Exercise-1

Marked questions are recommended for Revision.

PART - I : SUBJECTIVE QUESTIONS

Section (A) : ORES & Method of concentration

A-1. Name three ores which are concentrated by froth-floatation process.

A-2. What is meant by a depressant ?

A-3. Which concentration method is used for separating tungsten ore particles from cassiterite ore (SnO_2) ?

A-4. Which metals are obtained by self reduction of their ores ?

A-5. How carnallite ore is made anhydrous ?

A-6. What is the role of a stabiliser in froth-floatation process ?

Section (B) : Thermodynamic Principles of metallurgy

B-1. Out of C and CO, which is a better reducing agent for ZnO ?

B-2. Why the HgO decomposes into its constituent elements on heating ?

B-3. CuO is less reduced by carbon but more reduced by H_2. Explain in terms of thermodynamics, given: ΔG^o_f for CuO = –129.7 kJ mol^{-1}, CO = –137.2 kJ $mole^{-1}$, H_2O = –237.2 kJ mol^{-1}

Section (C) : Metallurgy of some useful metals

C-1. Cinnabar (HgS) and galena (PbS) on roasting often give their respective metals but zinc blende (ZnS) does not. explain.

C-2. Magnesium oxide is often used as the lining in steel making furnace, Explain.

C-3. In the extraction of tin from tin stone addition of excess lime stone should be avoided. Why ?

C-4. In the extraction of lead from galena lime stone is added, why ?

C-5. Why excess of carbon is added in the zinc metallurgy ?

C-6. In the extractive metallurgy of iron from haematite ore, lime stone is added during smelting. Explain why.

C-7. State the role of silica in the metallurgy of copper.

Section (D) : Electrochemical principles of metallurgy

D-1. Why air is continuously passed through the suspension of the concentrated ore of silver, the argentite during leaching with the aqueous solution of sodium cyanide ?

D-2. Alkali metals and alkaline earth metals can only be extracted by electrolytic reduction of their fused salts, why ?

D-3. What is the role of cryolite in the metallurgy of aluminium?

Section (E) : Purification or Refining of Impure Metals

E-1. Name the physical processes which are used for the purification of impure metals ?

E-2. Which impure metals are purified by Poling process ?

E-3. Give the name of the metals which are purified using vapour phase thermal decomposition method.

PART - II : ONLY ONE OPTION CORRECT TYPE

Section (A) : ORES & Method of Concentration

A-1. Calamine is an ore of :
(A) Zn (B) Mg (C) Ca (D) Pb

A-2. Which of the following is not the ore of aluminium ?
(A) Bauxite (B) Corundum (C) Langbeinite (D) Kaolinite

A-3. Which of the following is not an ore ?
(A) Malachite (B) Calamine (C) Salt cake (D) Cerussite

A-4. Which of the following set of metals mostly found as sulphide ores :
(A) Zn, Cu, Mg (B) Zn, Cu, Pb (C) Fe, Al, Ti (D) Cu, Ag, Au

A-5. The formula of carnallite is :
(A) $LiAl(Si_2O_5)_2$ (B) $KCl.MgCl_2.6H_2O$
(C) $K_2O.Al_2O_3.6SiO_2$ (D) $KCl.MgCl_2.2H_2O$

A-6. Magnetic separation process may be used for the concentration of :
(A) chalcopyrite (B) bauxite (C) haematite (D) calamine

A-7. Which mineral has been named incorrectly ?
(A) Bauxite : $Al_2O_3.2H_2O$ (B) Corundum : Al_2O_3
(C) Cryolite : $3NaF.AlF_3$ (D) Feldspar : $Be_3Al_2Si_6O_{18}$

A-8. Black tin is
(A) an alloy of Sn (B) an allotrope of Sn
(C) 60-70 percent SnO_2 (D) 100 percent SnO_2

A-9. NaCN is sometimes added in the froth flotation process as a depressant when ZnS and PbS minerals are expected because :
(A) $Pb(CN)_2$ is precipitated while no effect on ZnS.
(B) ZnS forms soluble complex $Na_2[Zn(CN)_4]$ while PbS forms froth
(C) PbS forms soluble complex $Na_2[Pb(CN)_4]$ while ZnS forms froth.
(D) NaCN is never added in froth floatation process.

A-10. Which one of the following reactions represents a calcination reaction?
(A) $HgS + O_2 \rightarrow Hg + SO_2$
(B) $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$
(C) $CuCO_3.Cu(OH)_2 \rightarrow CuO + CO_2 + H_2O$
(D) $Al_2O_3 + NaOH \rightarrow NaAlO_2 + H_2O$

Section (B) : Thermodynamic Principles of Metallurgy

B-1. Selection of temperature to carry out a reduction process depends so as to make :
(A) ΔG negative (B) ΔG positive (C) ΔH negative (D) ΔH positive

B-2. Ellingham diagram represents :
(A) change of ΔG with temperature.
(B) change of ΔH with temperature.
(C) change of ΔG with pressure.
(D) change of $(\Delta G - T\Delta S)$ with temperature.

B-3. Which of the following represents the thermite reaction?
(A) $3Mn_3O_4 + 8Al \rightarrow 9Mn + 4Al_2O_3$ (B) $MgCO_3 + SiO_2 \rightarrow MgSiO_3 + CO_2$
(C) $Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$ (D) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Section (C) : Metallurgy of some useful metals

C-1. Self-reduction of Cu_2S to Cu can be carried out in.
(A) bessemer convertor (B) blast furnace
(C) both (A) and (B) (D) none of these

C-2. Blister copper is :
(A) impure copper.
(B) obtained in self reduction process during bessemerisation.
(C) both (A) and (B) are correct.
(D) none is correct.

C-3. Main source of lead is PbS. It is converted to Pb by :

(X) : $PbS \xrightarrow[\Delta]{air} PbO + SO_2 \xrightarrow{C} Pb + CO_2$

(Y) : $PbS \xrightarrow[\Delta]{air} PbO + PbS \longrightarrow Pb + SO_2$

(Z) : $PbS \xrightarrow[\Delta]{air} PbO + SO_2 \xrightarrow{CO} Pb + CO_2$

Self - reduction process is :
(A) X (B) Y (C) Z (D) none

C-4. Identify the metal M whose extraction is based on the following reactions :

$MS + 2O_2 \rightarrow MSO_4$
$2MS + 3O_2 \rightarrow 2MO + 2SO_2$
$MS + 2MO \rightarrow 3M + SO_2$
$MS + MSO_4 \rightarrow 2M + 2SO_2$

(A) magnesium (B) aluminium (C) lead (D) tin

C-5. Which of the following reactions represents the self-reduction process?

(A) $\begin{cases} HgS + O_2 \rightarrow HgO + SO_2 \\ HgO + HgS \rightarrow Hg + SO_2 \end{cases}$ (B) $\begin{cases} Cu_2S + O_2 \rightarrow Cu_2O + SO_2 \\ Cu_2S + Cu_2O \rightarrow Cu + SO_2 \end{cases}$

(C) $\begin{cases} PbS + O_2 \rightarrow PbO + SO_2 \\ PbO + PbS \rightarrow Pb + SO_2 \end{cases}$ (D) All of these

Section (D) : Electrochemical Principles of Metallurgy

D-1. Magnesium is extracted from ore carnallite by :
(A) the self-reduction process
(B) the carbon-reduction process
(C) the electrolytic process
(D) treating the ore with aqueous NaCN and then reducing the mixture

D-2. NaCl and $CaCl_2$ are added to fused $MgCl_2$ in the electrolysis of $MgCl_2$ since :
(A) melting point is decreased and conductivity is increased.
(B) melting point is increased and conductivity is decreased.
(C) melting point and conductivity both are decreased.
(D) melting point and conductivity both are increased.

