4. ELECTROCHEMISTRY

SYNOPSIS

I. ELECTROLYTIC CONDUCTORS, ELECTROLYSIS AND FARADAY LAWS

It is a branch of science dealing with the study of processes involving the inter conversion of electrical energy and chemical energy. Conductors that permit the flow of charge are of two types.

1. **Electronic or metallic conductors :** They conduct due to the flow of mobile or valence electrons. Metallic conduction decreases with an increase of temperature. Ex : Cr, Fe, Ag, Zn, etc.
2. **Electrolytic conductors or electrolytes :** These conduct either in the dissolved or molten state. They conduct due to the movement of charged particles called ions. Electrolytic conduction increases with an increase of temperature.

Faraday's laws :

1st law : The amount of a substance that gets liberated or deposited during electrolysis is proportional to the quantity of electricity that is passed through. W = Zit = ZQ

2nd law : For the same quantity of charge that passes through different electrolytes, the amounts of different substances that get deposited or liberated are proportional to their chemical equivalents.

$\frac{w_1}{E_1}=\frac{w_2}{E_2}$ where w_1 and w_2 are the amounts deposited and E_1 and E_2 are their equivalent masses

II. ELECTROLYTIC CONDUCTANCE

Conductance (G) : $G=\frac{1}{R}, R=\rho\frac{l}{a}, \kappa=\frac{1}{\rho}$. Where R = Resistance in Ohms

Equivalent conductance ($\wedge_{eq}$) **:** Conductance of all the ions of 1g equivalent of an electrolyte is known as equivalent conductance. $\wedge_{eq}=\frac{\kappa\times1000}{N}, \wedge_{eq}=\kappa\times V$

Molar conductance ($\wedge_m$) **:** Conductance of all the ions of one mole of an electrolyte is known as molar conductance. $\wedge_m=\frac{\kappa\times1000}{M}$ $\wedge_m=\kappa\times V$

Kohlrausch's Law: Example : Na_2SO_4 : $\wedge^0_{Na_2SO_4}=2\wedge^0_{Na^+}+\wedge^0_{Cl^-}$

III. GALVANIC CELL & NERNST EQUATION

Electrochemical Cells (or) Galvanic Cells : In this two half cells (or two electrodes) are connected appropriately. Thus the Daniel cell has one zinc electrode and one copper electrode.

$Zn(s)Zn^{2+}(aq)\|Cu^{2+}(aq), Cu(s)$

Potential of the cell [EMF]: $E_{cell}=E_{RP_{(Cathode)}}-E_{RP_{(Anode)}}$

Nernst equation : $E_{cell}=E^0_{cell}-\frac{0.0591}{n}\log\frac{[\text{conc. of products}]}{[\text{conc. of reactants}]}$

For the cell reaction : $n_1A+n_2B\rightleftharpoons n_3C+n_4D$; $E^0=\frac{0.0591}{n}\log K_{eq}$

Concentration cells : These are two types. Electrode conc. cell and electrolytic conc. cell

Eg : $Zn, Zn^{2+}(C_1)\|Zn^{2+}(C_2), Zn$.

IV. ELECTRO CHEMICAL SERIES & BATTERIES

i) **Primary cell :** which cannot be charged again, Ex : Leclanche cell (Dry cell).

ii) **Secondary cell:** Which can be charged and discharged repeatedly. Ex : lead storage battery.

iii) **Fuel cell :** The device in which the energy liberated due to the combustion of a fuel is converted into electrical energy is said to be a fuel cell. $\eta=\Delta G/\Delta H$

LECTURE SHEET

EXERCISE-I

(Electrolytic conductors, Electrolysis and Faraday Laws)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. The reason for increase in electrical conduction of electrolyte with increase in temperature is
   1) increase in the number of ions 2) increase in the speed of ions
   3) increase in the degree of dissociation of electrolyte 4) all

2. Sodium metal in liquid ammonia is
   1) an ionic conductor 2) an electronic conductor
   3) a mixed conductor 4) non-conductor

3. Which of the following is 100% ionised at any dilution?
   1) CH_3COOH 2) HCN 3) NaCl 4) NH_4OH

4. The degree of dissociation of an electrolyte in aqueous solution depends on
   1) Temperature 2) Concentration of the electrolyte
   3) Nature of the electrolyte 4) All

5. Molten $CuCl_2$ is electrolysed using platinum electrode. The reaction occuring at anode is
   1) $2Cl^- \rightarrow Cl_2(g) + 2e^-$ 2) $Cl_2(g) + 2e^- \rightarrow 2Cl^-$ 3) $Cu^{2+} + 2e^- \rightarrow Cu$ (s) 4) Cu (s) $\rightarrow Cu^{2+} + 2e^-$

6. During the electrolytic reduction of alumina, the reaction at cathode is
   1) $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$ 2) $3F^- \rightarrow 3F + 3e^-$ 3) $Al^{3+} + 3e^- \rightarrow Al$ 4) $2H^+ + 2e^- \rightarrow H_2$

7. During the electrolysis of aqueous solution of the following, molarity of the solution increases without changing the chemical composition
   1) NaCl 2) HCl 3) $CuSO_4$ 4) H_2SO_4

8. **(A)** : Hydrogen gas always evolved only at cathode during electrolysis
   (R) : H^+ ions undergo reduction by gaining electrons
   1) Both (A) and (R) are true and (R) is the correct explanation of (A)
   2) Both (A) and (R) are true and (R) is not the correct explanation of (A)
   3) (A) is true but (R) is false 4) (A) is false but (R) is true

9. An aqueous solution containing one mole per litre of each $Cu(NO_3)_2$, $AgNO_3$, $Hg(NO_3)_2$, $Mg(NO_3)_2$ is being electrolysed using inert electrodes. The values of standard electrode potential (reduction potential) in volts are
   $Ag / Ag^+ = +0.80V$ $Hg / Hg^{2+} = +0.79V$ $Cu / Cu^{2+} = +0.34V$ $Mg / Mg^{2+} = -2.37V$
   With increasing voltage, the sequence of deposition of metals on cathode will be
   1) Ag, Hg, Cu, Mg 2) Mg, Cu, Hg, Ag 3) Ag, Hg, Cu 4) Cu, Hg, Ag

10. The electrolysis of an aqueous solution of KNO_3 between platinum electrode gives
    1) K at the cathode NO_2 at the anode 2) H_2 at cathode and O_2 at anode
    3) H_2 at cathode and NO_2 at anode 4) K at cathode and O_2 at anode

11. Aqueous solution of $AgNO_3$ is electrolysed using inert electrodes. At the end of electrolysis
1) pH of the solution increases
2) pH of the solution decreases
3) pH of the solution remains unchanged
4) pH of the solution becomes 14

12. Find wrong match.
1) Very dilute H_2SO_4 by inert electrodes $\Rightarrow$ H_2 at anode
2) Potential is zero Volts $\Rightarrow$ Pt, H_2(1atm)/H^+(1M)
3) 50% H_2SO_4 by inert electrodes $\Rightarrow$ $H_2S_2O_8$ at anode
4) $Zn/Zn^{+2}(aq)//Cu^{+2}(aq)/Cu$ $\Rightarrow$ Daniel cell

