METALS AND NON-METALS

Question 1: *Compare the properties of a typical metal and a non-metal on the basis of the following. Fill in Column A, B.*

PROPERTIES	A METAL	B NON- METAL
Electronic configuration	?	?
Nature of oxides	?	?
Oxidizing or reducing action	?	?
Conduction of heat and electricity	?	?

Answer:

PROPERTIES	A METAL	B NON- METAL
Electronic configuration	Have 1, 2, 3 valence electrons	Have 4, 5, 6, 7 valence electrons
Nature of oxides	Form metallic oxides i.e., basic or amphoreic oxides	Formic acidic oxides or neutral oxides
Oxidizing or reducing action	Metals are donors of electrons $M - e \rightarrow M^+$ Therefore they act as reducing agents	Non-metals generally accept electrons $X + e \rightarrow X^-$ and act as oxidizing agents
Conduction of heat and electricity	Good conductors of heat and electricity	Non-conductors of heat and electricity

Question 2: *Name the following:*

1) A molten metal that catches fire in chlorine gas and gives off white fumes
2) A metal that forms two types of oxides and rusts in moisture; write their formulae also
3) A metal used in hot water systems
4) A metal used in long distance cables wires
5) A metal added to gold to harden it

Answer:

1) The molten metal that catches fire in chlorine gas and gives off white fumes is sodium.
2) The metal that forms two types of oxides and rusts in moisture is iron. The formulas of its oxides are: FeO; Fe_2O_3.
3) The metal used in hot water systems is copper, because it is a good conductor of heat and electricity.
4) The metal used in long distance cables wires is aluminium, because it is a light metal and a very good conductor of electricity.
5) The metal added to gold to harden it is copper.

Question 3: *A copper plate was dipped in $AgNO_3$ solution. After certain time silver from the solution was deposited on the copper plate. State the reason why it happened. Give the chemical equation of the reaction involved.*

Answer: Copper is more reactive than silver, therefore, it displaces silver from silver nitrate.

$$\underset{\text{Copper}}{Cu} + \underset{\text{Silver nitrate}}{2AgNO_3(aq)} \longrightarrow \underset{\text{Blue}}{Cu(NO_3)_2} + \underset{\text{Silver}}{2Ag}$$

Question 4: *Name two metals which can displace hydrogen from dilute HCl.*

Answer: Zinc and Iron.

Question 5: *An element X on reacting with oxygen forms an oxide X_2O. This oxide dissolves in water and turns blue litmus red. State whether element X is metal or a non-metal.*

Answer: Since the oxide turns blue litmus red, therefore X is a non-metal because it is an acidic oxide.

Question 6: *Metals replace hydrogen from acid, whereas non-metals do not. Why?*

Answer: Non-metals cannot supply electrons to convert H^+ to $H_2(g)$ whereas metals can give electrons to convert

$$2H^+ + 2e^- \longrightarrow H_2(g).$$

Question 7: *Name the metal which occurs below copper in the reactivity series. Also name the metal that lies just above hydrogen in the reactivity series.*

Answer: Mercury occurs below copper in the reactivity series. Copper is the metal just above hydrogen in the reactivity series.

Question 8: *Why are the two non-metals, carbon and hydrogen are important chemical reference points with regard to the method of metal extraction and reactivity towards acids.*

Answer: The six metals K, Na, Li, Ca, Mg, and Al, which lie above carbon in the activity series, cannot be extracted by carbon reduction: they are usually extracted by electrolysis. Metals below hydrogen i.e., Cu, Ag, Au and Pt, are transition metals that will not displace hydrogen from acids.

Question 9:

a) What is the behaviour of magnesium when it is heated and steam is passed over it? Represent the equation.

b) Can carbon dioxide react with magnesium?

