Metals and Non-metals

CHAPTER 3

EXAM DRILL

ANSWERS

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

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

2. The element *A* has only one electron in its outermost shell (all inner shells being complete). Therefore, the element *A* is a metal.

The element *B* has seven electrons in its outermost shell (all inner shells being complete). Therefore, the element *B* is a non-metal.

3(i) A naturally occurring solid material from which a metal or valuable mineral can be extracted profitably.

3(ii) Leaching

3(iii) Gangue

3(iv) Hydraulic washing

4(i) The arrangement of metal in a vertical column in a decreasing order of their reactivities is called activities series.

4(ii) Gold, because it is least reactive.

4(iii) (a) Because potassium is present at the top of the activity series.

4(iv) (d)

5. (b) : Metals conduct electricity. The metals that produce a sound on striking a hard surface are said to be sonorous.

6. (c) : Most metal oxides are insoluble in water but some of these dissolve in water to form alkalies. All metals do not react with oxygen at the same rate. Different metals show different reactivities towards oxygen.

7. (d) : CuO is basic in nature, ZnO is amphoteric in nature. Oxide of K dissolves in water to form alkali.

$$K_2O_{(s)} + H_2O_{(l)} \longrightarrow 2KOH_{(aq)}$$

Pb does not react with cold or hot water.

Thus, *K*, *L*, *M* and *N* are Cu, Zn, K and Pb respectively.

OR

(d) : Iron is extracted from its ore haematite which is an oxide.

8. (a)

9. (a) : *X* is a metal and Cl is a non-metal. They react by forming ionic bonds. *X* exists as X^{2+} ion and Cl exists as Cl^- in XCl_2. Hence, *X* gives two electrons and each Cl receives one electron. XCl_2 is an ionic compound. Hence, *X* and Cl do not share a pair of electrons or form a double covalent bond.

OR

(a) : As aluminium is more reactive than zinc so aluminium will displace zinc from its sulphate solution.

$$\underset{\text{Colourless}}{3ZnSO_4} + 2Al \longrightarrow \underset{\text{Colourless}}{Al_2(SO_4)_3} + 3Zn$$

10. (b) : Na metal is soft and can be cut with a knife. It reacts vigorously with air and water and hence, it is kept in kerosene.

11. (d) : Aluminium is good conductor of heat and has a high melting point, hence it is used for making cooking utensils.

12. (d) : Sulphur is a non-metal.

OR

(a) : In roasting, ore is heated in excess of air to remove volatile impurities.

13. (c) : The reaction involved in removal of acidic impurities with basic flux is

$$\underset{\text{Acidic impurities}}{SiO_2} + \underset{\text{Basic flux}}{MgCO_3} \longrightarrow \underset{\text{Fusible slag}}{MgSiO_3} + CO_2\uparrow$$

14. (a)

15. (a) Magnesium chloride and aluminium chloride are formed respectively and H_2 gas is evolved.

$$Mg + 2HCl \longrightarrow \underset{\text{Magnesium chloride}}{MgCl_2} + H_2$$

$$2Al + 6HCl \longrightarrow \underset{\text{Aluminium chloride}}{2AlCl_3} + 3H_2$$

(b) Metal : Mercury, Non-metal : Bromine

(c) Roasting of sulphide ore :

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

Calcination of carbonate ore :

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

OR

(a) Metal *X* is least reactive. Hence, its oxide is reduced by the action of heat alone. As the most common ores of these metals are sulphide ores, therefore, the method used to obtain the metals from these ores is roasting, *i.e.*, heating the ore strongly in presence or excess of air. For example,

$$\underset{\text{Mercuric sulphide (Cinnabar)}}{HgS_{(s)}} + \underset{\text{(From air)}}{3O_{2(g)}} \xrightarrow{\text{Heat}} \underset{\text{Mercuric oxide}}{2HgO_{(s)}} + \underset{\text{Sulphur dioxide}}{2SO_{2(g)}}$$

$$\underset{\text{Mercuric oxide}}{2HgO_{(s)}} \xrightarrow{\text{Heat}} \underset{\text{Mercury}}{2Hg_{(l)}} + \underset{\text{Oxygen}}{O_{2(g)}}\uparrow$$

(b) Metal *Y* is in the middle of the reactivity series. Thus, it is moderately reactive. Hence, its oxide is reduced by chemical reduction *i.e.*, with a reducing agent like coke, sodium, calcium, aluminium, etc. For example,

$$\underset{\text{Ferric oxide}}{Fe_2O_{3(s)}} + \underset{\text{Coke}}{3C_{(s)}} \xrightarrow{\text{Heat}} \underset{\text{Iron}}{2Fe_{(s)}} + \underset{\text{Carbon monoxide}}{3CO_{(g)}}\uparrow$$