D-3. Which of the following metals cannot be extracted by the carbon reduction process ?
(A) Zn (B) Fe (C) Al (D) Sn

D-4. In electrolysis of Al_2O_3 by Hall-Heroult process :
(A) cryolite $Na_3[AlF_6]$ lowers the melting point of Al_2O_3 and increases its electrical conductivity.
(B) Al is obtained at cathode and probably CO_2 at anode
(C) both (A) and (B) are correct
(D) none of the above is correct

D-5. During the electrolytic reduction of aluminium, the carbon anodes are replaced from time to time because:
(A) the carbon anodes get decayed
(B) the carbon prevents atmospheric oxygen from coming in contact with aluminium
(C) oxygen liberated at the carbon anodes reacts with anodes to form CO and CO_2
(D) carbon converts Al_2O_3 to Al

Section (E) : Purification or Refining of Impure Metals

E-1. Poling process :
(A) reduces SnO_2 to Sn
(B) oxidises impurities like iron and removes as scum
(C) uses green poles
(D) all of the above are correct

E-2. Aluminium metal is purified by :
(A) Hoop's process
(B) Hall-Heroult process
(C) Serpeck's process
(D) Baeyer's process

E-3. High purity copper metal is obtained by :
(A) carbon reduction
(B) hydrogen reduction
(C) electrolytic reduction
(D) thermite reduction

E-4. In the electrolytic refining of lead, Sb, Cu, Ag and Au are found :
(A) on anode
(B) in electrolyte solution
(C) in anode mud
(D) in cathode mud

E-5. The anode mud in the electrolytic refining of silver contains :
(A) Zn, Cu, Ag, Au (B) Zn, Ag, Au (C) Cu, Ag, Au (D) Au only

E-6. Silver can be separated from lead by :
(A) fractional crystallisation
(B) liquation
(C) cupellation
(D) addition of zinc (Parke's method)

E-7. The method of zone refining of metals is based on the principle of :
(A) greater mobility of the pure metal than that of impurity
(B) higher melting point of the impurity than that of the pure metal
(C) greater noble character of the solid metal than that of the impurity
(D) greater solubility of the impurity in the molten state than in the solid

E-8. Which does not represent correct method ?
(A) $TiCl_2 + 2Mg \longrightarrow Ti + 2MgCl_2$: Kroll
(B) $Ni(CO)_4 \longrightarrow Ni + 4CO$: Mond
(C) $Ag_2CO_3 \longrightarrow 2Ag + CO_2 + \frac{1}{2}O_2$: Van Arkel
(D) $ZrI_4 \longrightarrow Zr + 2I_2$: Van Arkel

PART - III : MATCH THE COLUMN

1. Match the reactions listed in column (I) with processes listed in column (II).

	Column–I		**Column–II**
	(reactions)		**(processes)**
(A)	$4\,Au + 8\,NaCN + 2\,H_2O + O_2\,(air) \longrightarrow 4\,Na[Au(CN)_2] + 4\,NaOH$	(p)	Leaching
(B)	$CuFeS_2 + 2\,H_2SO_4 \longrightarrow CuSO_4 + FeSO_4 + 2H_2S$	(q)	Smelting
(C)	$CaO + SiO_2 \xrightarrow{\Delta} CaSiO_3$	(r)	Hydrometallurgy
(D)	$MgCl_2.6H_2O \xrightarrow[\text{dry HCl(g)}]{\Delta} MgCl_2 + 6H_2O$	(s)	Calcination

2. **Column-I** and **Column-II** contains four entries each. Entries of **Column-I** are to be matched with some entries of **Column-II**. One or more than one entries of **Column-I** may have the matching with the same entries of **Column-II**.

	Column–I		**Column–II**
	(Reaction)		**(Process)**
(A)	$FeO + SiO_2 \longrightarrow FeSiO_3$	(p)	Calcination
(B)	$3Mn_3O_4 + 8Al \longrightarrow 4Al_2O_3 + 9Mn$	(q)	Displacement method
(C)	$Cu_2S + 2Cu_2O \xrightarrow{\Delta} 6\,Cu + SO_2$	(r)	Smelting
(D)	$2Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + 3H_2O$	(s)	Thermite process
(E)	$2Na[Ag(CN)_2] + Zn \longrightarrow Na_2[Zn(CN)_4] + 2Ag$	(t)	Bessemerisation

3. Match the purification processes given in **Column-I** with the metal(s) given in **Column-II.**

	Column-I		**Column-II**
(A)	Poling	(p)	Titanium
(B)	Cupellation	(q)	Copper
(C)	Liquation	(r)	Silver
(D)	Van Arkel method	(s)	Tin

4. Match the ores given in column-I with type(s) of processes given in column-II.

	Column–I		**Column–II**
(A)	Haematite	(p)	Slag formation during roasting/smelting and bessemerisation.
(B)	Copper pyrites	(q)	Reduction by carbon monoxide/carbon at different temperatures.
(C)	Carnallite	(r)	Electrolytic reduction.
(D)	Bauxite	(s)	Calcination.

Exercise-2

Marked questions are recommended for Revision.

PART - I : ONLY ONE OPTION CORRECT TYPE

1. Match Column-I with Column-II and select the correct answer using the codes given below :

	Column-I		**Column-II**
	(Metals)		**(Ores)**
(A)	Tin	(p)	Calamine
(B)	Zinc	(q)	Cassiterite
(C)	Iron	(r)	Cerrusite
(D)	Lead	(s)	Siderite

Codes:

	(A)	(B)	(C)	(D)
(A)	p	q	r	s
(B)	q	p	s	r
(C)	s	r	q	p
(D)	q	p	r	s

2. Which is not correct statement ?
(A) Cassiterite, chromite and haematite may be concentrated by hydraulic washing (Tabling).
(B) Pure Al_2O_3 is obtained from the bauxite ore by leaching in the Bayer's process.
(C) Sulphide ore is concentrated by calcination method.
(D) Roasting can convert sulphide into oxide or sulphate and part of sulphide may also act as a reducing agent.

3. Bauxite is leached with :
(A) KCl (B) NaCN (C) NaOH (D) Na_2SO_4

4. Froth floatation process for the concentration of sulphide ores is an illustration of the practical application of:
(A) adsorption (B) absorption (C) sedimentation (D) coagulation

5. Which one of the following is not a method of concentration of ore ?
(A) electromagnetic separation (B) smelting
(C) gravity separation (D) froth floatation process

6. The metal which mainly occurs as oxide ore in nature is :
(A) gold (B) lead (C) aluminium (D) magnesium

7. The reason, for floating of ore particles in concentration by froth floatation process is that :
(A) they are light (B) they are insoluble
(C) they are charged (D) they are hydrophobic

8. Choose the correct option using the code regarding roasting process.
(I) It is the process of heating the ore in air in a reverberatory furnace to obtain the oxide.
(II) It is an exothermic process.
(III) It is used for the concentration of sulphide ore.
(IV) It removes easily oxidisable volatile impurities present in the concentrated ore.
(A) I, II and III (B) I, II and IV (C) I, III and IV (D) I, II, III and IV

9. Select correct statement for decomposition of metal oxide into solid/liquid metal and oxygen?
(A) Entropy increases.
(B) It is an endothermic change.
(C) To make $\Delta G°$ negative, temperature should be high enough so that $T\Delta S° > \Delta H°$.
(D) All are correct statements.