13. During the electrolysis of cryolite, aluminium and fluorine are formed in ..... molar ratio
1) 1: 2
2) 2 : 3
3) 1 : 1
4) 1 : 3

14. For the discharge of equal masses of the following ions, the number of electrons required is maximum in the case of
1) H^+
2) Cu^{2+}
3) Ag^+
4) Al^{3+}

15. Copper can be deposited from acidified copper sulphate and alkaline cuprous cyanide. If the same current is passed for a definite time :
1) The amount of copper deposited from acidic copper sulphate will be higher
2) The amount of copper deposited from alkaline cuprous cyanide will be higher
3) The same amount of copper will be deposited
4) None of the above

16. The no. of electrons involved in the electrolyticdeposition of 63.5 g. of Cu from an aq. $CuSO_4$ is
1) 6.0×10^{23}
2) 3.011×10^{23}
3) 12.04×10^{23}
4) 6.02×10^{22}

17. One coulomb of charge passes through solutions of $AgNO_3$ and $CuSO_4$. The ratio of the amounts of silver and copper deposited on platinum electrodes used for electrolysis is
1) 108 : 63.5
2) 54 : 31.75
3) 108 : 31.75
4) 215.8 : 31.75

18. The weight in grams of O_2 formed at Pt anode during the electrolysis of an aq. K_2SO_4 solution during the passage of one coulomb of electricity is
1) $\frac{16}{96800}$
2) $\frac{8}{96500}$
3) $\frac{32}{96500}$
4) $\frac{64}{96500}$

19. How many coulombs of electricity are required for the reduction of 1 mol of MnO_4^- to Mn^{2+} ?
1) 96500 C
2) 1.93×10^5 C
3) 4.83×10^5 C
4) 9.65×10^6 C

20. Electric charge on 1gm ion of N^{3-} is
1) 4.8×10^{-19} C
2) $10 \times 1.6 \times 10^{-19}$ C
3) 1.6×10^{-19} C
4) 2.89×10^5 C

21. Two electrolytic cells, one containing acidified ferrous sulphate and another acidified ferric chloride, are in series. The ratio of masses of Iron deposited at the cathode in the two cells will be
1) 3 : 1
2) 2 : 1
3) 1 : 1
4) 3 : 2

22. An ion is reduced to the element when it absorbs 6×10^{20} electrons. The number of equivalents of the ion is
1) 0.1
2) 0.01
3) 0.001
4) 0.0001

Numerical Value Type Questions

23. By passing 0.1 F of electricity through fused sodium chloride, the amount of Cl_2 liberated is

24. On electrolysing a sample of acidified water, 22.4 ml of hydrogen was obtained. The volume of oxygen in ml obtained is

25. An electrolytic cell is constructed for preparing hydrogen. For the average current of 1 ampere in the circuit, the time required for producing 112 ml of H_2 at STP is approximately

26. The charge used for the oxidation of one mole of Mn_3O_4 to MnO_4^{2-} in alkaline medium is ___ F.

27. The electrochemical equivalent of an element is 0.0006735 g/C. Its equivalent weight is ____

28. On passing current through molten KC*l*, 19.5 g of K is deposited. The amount of A*l* deposited by the same quantity of electricity when passed through molten A*lCl*$_3$ is ___ g.

29. The current strength required to displace 0.1 g. of H_2 in 10 sec is ____ amp.

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. A quantity of electrical charge that brings about the deposition of 4.5 g A*l* from Al^{3+} at the cathode will also produce the following volume (STP) of $H_2(g)$ from H^+ at the cathode

   a) 44.8 L b) 22.4 L c) 11.2 L d) 5.6 L

2. The electrolysis of acetate solution produces ethane according to reaction: $2CH_3COO^- \rightarrow C_2H_6(g) + 2CO_2(g) + 2e^-$. The current efficiency of the process is 80%. What volume of gases would be produced at 27^0 C and 740 torr. if the current of 0.5 amp is passed through the solution for 96.45 min? $(V_{C_2H_6} + V_{CO_2})$ = ?

   a) 6.0 L b) 0.60 L c) 1.365 L d) 0.91 L

3. A 0.200M KOH solutions is electrolysed for 1.5 h using a current of 8.00 A. How many moles of O_2 were produced at the anode?

   a) 0.48 b) 0.224 c) 0.112 d) 2.24×10^{-2}

4. A layer of chromium metal 0.25 mm thick is to be plated on an auto bumper with a total area of $0.32m^2$ from a solution containing CrO_4^{2-} ? What current flow is required for this electroplate if the bumper is to be plated in 60s ? The density of chromium metal is 7.20g / cm^3

   a) 4.9×10^3 A b) 1.78×10^3 A c) 5.3×10^4 A d) 10.69×10^4 A

5. Cost of electricity for the production of y L H_2 at STP at cathode is Rs. x, then cost of electricity for the production of y L O_2 gas at STP at anode will be

   a) 2 *x* b) 4 *x* c) 16 *x* d) 32 *x*

More than One correct answer Type Questions

6. Which of the following statements are true ?

   a) graphite is an electronic conductor b) Na/liqNH_3 is a mixed conductor
   c) 'Si–Ga' allows in a semiconductor d) Aqueous urea solution is not a conductor

7. Which of the following reaction occur during the electrolysis of aq. $CuSO_4$ using Cu electrodes?

   a) $Cu \rightarrow Cu^{+2} + 2e^-$ b) $2SO_4^{2-} + 2H_2O \rightarrow 2H_2SO_4 + O_2$
   c) $Cu^{+2} + 2e^- \rightarrow Cu$ d) $2H^+ + 2e^- \rightarrow H_2$

8. In which electrolysis one faraday can produce one mole at cathode or anode?

   a) aq. NaCl b) aq. $AgNO_3$ c) fused NaCl d) aq. $CuSO_4$

9. Select right statement(s) about electrolysis :
   a) Electric current is used to drive a non - spontaneous reaction
   b) ΔG is positive for chemical process during electrolysis
   c) Cations and anions move towards the anode and cathode respectively.
   d) Over voltage is generally associated with evolution of O_2 gas in case of aq. solution

10. Coulomb is the quantity of charge defined as :
   a) One ampere of current passing for 1 sec
   b) The charge which deposits 0.001118g of Ag on cathode
   c) The charge which deposits electrochemical equivalence of metal
   d) 1/2 ampere current for two second

11. An acidic solution of Cu^{2+} salt containing 0.4 g of Cu^{2+} is electrolysed until all the copper is deposited. The electrolysis is continued for seven more minutes with the volume of solution kept at 100 ml and the current at 1.2 amp. Calculate the volume of gases evolved at NTP during the entire electrolysis.
   a) $H_2 = 48.45ml$ b) $H_2 = 58.50ml$ c) $O_2 = 99.8ml$ d) $O_2 = 100ml$