Answer:

a) When steam is passed over heated magnesium a reaction takes place where a white powder magnesium oxide is formed along with hydrogen. Magnesium will burn with a bright white flame in steam, if previously ignited in air.

$$Mg_{(s)} + H_2O_{(g)} \Rightarrow MgO_{(s)} + H_{2(g)}$$

b) Ironically, magnesium will even burn in carbon dioxide forming black specks of carbon!

$$2Mg_{(s)} + CO_{2(g)} \Rightarrow 2MgO_{(s)} + C_{(s)}$$

Question 10: *A zinc rod was kept in a glass container having $CuSO_4$solution. On examining, it was found that the blue colour of the solution had faded. After few days when the zinc rod was taken out of the solution, a number of small holes were noticed in it. State the reason and give equation of chemical reaction involved.*

Answer:

$$\underset{\text{Blue}}{CuSO_4} + Zn \longrightarrow \underset{\text{colourless}}{ZnSO_4} + Cu$$

Zinc has displaced Cu from $CuSO_4$ solution; therefore holes were noticed on zinc plate.

Question 11: *What is metallurgy?*

Answer: The entire operation, involving all the physical and chemical processes in the extraction of metal from its ore, is called metallurgy.

Question 12: *How does the term "Ore" differ from "Mineral"? Give an example.*

Answer: Minerals are naturally occurring chemical compounds of a metal, which may be associated with more impurities. But ore is a chosen mineral of a metal, from which metal is extracted profitably on a large scale, in pure form. For e.g., the ore of Fe is Haemetite, while the minerals having Fe may be magnetite, iron pyrites, spathic iron ore etc.

Question 13: *What are the three major steps involved in extraction of a metal after its ore is mined?*

Answer: The three steps involved in extraction are:

1) Concentration of the ore to remove impurities.
2) Reduction of the ore to get the metal.
3) Purification of the ore.

Question 14: *Carbonates and sulphide ores are usually converted into oxide ores, why?*

Answer: It is easier to reduce oxide as compared to carbonate and sulphide.

Question 15: *Name the types of reduction processes involved in metallurgy with an example for each.*

Answer: The types of reduction processes involved in metallurgy are:

1) Electrolytic reduction of fused compound (chloride or oxide of very active metal). Example: K, Na, Ca Mg and Al
2) Chemical reduction of oxide by coke only, e.g., Zn is obtained from ZnO by reducing it with coke
3) Chemical reduction of oxide by CO gas, e.g., Fe is obtained from Fe_2O_3 gas by reducing it by CO gas
4) Self reduction for Cu extraction

$$Cu_2S + 2CU_2O \rightarrow 6Cu + SO_2$$

Question 16: *An ore gave SO_2on heating with oxygen. How will you concentrate this ore?*

Answer: It is concentrated by Froth floatation process.

Question 17: *In metallurgy what do the terms gangue, flux, slag stand for? Give examples.*

Answer: The term 'Gangue' is used for all the earthly impurities associated with the ore of the metal. These need to be removed before the extraction step.

Example: In iron ore, sand SiO_2 is the main gangue. The term 'Flux' refers to the compound added during extraction, which reacts with a non fusible (high melting point) gangue and forms a fusible product called slag.

This can then be removed by simple physical method.

Example: In the blast furnace for extraction of iron, the flux added is limestone $CaCO_3$. This decomposes to give CaO (a basic oxide) which reacts with sand (gangue - an acidic oxide) and forms a fusible slag $CaSiO_3$. The term Slag refers to the easily fusible product formed between gangue and flux.

$$\underset{\text{Gangue}}{SiO_2} + \underset{\text{Flux}}{CaO} \rightarrow \underset{\text{Slag}}{CaSiO_3}$$

Question 18: *1) In metallurgy, what does the term 'Roasting' stand for?*
2) Name the by-product formed during roasting and give one of its uses.

Answer:

1) Roasting is a chemical process where a sulphide ore is strongly heated in a current of O_2 to oxidize the ore. Therefore it is an oxidation process.
Examples:

$$2ZnS + 3O_2 \xrightarrow{\text{Roasting}} 2ZnO + 2SO_2\uparrow$$

$$4FeS + 7O_2 \xrightarrow{\text{Roasting}} 2Fe_2O_3 + 4SO_2\uparrow$$

2) SO_2 gas is the by-product formed and it is used for manufacture of sulphuric acid by the contact process.