10. A sulphide ore like ZnS is first roasted into its oxide prior to reduction by carbon because :
(A) a sulphide ore cannot be reduced to metal at all
(B) no reducing agent is found suitable for reducing a sulphide ore.
(C) the Gibb's free energy of formation of most sulphides are less than that for CS_2.
(D) a metal oxide is generally less stable than the metal sulphide.

11. Which of the following statements is correct regarding the slag obtained during the extraction of a metal like copper or iron ?
(A) The slag is lighter and has lower melting point than the metal
(B) The slag is heavier and has lower melting point than the metal
(C) The slag is lighter and has higher melting point than the metal
(D) The slag is heavier and has higher melting point than the metal

12. The slag consists of molten impurities, generally, in the form of :
(A) metal carbonate (B) metal silicate (C) metal oxide (D) metal nitrate

13. In the metallurgy of iron, the upper layer obtained in the bottom of blast furnace mainly contains :
(A) $CaSiO_3$ (B) spongy iron (C) Fe_2O_3 (D) $FeSiO_3$

14. Which one of the following reactions occurs during smelting in the reduction zone at lower temperature (in the top zone in blast furnace in iron metallurgy) ?
(A) $CaO + SiO_2 \longrightarrow CaSiO_3$ (slag)
(B) $Fe_2O_3 + 3C \longrightarrow 2Fe + CO$
(C) $3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$
(D) $CO_2 + C \longrightarrow 2CO$

15. Magnesium is extracted by electrolysing fused magnesium chloride containing NaCl & $CaCl_2$ using :
(A) a nickel cathode and a graphite anode.
(B) the iron container as anode and a nickel cathode.
(C) the iron container as cathode and a graphite rod as anode.
(D) the nickel container as cathode and iron anode.

16. The process of the isolation of a metal by dissolving the ore in a suitable chemical reagent followed by precipitation of the metal by a more electropositive metal is called :
(A) hydrometallurgy (B) electrometallurgy
(C) zone refining (D) electro-refining

17. Which method of purification is represented by the equations ?

$$\underset{\text{(impure)}}{Ti + 2I_2} \xrightarrow{500\ K} TiI_4 \xrightarrow{1675\ K} \underset{\text{(Pure)}}{Ti + 2I_2}$$

(A) Cupellation (B) Poling (C) Van Arkel (D) Zone refining

18. Select correct statement regarding silver extraction / purification process.
(A) When the lead-silver alloy is rich in silver, lead is removed by the cupellation process.
(B) Lead is removed from argentiferous lead by Parke's process.
(C) Zinc forms an alloy with lead, from which lead is separated by distillation.
(D) Zinc forms an alloy with silver, from which zinc is separated by distillation.

19. Formation of volatile $Ni(CO)_4$ and then its subsequent decomposition into Ni and CO makes basis of Mond's process :

$$Ni + 4CO \xrightarrow{T_1} Ni(CO)_4 \xrightarrow{T_2} Ni + 4CO,\ T_1 \text{ and } T_2 \text{ are :}$$

(A) 100ºC, 50ºC (B) 50ºC, 100ºC (C) 50ºC, 200ºC (D) 200ºC, 50ºC

20. Which one of the following processes involves the principle of fractional crystallisation for the refining of impure metals ?
(A) Parke's process (B) Mond's process (C) Van Arkel process (D) Zone refining

21. In Van Arkel method, if I_2 is introduced at 1800 K over impure zirconium metal, the product will be :
(A) iodide of the metal (B) pure metal
(C) impurities react with iodine (D) none of these

PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

1. How many of the following are oxides ores.
(i) Carnallite (ii) Cuprite (iii) Cassiterite (iv) Chromite (v) Cinnabar
(vi) Calamine (vii) Cerussite (viii) Chalcopyrite (ix) Chalcocite.

2. In an ore of iron, iron is present in two oxidation state. Fe^{n+} and $Fe^{(n+1)+}$
Number of $Fe^{(n+1)+}$ is twice the number of Fe^{n+}.
If empirical formula of ore is Fe_xO. Calculate value of $[x \times 100]$.

3. In extraction of metal how many of the following ores involve calcination process.
(i) Dolomite (ii) Malachite (iii) Calcite (iv) Copperpyrites (v) Sylvine
(vi) Cryolite (vii) Siderite (viii) Iron pyrite (ix) Argentite

4. How many of the following metallurgies involve leaching?
(i) $Al_2O_3 \longrightarrow Al$; (ii) $Ag_2S \longrightarrow Ag$; (iii) $Au \longrightarrow Au$; (iv) $CuFeS_2 \longrightarrow Cu$; (v) $PbS \longrightarrow Pb$
(vi) $MgCl_2 \longrightarrow Mg$; (vii) $FeCO_3 \longrightarrow Fe$; (viii) Low grade copper ore $\longrightarrow Cu$; (ix) $HgS \longrightarrow Hg$

5. Among the following metals how many metals are extracted by self-reduction method from their respective ores. Hg, Zn, Cu, Al, Mg, Pb, Fe, Sn.

6. Number of metals among following which are obtained by electrometallurgy in molten state are.
Li, Ba, Na, Al, Fe, Cu, Pb, Sn, Ag, Au, Zn, Ca, Mg

7. The number of reducing agents involved in the extraction of iron (as pig iron) using blast furnace from ore haematite is(are).

8. How many of following are correctly matched for electrolytic reduction in molten state.

	Ore	Reagent / Process	Remark
(a)	Al_2O_3	AlF_3 and CaF_2 added	Decrease M.P.
(b)	$MgCl_2$	KCl, $CaCl_2$	Increase conductivity
(c)	NaCl	$AlCl_3$	Decrease M.P.
(d)	AlF_3	Haroult process	Al form at anode
(e)	$MgBr_2$	Dow process	Br_2 form at anode
(f)	Al_2O_3	conc. NaOH	Leaching process
(g)	Carnallite	Dow process	Directly applied to carnallite crystals.

9. How many of the following reduction processes are correct :

(1) $B_2O_3 + Al \xrightarrow{\Delta} B.$ (2) $Cr_2O_3 + 2Al \xrightarrow{\Delta} Cr.$

(3) $TiCl_4 + Mg \xrightarrow{\Delta} Ti.$ (4) $PbS + PbO \xrightarrow{\Delta} Pb.$

(5) $3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$ (6) $Fe_3O_4 + CO \longrightarrow 3FeO + CO_2$

(7) $2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2$ (8) $SnO_2 + C \longrightarrow SnO + CO$

10. The minimum voltage required to electrolyse of Al_2O_3 in the Hall-Heroult process is
Given : $\Delta G^o_f (Al_2O_3) = -1520$ kJ mol^{-1} ; $\Delta G^o_f (CO_2) = -394$ kJ mol^{-1}
If net reaction in Hall-Heroult process is : $3C + 2Al_2O_3 \longrightarrow 4Al + 3CO_2$
(Report your answer as voltage × 10)

11. Calculate mass of Zn (at. mass = 65) required to recover Ag from a 500 ml solution of 0.5 M sodium argento cyanide (Give your answer by multiplying 8).