12. The charge required for the reduction of 0.4 mol of $K_2Cr_2O_7$ to Cr^{3+} ions is
   a) 0.6 F b) $2.4 \times 96500C$ c) 2.4 F d) $12.4 \times 96500F$

Linked Comprehension Type Questions

Passage-I :

Electrolysis is the process in which electrical energy is converted to chemical energy. Amount of substance liberated at electrode is directly proportional to the quantity of charge passed. w = Eit/96500

13. The plantium electrodes were immersed in a solution of cupric sulphate ($CuSO_4$) and electric current is passed through the solution. After sometime, it was observed that the colour of copper sulphate disappeared with evolution of a gas at the electrode. The colourless solution contains.
   a) platinum sulphate b) copper nitrate c) copper sulphate d) sulphuric acid

14. The passage of current liberates H_2 at cathode and Cl_2 at anode. The solution is
   a) $CuCl_2$ (aq) b) NaCl in water c) $HgCl_2$ (aq) d) $AuCl_3$ in water

15. Calculate the volume of gas liberated at the anode at STP during the electrolysis of an aq. $CuSO_4$ solution by a current of 1 A passed for 16 minutes and 5 seconds.
   a) 224 mL b) 56 mL c) 112 mL d) 448 mL

Passage-II :

Electrolysis involves electronation and de-electronation at the respective electrodes. Anode of electrolytic cell is the electrode at which de-electronation takes place whereas at cathode electronation is noticed. The products formed at either electrode is given in terms of Faraday's laws of electrolysis i.e. w = Eit/96500

16. During electrolysis of $CH_3COONa_{(aq)}$, the mole ratio of gases formed at cathode and anode is
   a) 1 : 2 b) 2 : 1 c) 3 : 1 d) 1 : 3

17. During electrolysis of $CuSO_{4(aq)}$, the pH of solution becomes
   a) < 7 b) > 7 c) $= 7$ d) ≥ 7

18. The volume of octane required to be used for its combustion by the oxygen liberated during electrolysis of $NaNO_3$(aq) by passing 9.65 ampere current for 1 hr. is
   a) 322.56 L b) 32.256 mL c) 3.22 mL d) 161.2 mL

Matrix Matching Type Questions

19.

Column-I	Column-II
A) Dilute solution of HCl	p) O_2 evolved at anode
B) Dilute solution of NaCl	q) H_2 evolved at cathode
C) Concentrate solution of NaCl	r) Cl_2 evolved at anode
D) Fairly concentrate solution of $AgNO_3$	s) Ag deposition at cathode

20.

Column-I	Column-II
A) 1 mole of MnO_4^- to Mn^{2+}	p) 193000 C
B) 1 mole of $Cr_2O_7^{2-}$ to Cr^{3+}	q) 289500 C
C) 1 mole of Sn^{4+} to Sn^{2+}	r) 482500 C
D) 1 mole of Al^{3+} to Al	s) 579000 C

Integer Type Questions

21. A current of 2 ampere passing for 5 hr through a molten tin salt deposits 22.2 g of tin. Find the oxidation number of tin (atomic weight of tin is 118.7) in the salt

22. What current is to be passed for 0.25 sec for deposition of certain weight of metal which is equal to its electrochemical equivalent ?

23. How many faradays are required for reduction of 1 mol $C_6H_5NO_2$ into $C_6H_5NH_2$

24. What is the equivalent weight of O_2 in the following reaction, $H_2O + \frac{1}{2}O_2 + 2e^- \rightarrow 2OH^-$?

25. During the electrolysis of a concentrated brine solution. Calculate the moles of chlorine gas produced by the passage of 4F electricity.

26. Total charge required for the oxidation of two moles Mn_3O_4 into MnO_4^{2-} in presence of alkaline medium is 2.0×10^x ; x is

27. In the oxidation of ferric oxalate $[Fe_2(C_2O_4)_3]$ to carbondioxide, if 18F of electricity is required how many moles of ferric oxalate is oxidized.

28. The electricity in term of faraday is required to produce 20g of Ca from molten $CaCl_2$ is:

EXERCISE-II

(Electrolytic Conductance)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. The ionic conductance of following cations in a given conc. aq. solution is in the order
   1) $Li^+ < Na^+ < K^+ < Rb^+$ 2) $Li^+ > Na^+ > K^+ > Rb^+$ 3) $Li^+ < Na^+ > K^+ > Rb^+$ 4) $Li^+ = Na^+ < K^+ < Rb^+$

2. **(A) :** The conductivity of an aqueous solution of NaCl is greater than that of pure solvent.
   (R) : Conductivity is independent of the number of ions in solution.
   1) Both (A) and (R) are true and (R) is the correct explanation of (A)
   2) Both (A) and (R) are true and (R) is not the correct explanation of (A)
   3) (A) is true but (R) is false
   4) (A) is false but (R) is true

3. The highest electrical conductivity among the following aqueous solutions is of
   1) 0.1 M acetic acid
   2) 0.1 M chloroacetic acid
   3) 0.1 M fluoroacetic acid
   4) 0.1 M difluoroacetic acid

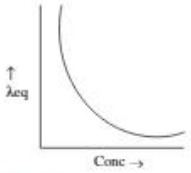
4. Conductance is directly proportional to area and the concentration of solution in it and is inversely proportional to the length of the vessel, then the unit of the constant of proportionality is
1) S.m mol^{-1} 2) $S.m^2\ mol^{-1}$ 3) $S^{-2}.m^2\ mol$ 4) $S^2.m^2\ mol^{-2}$

5. If the specific conductance and conductance of a solution are same, then its cell constant is equal to
1) 1 2) 0 3) 10 4) 100

6. **(A) :** The conductivity of 0.1M solutions of different electrolytes is same.
(R) : The conductivity depends on the size of the ions.

7. Specific conductivity of a solution
1) increases with dilution
2) decreases with dilution
3) remains unchanged with dilution
4) depends on mass of electrolyte

8. A graph is drawn between the λ_{eq} values and concentration of an electrolyte. Which of the following electrolyte will correspond to the graph given ?
1) KCl
2) $BaCl_2$
3) H_2SO_4
4) CH_3COOH



9. For which case 'λ' values v/s $\sqrt{c}$ shows a straight line
1) KCl 2) HCOOH 3) CH_3NH_2 4) CH_3COOH

10. The expression showing the relationship between equivalent conductivity and molar conductivity is
1) $\lambda_m = Z \times \lambda_{eq}$ 2) $\lambda_{eq} = Z \times \lambda_m$ 3) $\lambda_m = \frac{\lambda_{eq}}{Z}$ 4) $\lambda_m = \lambda^2_{eq}$

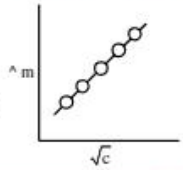
11. At infinite dilution stage, the solution of CH_3COOH in water does not contain:
1) H^+ ion 2) CH_3COO^- ion 3) CH_3COOH molecule 4) H_2O