Question 19: *How does roasting differ from calcination? Give equations.*

Answer:

Sl. No	ROASTING	CALCINATIONS
1.	Roasting is heating ore in the presence of air to oxidize it	Calcinations is heating of the ore, in the absence of air to decompose it or drive volatile matter
2.	Roasting occurs at higher temperatures, higher than the melting point of the ore	Calcinations occurs at temperatures lower than the melting point of the ore

$$\text{Roasting: } 2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2$$

$$\text{Calcination: } ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2\uparrow$$

In both cases, the ore becomes porous for easy reduction.

Question 20:

Why are aluminium containers used to transport nitric acid?

Answer: Aluminium containers are used to transport nitric acid because concentrated HNO_3 renders aluminium passive by forming a thin strong protective oxide layer. This protective layer prevents further reaction with the acid.

Question 21: *1) Why is aluminum used to reduce metal oxides like Fe_2O_3?*
2) What is "Thermite Welding"?

Answer: 1) Aluminium is a powerful reducing agent i.e., has great affinity for oxygen. Hence it reduces metallic oxides below it like Fe_2O_3 to metal, with evolution of lot of heat.

2) The property of aluminium to act as a powerful reducing agent and evolving a lot of heat is used in welding broken iron pieces.

$$2Al + Fe_2O_3 \xrightarrow{\Delta} Al_2O_3 + 2Fe + Heat$$

Question 22: *How is iron ore reduced in the blast furnace?*

Answer: Iron ore is reduced by a powerful reducing agent like carbon monoxide gas.

$$Fe_2CO_3 + 3CO \rightarrow 2Fe + 3CO_2\uparrow$$

Question 23: *Why is Al obtained only by electrolytic reduction of Alumina (pure)?*

Answer: Aluminium metal has a strong affinity for oxygen and the oxide of Al is Al_2O_3, which is a very stable oxide. Hence ordinary chemically reducing agents are not sufficient to reduce Al_2O_3 to Al. Electrolytic reduction is a more powerful reduction method.

Question 24: *Name the two ores of zinc commonly used.*

Answer: The two commonly used ores of zinc are zinc blende (ZnS) and calamine ($ZnCO_3$).

Question 25:

Name two common alloys of zinc with their property and uses.

Answer:

Alloys of Zinc	PROPERTY	USE
Brass (Cu + Zn)	Hard, tough, takes polish, can be cast	Utensils, decorative and household articles, artillery gun shells.
Zinc amalgam	More reactive than zinc.	In dry cell as negative electrode.

Question 26: *Name the following:*

1) A metal used in structural engineering
2) A metal used as fuse wire
3) A brittle metal, which is used to galvanize iron
4) A metal whose chloride and sulphate salts are both insoluble
5) A metallic chloride that is soluble in hot water but insoluble in cold water.

Answer:

1) Iron is used in structural engineering
2) Lead, has a low melting point it is therefore used as fuse wire
3) Zinc is the brittle metal used to galvanize iron
4) Lead metal has its chloride precipitate ($PbCl_2$) and sulphate precipitate ($PbSO_4$) as insoluble
5) Lead chloride is insoluble in cold water but dissolves in hot water.

Question 27: Arrange the following metals in the decreasing order of chemical reactivity;

placing the most active first. Cu, Mg, Fe, Na, Ca, Zn.

Answer: The decreasing order of chemical reactivity is (most active)

Na > Ca > Mg > Zn > Fe > Cu (least active).

Question 28: Give two metallurgical facts that justify placing magnesium above iron in the activity series.

Answer:

1) Magnesium metal is extracted by electrolytic reduction only, whereas iron can be extracted by chemical reduction using coke. Therefore Mg should be above iron.

2) Magnesium can displace iron from ferrous sulphate solution, but iron cannot displace magnesium from magnesium sulphate solution. Therefore magnesium should be above iron.

Question 29: In metallurgy, what do the term calcination stand for? Give examples.

Answer: Calcination is a chemical process wherein a carbonate ore or an oxide ore is strongly heated in the absence of air, to decompose it to remove volatile matter and moisture.

Examples:

$$CaCO_3 \xrightarrow{\text{Calcination}} CaO + CO_2 \uparrow$$

$$ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2 \uparrow$$

(Calamine)

$$Al_2O_3.2H_2O \xrightarrow{\Delta} Al_2O_3 + 2H_2O$$

Question 30: Name two metals that occur in a free state nature. What is the method of refining them?