12. What is the value of $\frac{\Delta G^o}{10}$ required in kJ/mole for prepration of Mg from Dow's process using 2.02 voltage.

13. Oxidation state of Zr in the compound formed by it in Van Arkel process; '□'
Bond order of the gas involved in Mond's process = 'm'
Total number of ions present in one formula unit of Thomas slag obtained during Bassemerisation of iron = 'n'
Report your answer as (□ × m × n)

14. How many of the following process of refining is/are chemical methods.

(i) Liquation process (ii) Fractional distillation process (iii) Zone refining method
(iv) Chromato graphic method (v) Cupellation (vi) Poling process
(vii) Hoop's process (viii) Kroll's process (ix) Mond's process

PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. Which of the following manufactured by the electrolysis of their fused salts.
(A) Copper (B) Sodium (C) Aluminium (D) Platinum

2. On the basis of ellingham diagram plotted for formation of metal oxide from metal and one mole of oxygen, which of the following is/are correct.
(A) Entropy change for all metal oxides is roughly same.
(B) Below the boiling point, 'TΔS' factor is nearly same irrespective of metal.
(C) Above $\Delta G = 0$ line, oxide decomposes into metal & oxygen.
(D) If randomness increases the slope increases

3. The smelting of iron in a blast furnace involves, which of the following process/(es) ?
(A) Combustion (B) Reduction (C) Slag formation (D) Sublimation

4. Addition of high proportion of manganese makes steel useful in making rails of rail roads, because manganese :
(A) gives hardness to steel (B) helps the formation of oxides of iron
(C) can remove oxygen and sulphur (D) can show highest oxidation state of +7

5. Complexes formed in the cynide process are :
(A) $[Au(CN)_2]^-$ (B) $[Ag(CN)_2]^-$ (C) $[Cu(CN)_4]^{2-}$ (D) $[Zn(CN)_4]^{2-}$

6. In poling process of purification of Cu, O_2 oxidises following group of elements :
(A) S, Sb, As (B) Sb, As, Fe (C) S, Sb, As (D) As, Ag, Au

7. Which of the following process(es) occur(s) during the extraction of copper from chalcopyrites ?
(A) Froth floatation (B) Roasting (C) Bessemerisation (D) calcination

8. Calcium silicate (slag) formed in the slag formation zone in extraction of iron from haematite ore :
(A) does not dissolve in molten iron.
(B) being lighter floats on the molten iron .
(C) is used in cement industry and as building material.
(D) prevents the re-oxidation of molten iron.

9. Which of the following statement(s) is (are) incorrect ?
(A) In Serpeck's process silica is removed by heating the bauxite to 1800°C with coke in a current of N_2
(B) In extraction of lead from galena roasting and self reduction takes place in the same furnace but under different conditions of temperature and supply of air
(C) The tin is obtained by the carbon reduction of black tin.
(D) None

10. Parting of gold may be done with :
(A) Sulphuric acid (B) Sodium hydroxide (C) Borax (D) Chlorine (Cl_2)

11. Liquation process may be applied for the purification of :
(A) copper (B) tin (C) iron (D) zinc

12. Of the following reduction processes, the correct process(es) is/are :
(A) $Fe_2O_3 + CO \longrightarrow Fe + CO_2$ (B) $ZnO + C \longrightarrow Zn + CO$
(C) $Cu_2O + Cu_2S \longrightarrow Cu + SO_2$ (D) $PbO + C \longrightarrow Pb + CO$

13. Roasting of copper pyrites is done :
(A) to remove moisture.
(B) to oxidise free sulphur and antimony.
(C) to convert pyrites completely into Cu_2O and FeO.
(D) to remove volatile organic impurities.

14. Select the correct statement(s) with respect to the differences between roasting and calcination.
(A) In roasting at higher temperature sulphide ores of the some metal like Cu, Pb, Hg etc. are reduced directly to metal but not in calcination.
(B) Partial fusion occurs in calcination but not in roasting.
(C) Calcination is done in limited supply of air or absence of air but in roasting supply of excess air is required.
(D) Combustion reaction occurs in roasting but not in calcination.

PART - IV : COMPREHENSION

Read the following passage carefully and answer the questions.

Comprehension # 1

Amongst the various ores of a metal (M) (sulphide, carbonates, oxides, hydrated or hydroxides) two ores [X] and [Y] show the following reactivity.
(i) [X] on calcination gives a black solid (S), water and a colourless gas which produces milkyness when passed through lime water. But this colourless gas does not decolourise the acidified $KMNO_4$.
(ii) [X] dissolved in dilute HCl on reaction with KI gives a white precipitate (P) and iodine gas.
(iii) [Y] on roasting at high temperature gives metal (M) and a gas (G_1) which turns starch iodate solution blue.
(iv) [Y] on reaction with dilute HCl gives a white precipitate (MS) and another gas (G_2) which turns lead acetate solution black and also reacts with gas (G_1) to precipitate colloidal sulphur in presence of moisture.
The M, S, [X] and [Y] gives greenish blue flame.

1. The metal ores [X] and [Y] are respectively :
(A) Carbonate and sulphide ores (B) Sulphide and carbonate ores
(C) Carbonate and hydroxide ores (D) Carbonate and oxide ores

2. Which of the following statements is correct about [Y] ?
(A) [Y] is converted to metal (M) by self reduction.
(B) Carbonate extract of [Y] gives yellow precipitate with suspension of $CdCO_3$.
(C) [Y] is copper glance or copper pyrite
(D) All of these

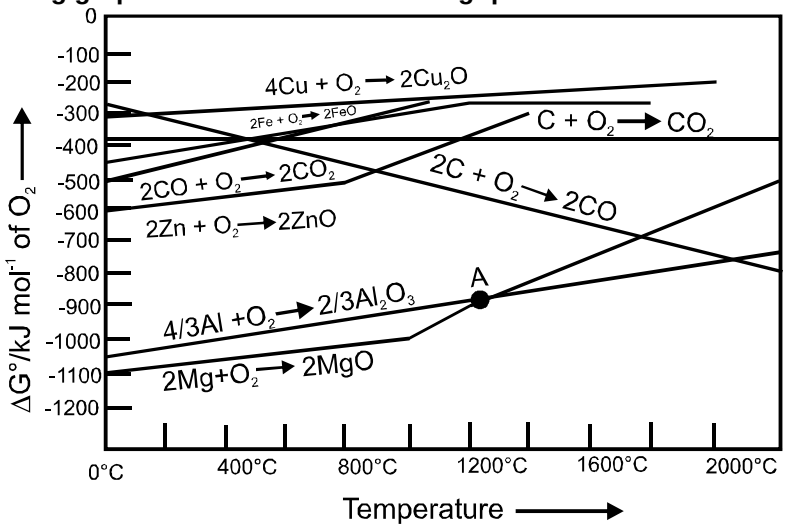
3. The gas (G_1) acts as
(A) oxidising agent (B) reducing agent
(C) oxidising and reducing agent (D) fluxing agent

4. The white precipitate (P) is of :
(A) Cu_2I_2 (B) CuI_2 (C) $K_2[CuI_4]$ (D) none

5. Identify the correct statement about [X].
(A) It is malachite or azurite ore
(B) Its solution in dil. HCl gives white ppt of Cu_2I_2 with KI
(C) It on calcination gives black cupric oxide
(D) All of these

Comprehension # 2

Read the following graph and answer the following questions.