(c) Metal *Z* is highly reactive. Hence, its compounds are reduced to the metal by electrolytic reduction. On passing current through their molten state, metals are deposited on the cathode. *e.g.*,

$$\underset{\text{Bauxite ore}}{2Al_2O_3} \xrightarrow{\text{Electric current}} 4Al^{3+} + 6O^{2-}$$

At cathode : $4Al^{3+} + 12e^- \xrightarrow{\text{Reduction}} 4Al_{(s)}$

At anode : $6O^{2-} \xrightarrow{\text{Oxidation}} 3O_{2(g)} + 12e^-$

16. The gas produced is carbon dioxide. Hence, the ore is a carbonate ore. Two methods required to obtain metal from it will be

(i) **Calcination :** This converts the metal carbonate into metal oxide.

Metal carbonate $\xrightarrow{\text{Calcination}}$ Metal oxide + CO_2

(ii) **Reduction with carbon :** This converts the metal oxide to free metal.

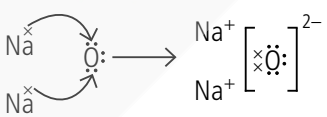
Metal oxide + Carbon $\longrightarrow$ Metal + Carbon monoxide

17. Gold and platinum.

(i) A thin impervious layer of aluminium oxide forms a protective layer which protects the aluminium metal underneath from further damage. Here, corrosion is an advantage.

(ii) Corrosion of iron is a serious problem. Every year enormous amount of money is spent to replace damaged iron and its products. Here, corrosion is a serious problem.

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



(b) Ionic compounds are usually hard due to strong electrostatic 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.

19.

	Reduction with carbon	Electrolytic reduction
1.	Carbon is used as a reducing agent.	Electrolysis process is used for reduction.
2.	Oxides of moderately reactive metals (*e.g.*, Zn, Fe, Cu, Ni) are reduced by carbon.	Oxides and chlorides of highly reactive metals (*e.g.*, Al, Na, K, Mg, Ca) are reduced by this process.
3.	In this process, the metal oxide is mixed with carbon (coke) and heated in a furnace. $\underset{\text{Zinc oxide}}{ZnO} + \underset{\text{Carbon}}{C} \longrightarrow \underset{\text{Zinc}}{Zn} + \underset{\text{Carbon monoxide}}{CO}$	In this process, molten metal oxide is electrolysed in an electrolytic cell where the cathode acts as a powerful reducing agent by supplying electrons to reduce metal ions into metal. $\underset{\text{Aluminium ion (from molten } Al_2O_3)}{Al^{3+}} + \underset{\text{Electrons (from cathode)}}{3e^-} \xrightarrow[\text{Reduction}]{\text{Electrolytic}} \underset{\text{Aluminium metal}}{Al}$

OR

(a)

	Electrolytic reduction	Electrolytic refining
(i)	It is a process of obtaining metals from their molten chlorides or molten oxides by electrolysis.	It is a process of refining of impure metals obtained by any of the reduction processes.
(ii)	The metals are deposited at the cathode whereas chlorine or oxygen is liberated at anode.	The impure metal is taken as anode, pure metal as cathode and metal salt solution as electrolyte.

(b) Minerals are the elements or compounds which occur naturally in the earth's crust. Ores are the minerals from which metals can be extracted profitably.

(c) Alloy is a homogeneous mixture of two or more metals or a metal and a non-metal. Amalgam is an alloy in which one of the metals is mercury.

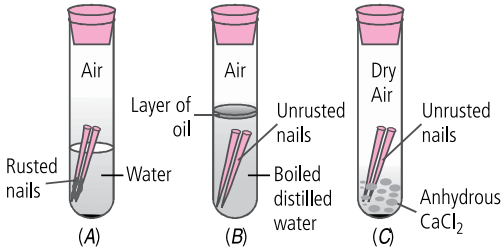
20. Iron when exposed to moist air for a long time acquires a coating of a brown flaky substance known as rust and this process is called rusting. Following activity can be performed to find out the conditions under which iron rusts :

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.

21. (a) Order of reactivity of given metals with water :
Potassium > Calcium > Zinc.