Answer: Gold and Platinum are two metals that occur in a free in state in nature. They only need to be cleaned by physical methods.

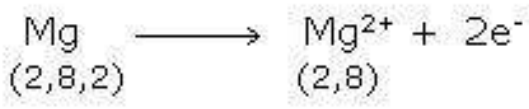
Question 31:

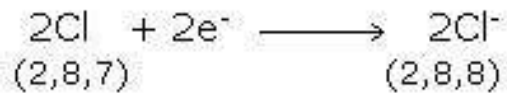
Explain the formation of an ionic compound between a metal and a non metal by transfer of electrons with Mg as the metal and chlorine as the non-metal to illustrate your answer. Give the reaction that occurs.

Answer: Magnesium, whose atomic number is 12, has 2, 8, 2 configuration. It has two electrons in its valence shell. Chlorine has an atomic number of 17 and an electronic configuration of is 2, 8, 7.

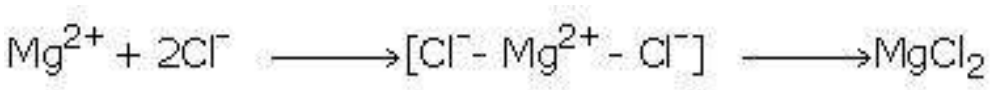
It has seven valence electrons. Chlorine is one electron short of the argon configuration (2,8,8) while magnesium has two electrons in excess of the neon configuration (2, 8,).

Accordingly, one atom of magnesium will find two atoms of chlorine to transfer its two electrons to (one to each) as shown below:

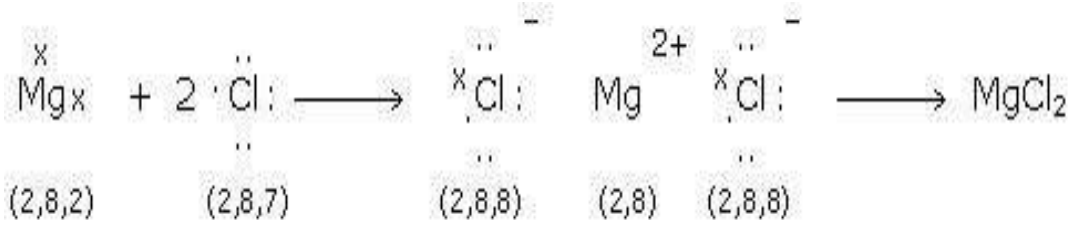




The Mg^{2+} and the two Cl^- so formed, then form ionic bonds between them.



In terms of Lewis dot structure,



Question 32:

1) Explain the chemical change that causes corrosion in iron.
2) If an iron nail is left in a filled bottle of boiled water how long will it take to corrode?

Answer: 1) Iron exposed to oxygen and water undergoes an oxidation reaction on the surface of a metal. Iron corrodes more quickly than most other transition metals to form a reddish brown powder of iron oxide.

The oxide formed does not firmly adhere to the surface of the metal causing it to flake off easily; this in turn causes further oxidation and rusting causing the surface of the iron metal to get pitted and deteriorate in structural strength.

Rust formation on iron is represented in the following equation (the equation is not meant to be balanced and the amount of water 'x' is variable, from dry to soggy).

$$\text{Rusting is } Fe_{(s)} + O_{2(g)} + H_2O_{(I)} \Rightarrow Fe_2O_3.xH_2O_{(s)}$$

i.e., rust is hydrated iron (III) oxide

Rusting is oxidation because it involves iron gaining oxygen

$$(Fe \Rightarrow Fe_2O_3)$$

Or; iron atoms losing electrons

$$(Fe - 3e^- \Rightarrow Fe^{3+}).$$

2) Iron can corrode or rust in three to four days the presence of a moist atmosphere. However, a full bottle of boiled water contains no oxygen content. So, the oxidization on the surface of the nail will not occur and the iron nail will not rust.

Question 33:

What is the one of the most important use of zinc?

Answer: The most important use of zinc is in galvanizing iron to prevent it from rusting.