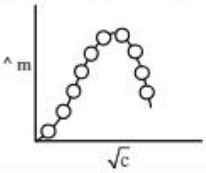
12. Which of the following solutions of NaCl has the higher specific conductance ?
1) 0.001N 2) 0.01N 3) 0.1 N 4) 1 N

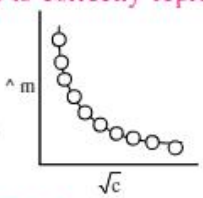
13. The equivalent conductances of two strong electrolytes at infinite dilution in H_2O (where ions move freely through a solution) at 25^0C are given below $\Lambda^0_{CH_3COONa}$ = 91.0 S cm^2 / equiv ; Λ^0_{HCl} = 426.2 S cm^2 / equiv. What additional information / quantity one needs to calculate Λ^0 of an aqueous solution of acetic acid ?
1) Λ^0 of CH_3COOK 2) Λ^0 of H^+ 3) Λ^0 of $ClCH_2COOH$ 4) Λ^0 of NaCl

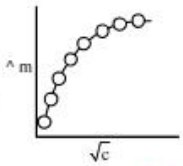
14. For a dilute solution of a strong electrolyte, which of the folllowing facts is correct?
1) The graph b/w λ_m and C is linear
2) The graph b/w log λ_m and C is linear
3) The graph b/w λ_m and $\sqrt{C}$ is not linear
4) The graph b/w λ_m and $\sqrt{C}$ has a negative slope.

15. The variation of $\hat{}_m$ of acetic acid with concentration is correctly represented by

1) 

2) 

3) 

4) 

16. CH_3COOH is titrated in the NaOH solution then which of the following statements is correct?
    1) Conductance increases upto equivalence point, then it decreases.
    2) Conductance decreases upto equivalence point, then it increases.
    3) First conductance increases slowly upto equivalence point and then increases rapidly.
    4) Before the equivalent point, there exists basic buffer solution.

17. $AgNO_{3(aq)}$ was added to an aqueous KC*l* solution gradually and the conductivity of the solution was measured. The plot of conductance Λ versus the volume of $AgNO_3$ is

18. Which one is correct about conductivity water ?
    1) The water whose own conductance is very small
    2) The water obtained after 7-8 times distillation
    3) Kohlrausch prepared the conductivity water for the first time
    4) All of these

Numerical Value Type Questions

19. The distance b/w two electrodes of a cell is 2.5cm and area of electrode is $5cm^2$ the cell constant is

20. For an electrolytic solution of 0.05 mole $litre^{-1}$, the conductivity has been found to be 0.0110 Scm^{-1}. The molar conductivity (in Scm^2mole^{-1}) is

21. The limiting molar conductivities (Λ^0) for NaCl, KBr and KCl are 126, 152 and 150 $S.cm^2mol^{-1}$ respectively. Then Λ^0 for NaBr is

22. Molar ionic conductivities of a bivalent electrolyte are 57 and 73. The $\wedge_m$ of the solution will be

23. The conductivity of 0.001 M acetic acid is 5×10^{-5} S cm^{-1} and $\wedge^0$ is 390.5 S cm^2 mol^{-1} then the calculated value of dissociation constant of acetic acid would be ____ $\times 10^{-6}$

24. The equivalent conductivity of 0.1 N CH_3COOH at 25^0C is 80 and at infinite dilution is 400ohm cm^2eq^{-1}. The degree of dissociation of CH_3COOH

25. The equivalent conductance at infinite dilution of NaCl, HCl and CH_3COONa at 298K are 126.0, 426.0 and 91.0 $ohm^{-1}cm^2$ respectively. The value of equivalent conductance of acetic acid at infinite dilution at the same temperature is

26. Given the following molar conductivities at 25^0C; HC*l*, 426 $\Omega^{-1}cm^2mol^{-1}$; NaC*l*, 126 $\Omega^{-1}cm^2$ mol^{-1}; NaC (sodium crotonate), 83 $\Omega^{-1}cm^2mol^{-1}$, $x \times 10^{-5}$ is the ionization constant of crotonic acid, if the conductivity of a 0.001 M crotonic acid solution is $3.83 \times 10^{-5} \Omega^{-1}cm^{-1}$. x =

27. Equivalent conductance of saturated $BaSO_4$ is $400ohm^{-1}cm^2equiv^{-1}$ and specific conductance is $8 \times 10^{-5} ohm^{-1}$, cm^{-1}. Hence, solubility of $BaSO_4$ is ____ $\times 10^{-4}$M.

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. The specific conductivity of dichloroacetic acid at dilution of 8 litres is 0.0238 C.G.S. unit, λ_0 for this acid is 385 C.G.S. unit, calculate the degree of ionisation at this dilution.
    a) 50% b) 45% c) 49.45% d) 36.02%

2. $\lambda_m^0(AgNO_3), \lambda_m^0(HCl)$ and $\lambda_m^0(HNO_3)$ are a, b and c S cm^2 mol^{-1} respectively. If the conductivity of a saturated solution is Z S cm^{-1}. Then the solubility of AgCl is

a) $\frac{a+b+c}{1000MZ}$ b) $\frac{(a+b+c)1000}{Z}$ c) $\frac{1000Z}{a+b-c}$ d) $\frac{Z(a+b-c)}{1000M}$

3. The specific conductance of a saturated solution of a salt MX is $2.8 \times 10^{-7}\,\Omega^{-1}cm^{-1}$ and the equivalent conductances at infinite dilution of M^{+1} and X^{-1} ions are 68 and $72\,\Omega^{-1}$ cm^2/ equivalent respectively. Hence, the K_{sp} of MX is found to be

a) 2×10^{-6} b) 4×10^{-12} c) 10^{-12} d) 4×10^{-6}

4. The resistance of 0.01 N solution of an electrolyte is 210 ohm at 298K, its conductance is :

a) 4.76×10^{-3} mho b) 4.76 mho c) 210 mho d) none of these

5. If the electrolyte used is $Ba(NO_3)_2$, then its molar conductance to equivalent conductance ratio is

a) 1 b) 2 c) 4 d) 3

More than One correct answer Type Questions

6. The molar conductivities of H^+ and $HCOO^-$ ions at infinite dilution are 34.6 and 5.4 Sm^2mol^{-1} respectively. The molar conductivity of 0.025M HCOOH is 4.0 Sm^2mol^{-1}. Then correct one for formic acid is

a) $pK_a = 3.6$ b) $K_a = 2 \times 10^{-3}$ c) $pK_a = 4.8$ d) $K_a = 2.5 \times 10^{-4}$

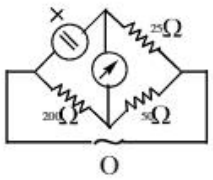
7. Limiting equivalent conductivities of different ions are given below.