(b) $\underset{\text{Potassium}}{2K_{(s)}} + \underset{\text{Water}}{2H_2O_{(l)}} \longrightarrow \underset{\substack{\text{Potassium}\\\text{hydroxide}}}{2KOH_{(aq)}} + \underset{\text{Hydrogen}}{H_{2(g)}}$

(c) Sulphur

22. (a) Certain metals react with carbon to form compounds. As a result such metals cannot be obtained by carbon reduction method. Oxides of such metals are reduced by aluminium powder, *e.g.*,

$3MnO_2 + 4Al \rightarrow 3Mn + 2Al_2O_3 + \text{Heat}$

$Fe_2O_3 + 2Al \rightarrow 2Fe + Al_2O_3 + \text{Heat}$

$Cr_2O_3 + 2Al \rightarrow 2Cr + Al_2O_3 + \text{Heat}$

(b) It is due to weak forces of attraction.

23. (a) Metal '*M*' is aluminium.

(b) Ore from which Al is extracted is Bauxite ($Al_2O_3 \cdot 2H_2O$)

(c) Bauxite is converted to Al by electrolytic reduction.

OR

(a) $\underset{\text{Magnesium}}{2Mg} + O_2 \xrightarrow{\text{Burn}} \underset{\text{Magnesium oxide}}{2MgO}$

(b) $\underset{\text{Sodium}}{2Na} + 2H_2O \longrightarrow \underset{\text{Sodium hydroxide}}{2NaOH} + H_2$

This reaction is highly exothermic. As a result, hydrogen gas evolved catches fire.

(c) $\underset{\text{Aluminium}}{2Al} + \underset{\text{Steam}}{3H_2O} \longrightarrow \underset{\text{Aluminium oxide}}{Al_2O_3} + \underset{\text{Hydrogen}}{3H_2}$

24. (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.

25. (a) (i) Iron is used as a catalyst in the preparation of ammonia gas by Haber's process.

(ii) Zinc is used for galvanizing iron to protect it from rusting.

(iii) Carbon (in the form of graphite) is used for making the electrodes of electrolytic cells and dry cells.

(b) Al is a reducing agent for the given reaction. Al is more reactive than Mn, because Al placed higher in the reactivity series as compared to Mn, and metals at the top of the series are very reactive.

26. (a) Hydrogen gas

(b) By carbon dioxide gas

(c) Because sodium reacts violently with water and air.

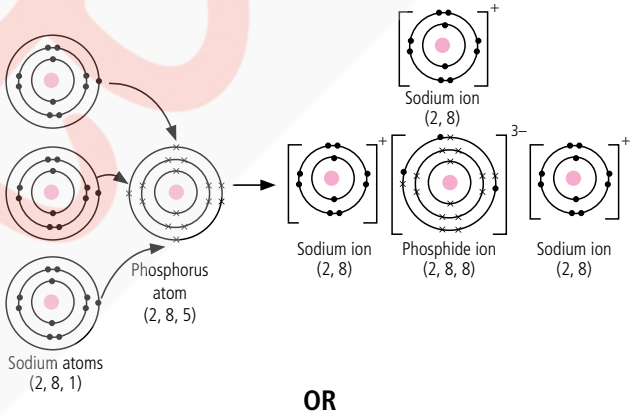
(d) Lead, copper and gold

(e) By painting or galvanising iron articles

27. When sodium (Na) reacts with phosphorus (P), each sodium atom loses one outer shell electron to the phosphorus atom to form sodium ion, Na^+, with the stable octet electronic configuration 2, 8.

The phosphorus atom gains three electrons from three sodium atoms to form phosphide ion, P^{3-}, with the stable octet electronic configuration 2, 8, 8.

Sodium phosphide is formed when the electrostatic attraction holds the sodium and phosphide ions together.



OR

(a) The process of purifying the impure (crude) metals by electrolysis is called electrolytic refining of metals. Many metals like Cu, Sn, Ni, Ag, Au, Cr, Zn, Al, Pb etc. are purified by this method.

(b) (i) Zinc dissolves to form zinc ions.

$Zn_{(s)} \longrightarrow Zn^{2+}_{(aq)} + 2e^-$

Electrons flow from the zinc along the wire to the copper.

(ii) The aqueous solution of sodium chloride contains the following ions :

From $NaCl_{(aq)}$: $Na^+_{(aq)}$ and $Cl^-_{(aq)}$

From $H_2O_{(l)}$: $H^+_{(aq)}$ and $OH^-_{(aq)}$

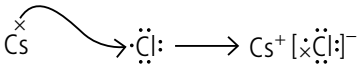
Sodium is above the hydrogen in the reactivity series. Sodium ions remain in the solution and H^+ ions accept electrons to form hydrogen gas.