6. At what approximate temperature, zinc and carbon have equal affinity for oxygen.
(A) 1000ºC (B) 1500ºC (C) 500ºC (D) 1200ºC

7. To make the following reduction process spontaneous, temperature should be :
$ZnO + C \longrightarrow Zn + CO$
(A) < 1000ºC (B) > 1000ºC (C) < 500ºC (D) > 500ºC but < 1000ºC

8. Which of the following statement is true ?
(A) In the extractive metallurgy of iron, the reduction of calcined / roasted haematite ore in blast furnace takes place in the lower temperature range as well as in the higher temperature range by carbon monoxide and carbon respectively.
(B) The reduction of zinc oxide by carbon takes place at higher temperature than that in case of copper.
(C) It is quite easy to reduce oxide ores of copper directly to the metal by heating with coke after 500-600K.
(D) All of these

Comprehension # 3

Answer Q.9, Q.10 and Q.11 by appropriately matching the information given in the three columns of the following table.

The scientific and technological process used for the extraction isolation of the metal from its are is called as metallurgy. Following information is given in columns :
Column-1 : Ore
Column-2 : Process desirable in metallurgy.
Column-3 : Process involved in column-II.

Column-1		Column-2		Column-3	
(I)	Copper pyrite	(i)	Dow's process	(P)	Electrolytic reduction in fused state
(II)	Bauxite	(ii)	Mac-Arthur Forrest process	(Q)	Molten $MgCl_2$ + $CaCl_2$ + NaCl electrolysis
(III)	Silver argentite	(iii)	Hall-Heroult process	(R)	Molten impure aluminum + fluorides of Na^+, Ba^{2+} and Al^{3+} electrolysis
(IV)	$MgCl_2$ from sea water	(iv)	Hoop's process	(S)	Complex formation and displacement by metal.

9. For Ag, the only correct combination is :
(A) (III) (i) (S) (B) (III) (iv) (P) (C) (III) (ii) (S) (D) (III) (iii) (R)

10. Metal which is obtained from carnallite can be extracted by following combination :
(A) (III) (iii) (R) (B) (II) (iv) (S) (C) (IV) (i) (S) (D) (IV) (i) (Q)

11. Select the only correct combination for Al :
(A) (II) (iv) (P) (B) (II) (iii) (R) (C) (II) (iii) (S) (D) (II) (iv) (R)

Exercise-3

*** Marked Questions may have more than one correct option.**

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. In the process of extraction of gold,

$$\text{Roasted gold ore} + CN^- + H_2O \xrightarrow{O_2} [X] + OH^-$$

$$[X] + Zn \longrightarrow [Y] + Au$$

Identify the complexes [X] and [Y]. **[JEE-2003(S), 3/84]**
(A) X = $[Au(CN)_2]^-$, Y = $[Zn(CN)_4]^{2-}$ (B) X = $[Au(CN)_4]^{3-}$, Y = $[Zn(CN)_4]^{2-}$
(C) X = $[Au(CN)_2]^-$, Y = $[Zn(CN)_5]^{4-}$ (D) X = $[Au(CN)_4]^-$, Y = $[Zn(CN)_4]^{2-}$

2. Write down the reaction involved in the extraction of lead. What is the oxidation number of lead in litharge ? **[JEE-2003(M), 2/60]**

3. Pb and Sn are extracted from their chief ores by : **[JEE-2004(S), 3/84]**
(A) carbon reduction and self reduction.
(B) self reduction and carbon reduction.
(C) electrolytic reduction and self reduction.
(D) self reduction and electrolysis.

4. Two ores A1 and A2 of a metal M show the following reactivity :

$$A1 \xrightarrow{\text{Calcination}} S \text{ (black solid)} + CO_2 + H_2O$$

$$A1 \xrightarrow[\text{(ii) KI}]{\text{(i) dil. HCl}} P \text{ (precipitate)} + I_2$$

$$A2 \xrightarrow{\text{Roasting}} G \text{ (gas)} + M \text{ (metal)}$$

$$G \xrightarrow{\text{Acidified } K_2Cr_2O_7 \text{ solution}} \text{green solution}$$

Write the chemical formulae of A1, A2, S, P and G. Explain using required chemical reactions.
[JEE-2004, 4/144]

5. Which of the following ore contains both Fe and Cu ? **[JEE - 2005, 3/144]**
(A) Chalcopyrite (B) Malachite (C) Cuprite (D) Azurite

6. Match the extraction processes listed in column-I with metals listed in column-II. **[JEE - 2006, 6/184]**

	Column-I		**Column-II**
(A)	Self reduction	(p)	Lead
(B)	Carbon reduction	(q)	Silver
(C)	Complex formation and displacement by metal	(r)	Copper
(D)	Decomposition of iodide	(s)	Boron

7. Extraction of zinc from zinc blende is achieved by : **[JEE - 2007, 3/162]**
(A) electrolytic reduction
(B) roasting followed by reduction with carbon
(C) roasting followed by reduction with another metal
(D) roasting followed by self-reduction

8. Native silver metal forms a water soluble complex with a dilute aqueous solution of NaCN in the presence of: **[JEE - 2008, 3/163]**
(A) nitrogen (B) oxygen (C) carbon dioxide (D) argon

9. Match the conversions in Column-I with the type(s) of reaction(s) given in Column-II. **[JEE-2008, 6/163]**

	Column-I		**Column-II**
(A)	$PbS \rightarrow PbO$	(p)	Roasting
(B)	$CaCO_3 \rightarrow CaO$	(q)	Calcination
(C)	$ZnS \rightarrow Zn$	(r)	Carbon reduction
(D)	$Cu_2S \rightarrow Cu$	(s)	Self reduction

Comprehension :

Copper is the most noble of the first row transition metals and occurs in small deposits in several countries, Ores of copper include chalcanthite ($CuSO_4.5H_2O$), atacamite ($Cu_2Cl(OH)_3$), cuprite (Cu_2O), copper glance (Cu_2S) and malachite ($Cu_2(OH)_2CO_3$). However, 80% of the world copper production comes from the ore chalcopyrite ($CuFeS_2$). The extraction of copper from chalcopyrite involves partial roasting, removal of iron and self-reduction.