Ion	K^+	Na^+	SO_4^{2-}
λ_{eq}^0 /Scm^2eq^{-1}	73	81	58.8

The limiting equivalent conductivity of the salt $NaKSO_4$ is ____ Scm^2eq^{-1}

a) 239.8 b) 201.4 c) 135.8 d) 141.6

8. A conductivity cell (X) employs two electrodes having surface area of $10cm^2$ and separated by a distance of 10cm. It is filled with 0.01M solution of an electrolyte and connected in the wheatstone bridge. The balanced bridge is shown in the diagram. What is the molar conductivity of the electrolyte?



a) 10^3 Scm^2 mol^{-1} b) 250 Scm^2 mol^{-1} c) 100 Scm^2 mol^{-1} d) 500 Scm^2 mol^{-1}

Linked Comprehension Type Questions

Passage-I :

Molar conductivity, $\wedge_m = K/C$ where K is conductivity (S-cm^{-1}), ($\wedge_m$ = Scm^2 mol^{-1}) and C is molar concentration (in mole /cm^3). The molar conductivity of 0.04 M solution of $MgCl_2$ is 200Scm^2 mol^{-1} at 298 K. A cell with electrodes that are 2.0cm^2 in surface area and 0.50 cm apart is filled with $MgCl_2$ solution.

9. Conductivity of $MgCl_2$ solution is :

a) 8×10^{-3}S cm^{-1} b) 32 S cm^{-1} c) 0.032S cm^{-1} d) None of these

10. How much current will flow when the potential difference between the two electrodes is 5.0V?
a) 156.25 A b) 0.16 A c) 160 A d) None of these

11. The cell constant is
a) $0.25 cm^{-1}$ b) $0.50 cm^2$ c) 0.025cm d) $0.35 cm^2$

Passage-II :

Specific conductance or conductivity of the electrolyte solution is given by the following relation: $K = G.\ell / A$ where, G=1/R is the conductance and 1/A is the cell constant, Molar conductance ($\wedge_m$) and equivalent conductance ($\wedge_e$) of an electrolyte solution are calculated using the following similar relations: $\wedge_m = K.1000 / M$; $\wedge_e = K.1000 / N$ where, M and N are the molarity and normality of the solution respectively. Molar conductance of strong electrolyte depends on concentration : $\wedge_m = \wedge_m^0 - b\sqrt{C}$ where, $\wedge_m^0$ = molar conductance at infinite dilution; C = concentration of the solution b = constant. $\alpha = \wedge_m / \wedge_m^0 = \wedge_e / \wedge_e^0$

12. Which of the following decreases on dilution of electrolytic solution?
a) $\wedge_{eq}$ b) $\wedge_m$ c) K d) G

13. For which of the following electrolytic solution $\wedge_m$ and $\wedge_e$ are equal ?
a) $BaCl_2$ b) KCl c) $Al_2(SO_4)_3$ d) $CaCl_2$

14. Which of the following equality holds good for the strong electrolytes?
a) $\Lambda = \Lambda^0$ as $C \to 1$ b) $\Lambda = \Lambda^0$ as $C \to 0$ c) $\Lambda = \Lambda^0$ as $C \to \infty$ d) $\Lambda = \Lambda^0$ as $C \to \sqrt{b}$

Matrix Matching Type Questions

15.

Column-I (In fused state)	Column-II (Conductivity in $Ohm^{-1}cm^{-1}$)
A) H^+	p) 350
B) Na^+	q) 50
C) Li^+	r) 39
D) Cs^+	s) 77

16.

Column-I (Term)	Column-II (Relation)
A) α (Degree of ionization)	p) λ^+ / λ
B) t_+ (Transport number)	q) $\Lambda_m^c / \Lambda_m^o$
C) Fraction of a mole undergoing ionization	r) $U^+ / U^+ + U^-$
D) Transport number of Na^+ ion in NaCl	s) $\Lambda_e^c / \Lambda_e^o$

Integer Type Questions

17. The ratio of (Λ_m / Λ_e) for $Ca_3(PO_4)_2$ will be equal to _____

18. The resistance of 0.1 N solution of formic acid is 200 ohm and cell constant is $2.0 cm^{-1}$. The equivalent conductivity $(in\ Scm^2eq^{-1})$ of 0.1 N formic acid is 1.0×10^x ; x is

19. The conductance of a salt solution (AB) measured by two parallel electrodes of area $100 cm^2$ separated by 10 cm was found to be $0.0001\Omega^{-1}$. If volume enclosed between two electrode contains 0.1 mole of salt, and the molar conductivity (Scm^2mol^{-1}) of salt at same concentration is 1.0×10^{-x}; x is

20. Molar conductivities at infinite dilution of KCl, HCl and CH_3COOK are 0.013, 0.038 and 0.009 Sm^2mol^{-1} respectively at 291K. If conductivity of 0.001M CH_3COOH is 2.72×10^{-3} Sm^{-1} then find % degree of ionization of CH_3COOH.

21. For a saturated solution of AgCl at 25^0C, specific conductance is 3.41×10^{-6} ohm^{-1}cm^{-1}. If λ^{∞}_{AgCl} = 138.3 ohm^{-1}cm^{2}eq^{-1}, the Ksp of AgCl is 0.17×10^{-x} M^2. The value of 'x' is

22. The equivalent conductance of 1.0M CH_3COOH is $12\,\Omega^{-1}$cm^{2}eq^{-1} and that at infinite dilution is $240\,\Omega^{-1}$cm^{2}eq^{-1}. The % ionization of CH_3COOH is :

EXERCISE-III

(Galvanic cell & Nernst Equation)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. In a Galvanic cell, the electrons flow from
   1) anode to cathode through the solution
   2) cathode to anode through the solution
   3) anode to cathode through the external circuit
   4) cathode to anode through the external circuit

2. Which of the following statements is wrong about galvanic cells
   1) cathode is the positive electrode
   2) cathode is the negative electrode
   3) e^- flow from anode to cathode in the external circuit
   4) reduction occurs at cathode

3. Which of the following statements is correct w.r.t. both electrolytic cell and Galvanic cell
   1) in both cells, anode is shown by +ve sign
   2) in both cells, cathode is shown by –ve sign
   3) in both cells, reduction reaction takes place at the cathode
   4) in both cells, oxidation reaction takes place at the cathode

4. Saturated solution of KNO_3 is used to make salt bridge because
   1) velocity of K^+ is greater than that of NO_3^-
   2) velocity of NO_3^- is greater than that of K^+
   3) velocities of K^+ and NO_3^- are $\approx$ the same
   4) KNO_3 is highly soluble in water

5. **(A) :** A salt bridge allows the flow of current by completing the electrical circuit.
   (R) : A salt bridge maintains the electrical neutrality of the two half cells.
   1) Both (A) and (R) are true and (R) is the correct explanation of (A)
   2) Both (A) and (R) are true and (R) is not the correct explanation of (A)
   3) (A) is true but (R) is false
   4) (A) is false but (R) is true

6. Which of the following is correct?
   1) Zinc acts as cathode in Daniel cell
   2) In a Li–Zn couple, zinc acts as anode
   3) Copper displaces iron from its salt solution
   4) Zinc dsplaces tin from its salt solution