$2H^+_{(aq)} + 2e^- \longrightarrow H_{2(g)}$

Hydrogen gas is produced at copper electrode.

28. 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.

29. (a) The surface of some metals is attacked when exposed to atmosphere. They react with air or water (oxygen, CO_2, moisture, etc.) to form undesirable compounds on their surfaces. This process is called corrosion.

(b) Sodium and potassium placed higher in the reactivity series, react violently even with cold water with the evolution of hydrogen gas.

$$2Na_{(s)} + 2H_2O_{(l)} \longrightarrow 2NaOH_{(aq)} + H_{2(g)}\uparrow + \text{Heat}$$

$$2K_{(s)} + 2H_2O_{(l)} \longrightarrow 2KOH_{(aq)} + H_{2(g)}\uparrow + \text{Heat}$$

The reaction is highly exothermic. Hence, hydrogen evolved catches fire. For this reason, sodium and potassium metals are kept in kerosene in order to avoid contact with air and water.

(c) Metals are good conductors of electricity due to availability of free electrons in the metallic lattice which can act as carrier of charge.

(d) Tungsten has high resistance and high melting point therefore, it is used for making filaments of incandescent bulbs.

(e) Nitric acid is a strong oxidizing agent and it oxidises hydrogen produced to water and itself gets reduced to nitrogen oxides (N_2O, NO, NO_2).

OR

(a) The decreasing order of reactivity is Mg > Al > Zn > Fe > Cu.

(b) (i) As Zn is more reactive than copper, it can displace copper from its solution and the solution becomes colourless due to formation of $ZnSO_4$ and copper metal gets deposited.

(ii) Nothing will happen because copper is less reactive than iron, hence it cannot displace iron from ferrous sulphate solution.

(c) Sodium and calcium

$$2Na_{(s)} + H_{2(g)} \xrightarrow{\text{Heat}} \underset{\text{Sodium hydride}}{2NaH_{(s)}}$$

$$Ca_{(s)} + H_{2(g)} \xrightarrow{\text{Heat}} \underset{\text{Calcium hydride}}{CaH_{2(s)}}$$

(d) Iron metal alloyed with other metals such as chromium and nickel are the constituents of stainless steel.

30. (a) Ore of zinc is zinc blende (ZnS). The ore is changed into oxide by roasting it in excess of air

$$\underset{\text{Zinc blende}}{2ZnS_{(s)}} + \underset{\text{(from air)}}{3O_{2(g)}} \xrightarrow{\text{Heat}} \underset{\text{Zinc oxide}}{2ZnO_{(s)}} + \underset{\text{Sulphur dioxide}}{2SO_{2(g)}}$$

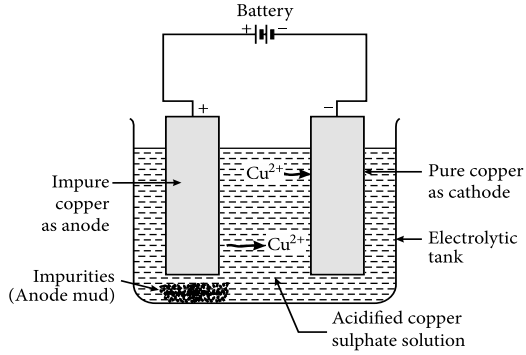
(b) The process of purifying the impure (crude) metal is called refining of metals. The most widely used method of refining impure metals produced by various reduction processes is electrolytic refining. In electrolytic refining, a thick block of impure metal acts as anode. It is connected to the positive 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 electrolyte. The impurities either dissolve in the solution or settle down at the bottom of the anode as anode mud.

OR

(a) Chief ore of iron is haematite. Its formula is Fe_2O_3.

(b) Concentration of ore means removal of unwanted impurities from the ore. The earthy, sandy and rocky impurities associated with mineral are called gangue.

