clips one by one and turn the switch on. If the bulb glows, the sample is a metal, if not, then the sample is non-metal.



(b) The above two methods can, in general, be used to distinguish between metals and non-metals.

6. What are amphoteric oxides? Give two examples of amphoteric oxides.
Ans. Metal oxides which show both acidic as well as basic behavior are called amphoteric oxides. Such metal oxides react with both acids and bases.
Example: Aluminum oxide, zinc oxide

7. Name two metals which will displace hydrogen from dilute acids, and two metals which will not.
Ans. Magnesium and zinc metals displace hydrogen from dilute acids. Copper and silver do not displace hydrogen from dilute acids.

8. In the electrolytic refining of a metal M, what would you take as the anode, the cathode and the electrolyte?
Ans. Impure metal M is made the anode, thin strips of pure metal M as cathode and a salt solution of metal M as electrolyte.

9. Pratyush took Sulpher powder on spatula and heated it. He collected the gas evolved by inverting a test tube over it as shown in fig. 3.12 below:
(a) What will be the action of gas on
(i) Dry litmus paper?
(ii) Moist litmus paper?
(b)Write a balanced chemical equation for the reaction taking place.
Ans. (a) Sulphur is a non-metal. Oxides of non-metals are acidic. In this case sulphur dioxide is produced which is acidic.
(i) No action of the gas
(ii) wet litmus paper will turn red.
(b)

$$S\,(s) \; + O_2\,(g) \rightarrow SO_2\,(g)$$

10. State two ways to prevent the rusting of iron.
Ans. Rusting of iron can be prevented by
(i) By applying grease or paint.
(ii) By galvanizing

11. What types of oxides are formed when non-metals combine with oxygen?
Ans. Acidic oxides are formed when non-metals combine with oxygen.

12. Give reasons:
(a) Platinum, gold and silver are used to make jewellery.
(b) Sodium, potassium and lithium are stored under oil.
(c) Aluminum is highly reactive metal, yet it is used to make utensils for cooking.
(d) Carbonate and sulphides ores are usually converted into oxides during the process of extraction.
Ans. (a) These metals are un-reactive. They do not react with oxygen and other gases present in air and with moisture. Thus, their shine is maintained. That is why these metals are used to make jewellery.
(b) Reaction of sodium, potassium and lithium with oxygen is so violent that they catch fire. To prevent accidental fire, they are stored under kerosene oil.
(c) This is because aluminum is a good conductor of heat. Aluminum forms a layer of aluminum oxide at high temperature which is prevent the further corrosion.
(d) It is easier to reduce oxide than the carbonates and sulphide to the metals.

13. You must have seen tarnished copper vessels being cleaned with lemon or tamarind juice. Explain why these sour substances are effective in cleaning the vessels.
Ans. Copper, on keeping in air reacts with atmospheric carbon dioxide to form a green layer of copper carbonate. Copper carbonate reacts with citric acid present in lemon or tartaric acid present in tamarind to form soluble copper citrate or copper tartarate. The vessels are thus cleaned using water.

14. Differentiate between metal and non-metal on the basis of their chemical properties.

Ans. Metals and non-metals can be differentiated on the basis of following chemical properties.

Metals	Non-metals
1. Metals displace hydrogen from water.	1. Non-metal do not displace hydrogen from water.
2. Metals are basic oxide.	2. Non-metals are acidic oxides.
3. Metals displace hydrogen from dilute acids.	3. Non-metals displace hydrogen from dilute acids.
4. Metals form ionic chlorides with chlorine.	4. Non-metals form covalent chlorides with chlorine.

15. A man went door to door posing as a goldsmith. He promised to bring back the glitter of the old and dull ornaments. An unsuspecting lady gave a set of gold bangles to him which he dipped in a particular solution. The bangles sparkled like new but their weight was reduced drastically. The lady was upset but after a futile argument the man beat a hasty retreat. Can you play the detective to find out the nature of the solution he had used?

Ans. Aqua regia, which is a mixture of 3 parts concentrated HCl and part of concentrated nitric acid dissolves gold. The man put the gold bangles in this solution. The outer dirty layer of gold bangles dissolved in aqua regia bring out the shining bangles.

As the outer layer of bangles dissolved in aqua regia, the weight was reduced drastically.

16. Give reasons, why copper is used to make hot water tanks and not steel (an alloy of iron).

Ans. Electrical conductivity of a metal is decreased when it is alloyed with another metal or non-metal. Thus, the electrical conductivity of steel is much less than that of pure. That is why copper is used to make hot water tanks and not steel.