10. Partial roasting of Chalcopyrite produces : **[JEE - 2010, 3/163]**
(A) Cu_2S and FeO (B) Cu_2O and FeO (C) CuS and Fe_2O_2 (D) Cu_2O and Fe_2O_2

11. Iron is removed from chalcopyrite as : **[JEE - 2010, 3/163]**
(A) FeO (B) FeS (C) Fe_2O_3 (D) $FeSiO_3$

12. In self-reduction, the reducing species is : **[JEE - 2010, 3/163]**
(A) S (B) O^{2-} (C) S^{2-} (D) SO_2

13.* Extraction of metal from the ore **cassiterite** involves **[JEE - 2011, 4/180]**
(A) carbon reduction of an oxide ore (B) self-reduction of a sulphide ore
(C) removal of copper impurity (D) removal of iron impurity

14. Oxidation states of the metal in the minerals haematite and magnetite, respectively, are : **[JEE - 2011, 3/180]**
(A) II, III in haematite and III in magnetite (B) II, III in haematite and II in magnetite
(C) II in haematite and II, III in magnetite (D) III in haematite and II, III in magnetite

15. In the cyanide extraction process of silver from argentite ore, the oxidizing and reducing agents used are
(A) O_2 and CO respectively (B) O_2 and Zn dust respectively
(C) HNO_3 and Zn dust respectively. (D) HNO_3 and CO respectively **[JEE-2012, 3/136]**

16. Sulfide ores are common for the metals : **[JEE(Advanced) 2013, 2/120]**
(A) Ag, Cu and Pb (B) Ag, Cu and Sn (C) Ag, Mg and Pb (D) Al, Cu and Pb

17.* The carbon-based reduction method is **NOT** used for the extraction of: **[JEE(Advanced) 2013, 3/120]**
(A) tin from SnO_2 (B) iron from Fe_2O_3
(C) aluminium from Al_2O_3 (D) magnesium from $MgCO_3$, $CaCO_3$

18.* Upon heating with Cu_2S, the reagent(s) that give copper metal is/are: **[JEE(Advanced) 2014, 3/120]**
(A) $CuFeS_2$ (B) CuO (C) Cu_2O (D) $CuSO_4$

19.* Copper is purified by electrolytic refining of blister copper. The correct statement(s) about this process is (are): **[JEE(Advanced) 2015, 4/168]**
(A) Impure Cu strip is used as cathode (B) Acidified aqueous $CuSO_4$ is used as electrolyte
(C) Pure Cu deposits at cathode (D) Impurities settle as anode-mud

20. Match the anionic species given in Column-I that are present in the ore(s) given in Column-II. **[JEE(Advanced) 2015, 8/168]**

	Column-I		**Column-II**
(A)	Carbonate	(P)	Siderite
(B)	Sulphide	(Q)	Malachite
(C)	Hydroxide	(R)	Bauxite
(D)	Oxide	(S)	Calamine
		(T)	Argentite

21.* Extraction of copper from copper pyrite ($CuFeS_2$) involves **[JEE(Advanced) 2016, 4/124]**
(A) crushing followed by concentration of the ore by froth-flotation
(B) removal of iron as slag
(C) self-reduction step to produce 'blistercopper' following evolution of SO_2
(D) refining of 'blister copper' by carbon reduction

22. Galena (an ore) is partially oxidized by passing air through it at high temperature. After some time, the passage of air is stopped, but the heating is continued in a closed furnace such that the contents undergo self-reduction. The weight (in kg) of Pb produced per kg of O_2 consumed is _____.
(Atomic weights in g mol^{-1} : O = 16, S = 32, Pb = 207) **[JEE(Advanced) 2018, 3/120]**

PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

JEE(MAIN) OFFLINE PROBLEMS

1. Refining of impure copper with zinc impurity is to be done by electrolysis using electrodes as : **[AIEEE-2002, 3/225]**

Cathode	**Anode**	**Cathode**	**Anode**
(1) pure copper	pure zinc	(2) pure zinc	pure copper
(3) pure copper	impure copper	(4) pure zinc	impure zinc

2. Aluminium is extracted by the electrolysis of : **[AIEEE-2002, 3/225]**
(1) alumina (2) bauxite
(3) molten cryolite (4) alumina mixed with molten cryolite

3. The metal extracted by leaching with a cyanide is : **[AIEEE-2002, 3/225]**
(1) Mg (2) Ag (3) Cu (4) Na

4. Which one of the following ores is best concentrated by froth floatation method ? **[AIEEE-2004, 3/225]**
(1) magnetite (2) cassiterite (3) galena (4) malachite.

5. Heating mixture of Cu_2O and Cu_2S will give : **[AIEEE-2005, 3/225]**
(1) Cu_2SO_3 (2) CuO + CuS (3) Cu + SO_3 (4) Cu + SO_2

6. During the process of electro-refining of copper some metals present as impurity settle as anode mud. These are : **[AIEEE-2005, 3/225]**
(1) Sn and Ag (2) Pb and Zn (3) Ag and Au (4) Fe and Ni

7. Which of the following factors is of no significance for roasting sulphide ores to the oxides and not subjecting the sulphide ores to carbon reduction directly ? **[AIEEE-2008, 3/105]**
(1) CO_2 is thermodynamically more stable than CS_2
(2) Metal sulphides are less stable than the corresponding oxides
(3) CO_2 is more volatile than CS_2
(4) Metal sulphides are thermodynamically more stable than CS_2

8. Which method of purification is represented by the following equation : **[AIEEE-2012, 4/120]**

$$Ti\,(s) + 2I_2(g) \xrightarrow{523K} TiI_4(g) \xrightarrow{1700\ K} Ti\,(s) + 2I_2(g)$$

(1) Zone refining (2) Cupellation (3) Polling (4) Van Arkel

9. In the context of the Hall-Heroult process for the extraction of Al, which of the following statements is false? **[JEE-Main 2015, 4/120]**
(1) CO and CO_2 are produced in this process
(2) Al_2O_3 is mixed with CaF_2 which lowers the melting point of the mixture and brings conductivity
(3) Al^{3+} is reduced at the cathode to form Al
(4) Na_3AlF_6 serves as the electrolyte

10. Which one of the following ores is best concentrated by froth floatation method? **[JEE-Main 2016, 4/120]**
(1) Siderite (2) Galena (3) Malachite (4) Magnetite

11. When metal 'M' is treated with NaOH, a white gelatinous precipitate 'X' is obtained, which is soluble in excess of NaOH. Compound 'X' when heated strongly gives an oxide which is used in chromatography as an adsorbent. The metal 'M' is : **[JEE-Main 2018, 4/120]**
(1) Al (2) Fe (3) Zn (4) Ca

JEE(MAIN) ONLINE PROBLEMS

1. The form of iron obtained from blast furnace is : **[JEE(Main) 2014 Online (09-04-14), 4/120]**
(1) Steel (2) Cast Iron (3) Pig Iron (4) Wrough Iron

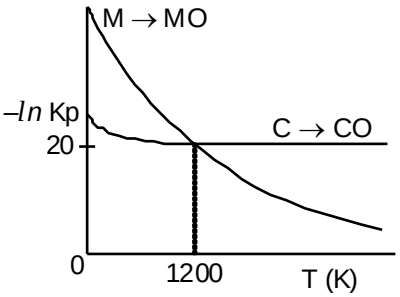
2. Which One of the following ores is known as Malachite : **[JEE(Main) 2014 Online (19-04-14), 4/120]**
(1) Cu_2O (2) Cu_2S (3) $CuFeS_2$ (4) $Cu(OH)_2.CuCO_3$

3. In the isolation of metals, reaction process usually results in : **[JEE(Main) 2015 Online (10-04-15), 4/120]**
(1) Metal sulphide (2) metal carbonate
(3) metal hydroxide (4) metal oxide

4. Calamine is an ore of : **[JEE(Main) 2015 Online (11-04-15), 4/120]**
(1) Zinc (2) Aluminium (3) Iron (4) Copper

5. The plot shows the variation of –ln Kp versus temperature for the two reactions.

$M(s) + \frac{1}{2}O_2(g) \longrightarrow MO(s)$ and $C(s) + \frac{1}{2}O_2(g) \longrightarrow CO(s)$



Identify the correct statement: **[JEE(Main) 2016 Online (09-04-16), 4/120]**
(1) At T > 1200 K, carbon will reduce MO(s) to M(s).
(2) At T < 1200 K, oxidation of carbon is unfavourable.
(3) Oxidation of carbon is favourable at all temperatures.
(4) At T < 1200 K, the reaction MO(s) + C(s) → M(s) + CO(g) is spontaneous.