(c) Experimental set up for the electrolytic refining of copper :



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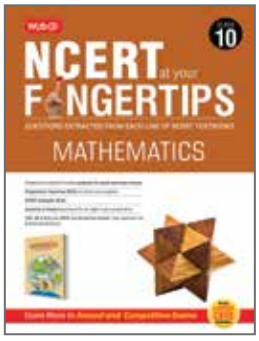

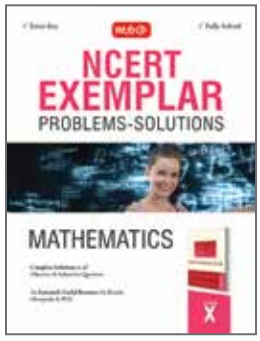

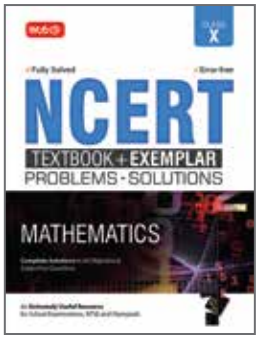

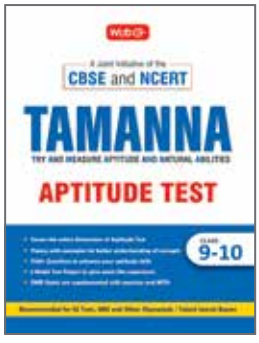

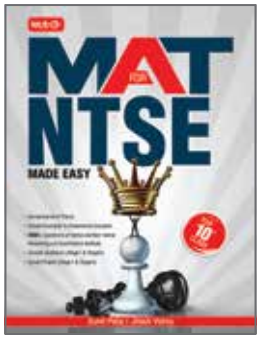

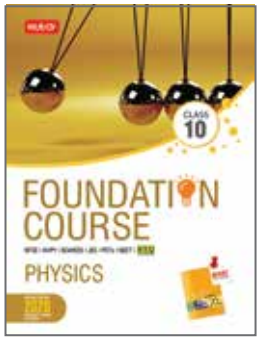

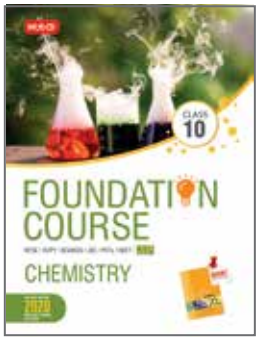

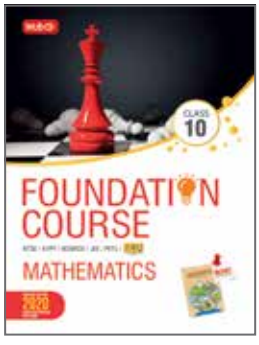

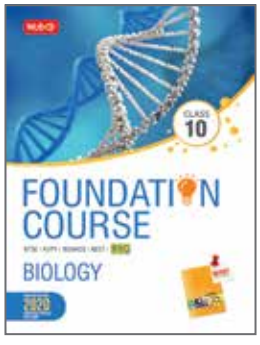

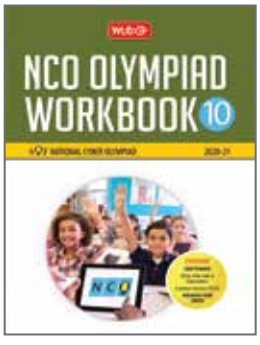

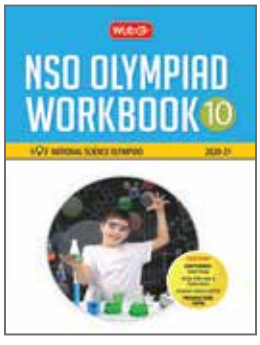

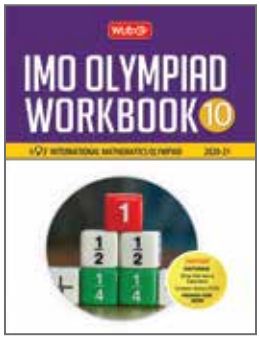

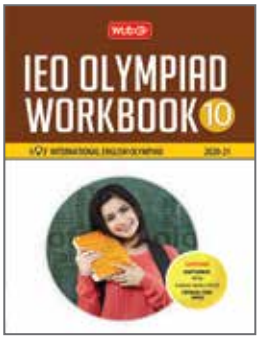

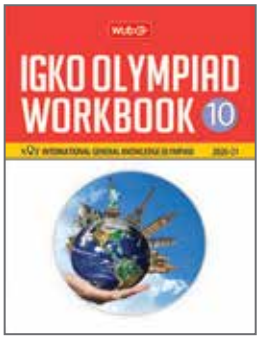

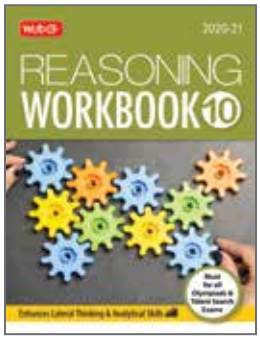

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