7. Which of the following statements is true for the electrochemical Daniel cell ?
   1) e^- flow from Cu electrode to Zn electrode
   2) Current flows from Zn electrode to Cu electrode
   3) Cations move towards copper electrode
   4) Cations move toward zinc electrode

8. The cell reaction of the galvanic cell, $Cu(s) / Cu^{2+}(aq) // Hg^{2+}(aq) // Hg(l)$ is
   1) $Hg + Cu^{2+} \rightarrow Hg^{2+} + Cu$
   2) $Hg + Cu^{2+} \rightarrow Hg^{+} + Cu^{+}$
   3) $Hg + Cu^{+} \rightarrow CuHg$
   4) $Cu + Hg^{2+} \rightarrow Cu^{2+} + Hg$

9. **(A) :** The Daniel cell becomes dead after some time.
(R) : Oxidation potential of zinc anode increases and that of copper cathode decreases.
1) Both (A) and (R) are true and (R) is the correct explanation of (A)
2) Both (A) and (R) are true and (R) is not the correct explanation of (A)
3) (A) is true but (R) is false
4) (A) is false but (R) is true

10. The cell for which the cell reaction is $H_2 + Cu^{2+} \rightarrow 2H^+ + Cu$ is represented as
1) $Cu/Cu^{2+}//H^+/H_2$
2) $H_2(g)/H^+//Cu^{2+}/Cu$
3) Pt, H_2(1 atm), $H^+//Cu^{2+}/Cu$
4) Pt, H_2/H^+(aq) (1atm)$//Cu^{2+}/Cu$

11. Which metal will dissolve if the cell works $Cu|Cu^{2+}||Ag^+|Ag$
1) Cu
2) Ag
3) Both (1) and (2)
4) None of these

12. Which is a correct cell reaction ?
1) $Zn + 2Ag^+ \rightarrow Zn^{2+} + 2Ag$
2) $2Ag + Zn^{+2} \rightarrow 2Ag^+ + Zn$
3) Both
4) None

13. The reaction, $1/2H_{2(g)} + AgCl_{(s)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)} + Ag_{(s)}$ occurs in the galvanic cell :
1) $Ag\left|AgCl_{(s)}\right|KCl_{(Soln)}\left|AgNO_{3(soln)}\right|Ag$
2) $Pt,H_{2(s)}\left|HCl_{(Soln)}\right|AgNO_{3(Soln)}\left|Ag\right.$
3) $Pt,H_{2(g)}\left|HCl_{(Soln)}\right|AgCl_{(s)}\left|Ag\right.$
4) $Pt,H_{2(g)}\left\|KCl_{(Soln)}\right\|AgCl_{(s)}\left|Ag\right.$

14. For spontanity of a cell, which is correct ?
1) $\Delta G = 0, \Delta E = 0$
2) $\Delta G = -Ve, \Delta E = 0$
3) $\Delta G = +Ve, \Delta E = 0$
4) $\Delta G = -Ve$

15. If the cell reaction is spontaneous
1) E^0 is –ve
2) ΔG is positive
3) E^0 is +ve
4) ΔG and E^0 are positive

16. **(A) :** If E^0 of Cu^{2+}/Cu = +0.34V and E^0 of Ag^+/Ag = +0.80V then galvanic cell constructed from these is $Ag/Ag^+//Cu^{2+}/Cu$
(R) : In any galvanic cell the reaction that takes place is a redox reaction
1) Both (A) and (R) are true and (R) is the correct explanation of (A)
2) Both (A) and (R) are true and (R) is not the correct explanation of (A)
3) (A) is true but (R) is false
4) (A) is false but (R) is true

17. A galvanic cell is composed of two hydrogen electrodes, one of which is a standard one. In which of the following solutions should the other electrode be immersed to get maximum EMF?
1) 0.1 M HCl
2) 0.1 M CH_3COOH
3) 0.1 M H_3PO_4
4) 0.1 M H_2SO_4

18. For the cell $Zn\left|Zn^{2+}\right\|\left.Cu^{2+}\right|Cu$, if the conc. of Zn^{2+} and Cu^{2+} ions is doubled, the EMF of the cell:
1) doubles
2) reduces to half
3) remains same
4) becomes zero

19. For which cell EMF is independent of the concentration of electrolytes used?
1) $Fe\left|FeO_{(s)}\right|KOH_{(aq)}\left|NiO_{(s)}\right|Ni_2O_{3(s)}\left|Ni\right.$
2) $Pt(H_2)|HCl|Pt(Cl_2)$
3) $Zn\left|Zn(NO_3)_2\right\|CuSO_4\left|Cu\right.$
4) $Hg,HgCl_2\left|KCl\right\|AgNO_3\left|Ag\right.$

20. $Pb_{(s)} \mid \underset{\text{saturated solution}}{PbSO_4} \mid\mid \underset{\text{saturated solution}}{PbI_2} \mid Pb_{(s)}$. Which of the following expressions represent the EMF of the above cell at 25^0C?

1) $E = \frac{0.0592}{2} \log \frac{[a_{Pb^{+2}}]_{RHS}}{[a_{Pb^{2+}}]_{LHS}}$

2) $E = \frac{0.0592}{2} \log \frac{[a_{Pb^{2+}}]_{LHS}}{[a_{Pb^{2+}}]_{RHS}}$

3) $E = \frac{0.0592}{2} \log [K_{sp_{(PbI_2)}}]^{1/2}$

4) $E = \frac{0.0592}{2} \log \frac{K_{sp_{[PbI_2]}}}{K_{sp_{[PbSO_4]}}}$

21. Given, $Cu^{2+} + e^- \rightarrow Cu^+ E^0 = 0.15$ volt ; $Cu^+ + e^- \rightarrow Cu\ E^0 = 0.5$ volt . E for $Cu^{2+} + 2e^- \rightarrow Cu$

1) 0.65 V 2) 0.325 V 3) 0.45 V 4) 1.2 V

Numerical Value Type Questions

22. If the standard electrode protential of Cu^{2+}/ Cu electrode is 0.34 V, what is the electrode potential at 0.01 M concentration of Cu^{2+}? (T = 298^0K)

23. The potential of hydrogen electrode is –118 mV. The H^+ concentration of the solution is

24. The standard potentials (E^0) for the half reactions are as $Zn \rightarrow Zn^{2+} + 2e^-$, $E^0 = +0.76$ V
$Fe \rightarrow Fe^{2+} + 2e^-$, $E^0 = +0.41$ V. The emf for the cell reaction $Fe^{2+} + Zn \rightarrow Zn^{2+} + Fe$ is

25. Consider the following E^0 values $E^0_{Fe^{3+}/Fe^{2+}} = +0.77$ V; $E^0_{Sn^{2+}/Sn} = -0.14$ V Under standard conditions the potential for the reaction $Sn_{(s)} + 2Fe^{3+}_{(aq)} \rightarrow 2Fe^{2+}_{(aq)} + Sn^{2+}_{(aq)}$ is