6. Extraction of copper by smelting uses silica as an additive to remove : **[JEE(Main) 2016 Online (10-04-16), 4/120]**
(1) FeS (2) FeO (3) Cu_2S (4) Cu_2O

7. In the leaching method, bauxite ore is digested with a concentrated solution of NaOH that produces 'X'. When CO_2 gas is passed through the aqueous solution of 'X', a hydrated compound 'Y' is precipitated. 'X' and 'Y' respectively are : **[JEE(Main) 2018 Online (15-04-18), 4/120]**
(1) $NaAlO_2$ and $Al_2(CO_3)_3.xH_2O$ (2) $Al(OH)_3$ and $Al_2O_3.xH_2O$
(3) $Na[Al(OH)_4]$ and $Al_2O_3.xH_2O$ (4) $Na[Al(OH)_4]$ and $Al_2(CO_3)_3.xH_2O$

8. In the extraction of copper from its sulphide ore, metal is finally obtained by the oxidation of cuprous sulphide with : **[JEE(Main) 2018 Online (16-04-18), 4/120]**

(1) SO_2 (2) Fe_2O_3 (3) Cu_2O (4) CO

9. The ore that contains both iron and copper is : **[JEE(Main) 2019 Online (09-01-19), 4/120]**

(1) azurite (2) copper pyrites (3) malachite (4) dolomite

10. The correct statement regarding the given Ellingham diagram is:

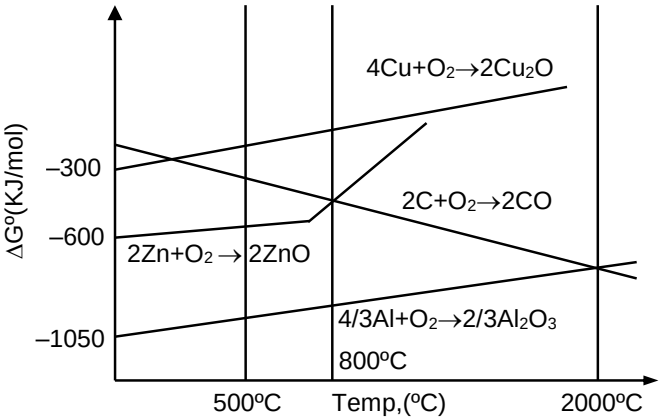
[JEE(Main)2019 Online (09-01-19), 4/120]

(1) At 1400ºC, Al can be used for the extraction of Zn from ZnO

(2) Coke cannot be used for the extraction of Cu from Cu_2O

(3) At 800ºC, Cu can be used for the extraction of Zn from ZnO

(4) At 500ºC, coke can be used for the extraction of Zn from ZnO



11. Hall-Heroult's process is given by : **[JEE(Main) 2019 Online (10-01-19), 4/120]**

(1) $2Al_2O_3 + 3C \rightarrow 4Al + 3CO_2$ (2) $Cu^{+2}(aq) + H_2(g) \rightarrow Cu(s) + 2H^+(aq)$

(3) $ZnO + C \xrightarrow{\text{Coke, 1673 K}} Zn + CO$ (4) $Cr_2O_3 + 2Al \rightarrow Al_2O_3 + 2Cr$

12. Match the ores (column A) with the metals (column B) : **[JEE(Main) 2019 Online (11-01-19), 4/120]**

	(Column A) Ores		**(Column B) Metals**
(I)	Siderite	(a)	Zinc
(II)	Kaolinite	(b)	Copper
(III)	Malachite	(c)	Iron
(IV)	Calamine	(d)	Aluminium

(1) (I) → (c); (II) → (d); (III) → (b); (IV) → (a)

(2) (I) → (b); (II) → (c); (III) → (d); (IV) → (a)

(3) (I) → (c); (II) → (d); (III) → (a); (IV) → (b)

(4) (I) → (a); (II) → (b); (III) → (c); (IV) → (d)

13. The reaction that does NOT define calcination is : **[JEE(Main) 2019 Online (11-01-19), 4/120]**

(1) $CaCO_3.MgCO_3 \xrightarrow{\Delta} CaO + MgO + 2CO_2$

(2) $2Cu_2S + 3O_2 \xrightarrow{\Delta} 2Cu_2O + 2SO_2$

(3) $Fe_2O_3.XH_2O \xrightarrow{\Delta} Fe_2O_3 + XH_2O$

(4) $ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2$

14. In the Hall-Heroult process, aluminium is formed at the cathode. The cathode is made out of : **[JEE(Main) 2019 Online (12-01-19), 4/120]**

(1) Carbon (2) Copper (3) Pure aluminium (4) Platinum

15. The pair that does NOT require calcination is : **[JEE(Main) 2019 Online (12-01-19), 4/120]**

(1) ZnO and MgO (2) $ZnCO_3$ and CaO

(3) Fe_2O_3 and $CaCO_3.MgCO_3$ (4) ZnO and $Fe_2O_3.xH_2O$

Answers

EXERCISE - 1

PART - I

A-1. This method is commonly used for the concentration of low grade sulphide ores like. ZnS, Cu_2S, PbS.

A-2. Substances which are used to prevent certain type of particles, from forming the froth with the bubbles by complexation.

A-3. By magnetic separation as wolframite ($FeWO_4 + MnWO_4$) has magnetic property.

A-4. Copper, Lead, Mercury etc.

A-5. By heating in a current of dry hydrogen chloride gas.

A-6. Stabiliser like cresol and aniline tend to stabilise the froth (i.e. the froth last for longer period).

B-1. All three oxidation curves for the carbon system lie above that for oxidation of zinc, until a temperature of approximately 1000ºC is reached. At this point, C is thermodynamically capable of reducing ZnO to Zn. Since this temperature is greater than the boiling point of Zn (907ºC), it will be formed as a vapour. The overall equation for reduction is, $ZnO(s) + C(s) \longrightarrow Zn(g) + CO(g)$.

B-2. When the temperature is raised a point will be reached where the graph crossed the $\Delta G = 0$ line. Below this temperature the free energy of formation of oxide is negative, so the oxide is stable. Above this temperature the free energy of formation of the oxide is positive, and the oxide becomes unstable and should decompose into metal and oxygen. This explains why HgO, for instance, decomposes spontaneously into its elements when heated.