26. E.M.F of the cell reaction, $2Ag^+ + Cu \rightarrow 2Ag + Cu^{2+}$ is 0.46 V. If $E^0_{Cu^{2+}/Cu}$ is +0.34 V, $E^0_{Ag^+/Ag}$ is

27. If the SRP of nickel and chlorine electrodes are –0.25V and +1.36V respectively. The EMF of the cell $Ni/Ni^{2+}(0.01M)//Cl^-(0.01M)/Cl_2$, Pt is ____ V

28. The standard electrode potential of the two half cells are given below. $Ni^{+2} + 2e^- \rightarrow Ni$; $E^o = -0.25$V; $Zn^{+2} + 2e^- \rightarrow Zn$; $E^o = -0.77$ V. The voltage of cell formed by combining the two half cells would be

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. For the cell $Zn|Zn^{2+}(C_1)||Zn^{2+}(C_2)|Zn$. ΔG is negative if :

a) $C_1 = C_2$ b) $C_1 > C_2$ c) $C_2 > C_1$ d) None of these

2. The Nernst eqn., $E = E^0 - \frac{RT}{nF}$, the equilibrium constant K_c will be equal to Q when :

a) $E = E^0$ b) $\frac{RT}{nF} = 1$ c) E = zero d) $E^0 = 1$

3. The standard emf of the cell, Pt, H_2 / $H^+(C_1)$/ $H^+(C_2)$/H_2, Pt, is :

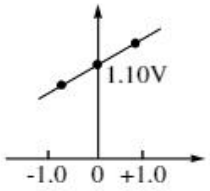
a) ±0.00V b) +1.36V c) –1.36V d) insufficient data

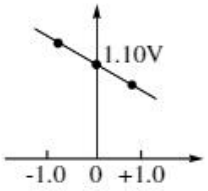
4. Which statement is true about a spontaneous cell reaction in galvanic cell?

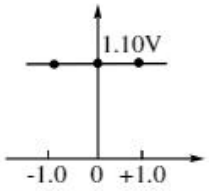
a) $E^0_{cell} > 0$, $\Delta G^0 < 0$, $Q < K_c$ b) $E^0_{cell} > 0$, $\Delta G^0 > 0$, $Q < K_c$

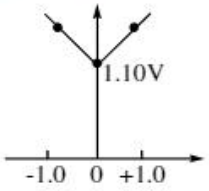
c) $E^0_{cell} > 0$, $\Delta G^0 > 0$, $Q > K_c$ d) $E^0_{cell} < 0$, $\Delta G^0 < 0$, $Q < K_c$

5. Which graph correctly correlates E_{cell} as a function of concentrations for the cell (for different values of M and M'): $Zn_{(s)} + Cu^{2+}_{(M)} \rightarrow Zn^{2+}_{(M')} + Cu_{(s)}$; $E^0_{cell} = 1.10V$; X-axis: $\log_{10}\frac{[Zn^{2+}]}{[Cu^{2+}]}$; Y-axis: E_{cell}

a) 

b) 

c) 

d) 

6. The standard reduction potential of Cu^{2+}/Cu and Cu^{+}/Cu are 0.337 and 0.153V respectively. The standard electrode potential of Cu^{2+}/Cu^{+} half cell will be

a) 0.184 V b) 0.827 V c) 0.521 V d) 0.490 V

7. What is reaction quotient, Q, for the cell $Ni_{(s)} | Ni^{2+}(0.190M) \| Cl^{-}(0.40M) | Cl_{2\,(g)}, Pt_{(s)}(1.0atm)$

a) 3.1×10^{-1} b) 1.3×10^{-1} c) 8.0×10^{-2} d) 3.0×10^{-2}

8. Consider the following standard reduction potentials. $Fe^{3+}(aq) + e^{-} \rightleftharpoons Fe^{2+}(aq)$, $E^0 = 0.77$ V, $H_2O_2(aq) + 2e^{-} \rightleftharpoons 2OH^{-}(aq)$, $E^0 = 0.88$ V. For the voltaic cell reaction below, calculate the Fe^{2+} concentration (in M) that would be needed to produce a cell potential equal to 0.16V at 25^0C when $[OH^-] = 0.1M$, $[Fe^{3+}] = 0.5$ M and $[H_2O_2] = 0.35M$; $2Fe^{2+}(aq) + H_2O_2(aq) \rightleftharpoons 2Fe^{3+}(aq) + 2OH^{-}(aq)$

a) 0.3M b) 0.6M c) 0.41M d) 0.35M

9. $\Delta G = \Delta H - T\Delta S$ and $\Delta G = \Delta H + T\left[\frac{d(\Delta G)}{dT}\right]$ then $\left(\frac{dE_{cell}}{dT}\right)$ is

a) $\frac{\Delta S}{nF}$ b) $\frac{nE}{\Delta S}$ c) $-nFE_{cell}$ d) $+nFE_{cell}$

More than One correct answer Type Questions

10. Which of the following facts regarding the movement of anions in the solution is incorrect?

a) Towards cathode in an electrolyte cell and towards anode in a galvanic cell.
b) Towards anode in an electrolytic cell and towards cathode in a galvanic cell.
c) Towards cathode in both type cells. d) Towards anode in both type cells.

11. E^0 for $Cl_2 + 2e^{-} \rightleftharpoons 2Cl^{-}$ is E^0_1 then E^0_2 for $\frac{1}{2}Cl_2 + 1e^{-} \rightleftharpoons Cl^{-}$ is (If Pt, E^0 of $\frac{1}{2}Cl_2 | Cl^{-} = +1.36V$)

a) $E^0_1 = +1.36V$ b) $E^0_2 = +1.36V$ c) $E^0_1 = +2.72V$ d) $E^0_2 = +0.34V$

12. Which of the following statement is correct?
If $E^0_{Cu^{2+}|Cu} = 0.34$ V and $E^0_{Sn^{2+}|Sn} = -0.136$ V, $E^0_{H^+|H_2} = -0.0$ V

a) Cu^{+2} ions can be reduced by $H_2(g)$ b) Cu can be oxidized by H^+
c) Sn^{2+} ions can be reduced by H_2 d) Sn can be oxidized by Cu^{2+}

13. The oxidation potential of hydrogen half-cell will be negative if :

a) $p(H_2) = 1atm$ and $[H^+] = 1M$ b) $p(H_2) = 1atm$ and $[H^+] = 2M$
c) $p(H_2) = 0.2atm$ and $[H^+] = 1M$ d) $p(H_2) = 0.2atm$ and $[H^+] = 0.2M$