B-3. $CuO + H_2 \longrightarrow Cu + H_2O$ $\qquad$ $CuO + C \longrightarrow Cu + CO$

$\Delta G^o_f = -237.2 - (-129.7)$ $\qquad$ $\Delta G^o_f = -137.2 - (-129.7)$

$\Delta G^o_f = -107.9$ kJ $\qquad$ $\Delta G^o_f = -7.5$ kJ

So, reduction of CuO is quite feasible with H_2 than C.

C-1. Oxide of Pb and Hg are unstable while that of zinc is stable towards heat, therefore, oxides of mercury and lead are reduced by their respective sulphides to the corresponding metals but zinc oxide does not.

C-2. MgO acts as a basic flux and removes certain acidic impurities present in steel in the form of slag.

$MgO + SiO_2 \longrightarrow MgSiO_3$ **;** $3MgO + P_2O_5 \longrightarrow Mg_3(PO_4)_2$

C-3. It will combine with tin to form calcium stannate.

C-4. $CaO + SiO_2 \longrightarrow CaSiO_3$(slag) ; $PbO + SiO_2 \longrightarrow PbSiO_3$

CaO converts the $PbSiO_3$ to PbO, $PbSiO_3 + CaO \longrightarrow PbO + CaSiO_3$, and also prevents the formation of $PbSO_4$.

C-5. It reduces ZnO to Zn and also reduces CO_2 to CO which is used as a fuel.

C-6. Remove the infusible impurities of silica as slag

$CaCO_3 \longrightarrow CaO + CO_2$; $CaO + SiO_2 \longrightarrow CaSiO_3$ (slag)

formed CO_2 reacts with carbon and form CO which works as reducing agent

$CO_2 + C \longrightarrow 2CO$

C-7. Silica removes iron oxide impurity remaining in the matte by forming silicate, $FeSiO_3$.

D-1. Na_2S is oxidised to Na_2SO_4 in the presence of air and thus equilibrium is shifted in the forward direction according to the following reactions.

$Ag_2S + 2NaCN \overset{Air}{\rightleftharpoons} 2AgCN + Na_2S$; $4Na_2S + 5O_2 + 2H_2O \longrightarrow 2Na_2SO_4 + 4NaOH + 2S\downarrow$

$Ag_2S + 4\ NaCN \rightleftharpoons 2Na\ [Ag(CN)_2] + Na_2S$

D-2. As they have low ionisation energies and are more electropositive elements, they themselves act as strong reducing agent.

D-3. To lower the melting point and increase conductivity of the mixture.

E-1. (A) liquation process, (B) fractional distillation process,
(C) zone refining method and (D) chromatographic methods.

E-2. This method is used for the purification of those impure metals which contain their own oxides as one of the impurities. This process is used for the purification of copper and tin.

E-3. Ni, Zr, Ti etc.

PART - II

A-1.	(A)	**A-2.**	(C)	**A-3.**	(C)	**A-4.**	(B)	**A-5.**	(B)
A-6.	(C)	**A-7.**	(D)	**A-8.**	(C)	**A-9.**	(B)	**A-10.**	(C)
B-1.	(A)	**B-2.**	(A)	**B-3.**	(A)	**C-1.**	(A)	**C-2.**	(C)
C-3.	(B)	**C-4.**	(C)	**C-5.**	(D)	**D-1.**	(C)	**D-2.**	(A)
D-3.	(C)	**D-4.**	(C)	**D-5.**	(C)	**E-1.**	(D)	**E-2.**	(A)
E-3.	(C)	**E-4.**	(C)	**E-5.**	(D)	**E-6.**	(D)	**E-7.**	(D)
E-8.	(C)								

PART - III

1. $(A \rightarrow p,r); (B \rightarrow p,r); (C \rightarrow q); (D \rightarrow s)$

2. $(A \rightarrow r,t); (B \rightarrow q,s); (C \rightarrow t); (D \rightarrow p); (E \rightarrow q)$.

3. $(A \rightarrow q,s); (B \rightarrow r); (C \rightarrow s); (D \rightarrow p)$

4. $(A \rightarrow p,q,s); (B \rightarrow p); (C \rightarrow r,s); (D \rightarrow r,s)$

EXERCISE - 2

PART - I

1.	(B)	**2.**	(C)	**3.**	(C)	**4.**	(A)	**5.**	(B)
6.	(C)	**7.**	(D)	**8.**	(B)	**9.**	(D)	**10.**	(C)
11.	(A)	**12.**	(B)	**13.**	(A)	**14.**	(C)	**15.**	(C)
16.	(A)	**17.**	(C)	**18.**	(D)	**19.**	(C)	**20.**	(D)
21.	(D)								

PART - II

1.	3 (ii, iii, iv)	**2.**	75	**3.**	4 (i, ii, iii & vii)	**4.**	4 (i, ii, iii, viii)
5.	3 (Hg, Cu, Pb)	**6.**	6 (Li, Ba, Na, Al, Ca, Mg)			**7.**	2

8.	4 (a, b, e, f)	**9.**	7 (except 8)	**10.**	16	**11.**	65	**12.**	39
13.	60	**14.**	5 (v, vi, viiI, viii, ix)						

PART - III

1.	(BC)	**2.**	(BCD)	**3.**	(ABC)	**4.**	(AC)	**5.**	(ABD)
6.	(ABC)	**7.**	(ABC)	**8.**	(ABCD)	**9.**	(D)	**10.**	(AD)
11.	(BD)	**12.**	(ABCD)	**13.**	(ABD)	**14.**	(AC)		

PART - IV

1.	(A)	**2.**	(D)	**3.**	(C)	**4.**	(A)	**5.**	(D)
6.	(A)	**7.**	(B)	**8.**	(D)	**9._**	(C)	**10._**	(D)
11._	(D)								

EXERCISE - 3

PART - I

1.	(A)	**2.**	O.N. is +2, litharge is PbO.			**3.**	(B)		
4.	A1 = $CuCO_3 .Cu(OH)_2$ or $2CuCO_3 .Cu(OH)_2$; A2 = Cu_2S ; S = CuO; P = Cu_2I_2 ; G = SO_2								
5.	(A)	**6.**	(A - p,r), (B - p), (C - q), (D - s).			**7.**	(B)	**8.**	(B)
9.	(A - p) ; (B - q) ; (C - p,r) ; (D - p, s)			**10.**	(A)	**11.**	(D)	**12.**	(C)
13.*	(AD)	**14.**	(D)	**15.**	(B)	**16.**	(A)	**17.***	(CD)
18.*	(BCD)	**19.***	(BCD)	**20.**	(A - P,Q,S); (B - T); (C - Q,R); (D - R)			**21.***	(ABC)
22.	6.47 kg								

PART - II

JEE(MAIN) OFFLINE PROBLEMS

1.	(3)	**2.**	(4)	**3.**	(2)	**4.**	(3)	**5.**	(4)
6.	(3)	**7.**	(3)	**8.**	(4)	**9.**	(4)	**10.**	(2)
11.	(1)								

JEE(MAIN) ONLINE PROBLEMS

1.	(3)	**2.**	(4)	**3.**	(4)	**4.**	(1)	**5.**	(4)
6.	(2)	**7.**	(3)	**8.**	(3)	**9.**	(2)	**10.**	(1)
11.	(1)	**12.**	(1)	**13.**	(2)	**14.**	(1)	**15.**	(1)