14. The cell reaction for the given cell is : $\underset{P_1=1atm}{Pt(H_2)}|pH = (X)||pH = 3|\underset{P_2=1atm}{(H_2), Pt}$, it may be

a) Spontaneous b) Non-spontaneous
c) In equilibrium d) It is a half cell

15. Which represents a concentration cell?

a) $Pt H_2 \underset{C_1}{|} HCl \| \underset{C_2}{HCl} | Pt H_2$

b) $Pt H_2 \underset{C_1}{|} HCl \| Cl_2 Pt$

c) $Zn | Zn^{2+}(C_1) \| Zn^{2+}(C_2) | Zn$

d) $Pt, Cl_2 | Cl^{(-)}{}_{(C_1)} \| Cl^{(-)}{}_{(C_2)} | Cl_2, Pt$

16. For the cell at 298 K $Ag_{(s)} | AgCl_{(s)} | KCl_{(aq)} | AgNO_{3(aq)} | Ag_{(s)}$ Which of the following is wrong

a) The EMF of the cell is zero when $[Ag^+]_{anodic} = (Ag^+)_{cathodic}$

b) The amount of $AgCl_{(s)}$ ppt. in anodic compartment will decrease with the working of the cell

c) The concentration of $[Ag^+]$ is constant in anodic compartment with the working of cell

d) $E_{cell} = E^0_{Ag^+/Ag} - E^0_{Cl^-/AgCl/Ag^+} + \frac{0.059}{1} \log \frac{1}{[Cl^{-1}]}$ anodic

17. The cell emf depends on

a) Temperature b) Size of cell c) Cathode electrolyte d) Anode electrolyte

18. Which of the following statements is/are correct ?

a) ΔG° depends on cell reaction

b) E°_{cell} depends upon making up of the cell

c) Both ΔG° and E° are path functions

d) E° is path function but ΔG° is a state function.

19. Which is/are concentration cells?

a) $Pt : H_2/HCl \,//\, HCl/H_2 : pt$

b) $Pt : H_2 / \underset{(P^{II}=4)}{HCl} \,//\, \underset{P^{II}=2}{HCl} / H_2 : Pt$

c) $Ag / \underset{(1M)}{AgCl} // \underset{1M}{AgBr} / Ag$

d) $Ag / \underset{(s)}{AgCl, KCl} \,//\, \underset{1M}{AgNO_3} / Ag$

Linked Comprehension Type Questions

Passage-I :

The E^0 values for the changes given below are measured against NHE at 27°C
$Cu^{2+} + e \rightarrow Cu^+$, $E^0 = +0.15$ V; $Cu^+ + e \rightarrow Cu$, $E^0 = +0.50$V; $Zn^{2+} + 2e \rightarrow Zn$, $E^0 = -0.76$V.
The temperature coefficient of emf a cell designed as $Zn|Zn^{2+}||Cu^{2+}|Cu$ is -1.4×10^{-4}v per degree. For a cell reaction in equilibrium $\Delta G = 0$ and $\Delta G^\circ = -2.303 RT \log K_c$. The heat of reaction and entropy change during the reaction are related by $\Delta G = \Delta H - T\Delta S$.

20. The E° for the reaction $2Cu^+ \rightarrow Cu^{2+} + Cu$ is

a) +0.35 V b) –0.35 V c) +0.65 V d) –0.65 V

21. The decrease in free energy during the cell reaction in $Zn | Zn^{2+}(1M) \| Cu^{2+}(1M) | Cu$, when its changes to 1M (Zn^{+2}) and 0.1M (Cu^{+2}) is

a) 2.037×10^5 J b) 2.116×10^5 J c) 2.037×10^6 J d) 2.116×10^6 J

22. The equilibrium constant for the reaction : $Zn + Cu^{2+} \rightleftharpoons Zn^{2+} + Cu$ is

a) 6.0×10^{36} b) 1.94×10^{37} c) 1.47×10^{38} d) 7.0×10^{30}

Passage-II :

The driving force ΔG diminishes to zero on the way to equilibrium, just as in any other spontaneous process. Both ΔG and the corresponding cell potential $(E = -\Delta G / nF)$ are zero when the redox reaction comes to equilibrium. The Nernst equation for the redox process of the cell may be given as : $E = E^o - (0.059/n)\log Q$. $E^0 = (-\Delta G^0 / nF)$; $E^0 = (-0.059/n)\log K$

23. On the basis of information available for the reaction : $\frac{4}{3}Al + O_2 \rightarrow \frac{2}{3}Al_2O_3; \Delta G = -827$ kJ/mol of O_2, the minimum emf required to carry out an electrolysis of Al_2O_3 is :

a) 2.14 V b) 4.28 V c) 6.42 V d) 8.56 V

24. If E^0 for the electro chemical cell, $Zn(s)\left|Zn^{2+}(1M)aq.\right\|Cu^{2+}(1M)aq.\left|Cu(s)\right.$ is 1.1V. The $\left[\frac{[Cu^{+2}]}{[Zn^{+2}]}\right]_{eq}$ for the cell reaction: $Zn(s)+Cu^{2+}(aq.) \rightleftharpoons Cu(s)+Zn^{2+}(aq.)$ will be :

a) 10^{37} b) 10^{-37} c) 10^{-39} d) 10^{39}

Matrix Matching Type Questions

25. The standard reduction potential data at 25°C is given below:
$E^0(Fe^{3+}, Fe^{2+}) = +0.77V$; $E^0(Fe^{2+}, Fe) = -0.44V$; $E^0(Cu^{2+}, Cu) = +0.34V$; $E^0(Cu^{+}, Cu) = +0.52V$;
$E^0(O_2(g) + 4H^+ + 4e^- \rightarrow 2H_2O) = +1.23V$; $E^0(O_2(g) + 2H_2O + 4e^- \rightarrow 4OH^-) = +0.40V$;
$E^0(Cr^{3+}, Cr) = -0.74V$; $E^0(Cr^{2+}, Cr) = -0.91V$;
Match E^0 of the redox pair in Column-I with the values given in List-II and select the correct answer using the code given below the lists.

Column-I	Column-II
A) $E^0(Fe^{2+}, Fe)$	p) –0.18V
B) E^0 ($4H_2O \rightleftharpoons 4H^+ + 4OH^-$)	q) –0.4V
C) E^0 ($Cu^{2+} + Cu \rightarrow 2Cu^+$)	r) –0.04V
D) E^0 (Cr^{3+}, Cr^{2+})	s) –0.83V

Integer Type Questions

26. $I_2(s)\left|I^-(0.1M)\right.$ half cell is connected to a $H^+(aq)\left|H_2(1bar)\right|Pt$ half cell and e.m.f. is found to be 0.7714 V. If $E^o_{I_2|I} = 0.535$ V, find the pH of $H^+\left|H_2\right.$ half-cell.

27. The E^0 at 25°C for the following reaction is 0.22 V $H_{2(g)} + 2AgCl_{(s)} \rightarrow 2Ag_{(s)} + 2HCl_{(aq)}$ .If the equilibrium constant at 25°C is 2.8×10^x ; x is

28. Given the following standard electrode potential, $PbBr_2(s) + 2e^- \rightarrow Pb(s) + 2Br^-(aq)$; $E^o = -0.248$ V
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$; $E^o = -0.126$ V . If the K_{sp} for $PbBr_2$ is 7.4×10^{-x} ; x is

29. If the equilibrium constant (K_c) for the reaction, $Zn^{2+}{}_{(aq)} + 4OH^-{}_{(aq)} \rightleftharpoons Zn(OH)^{2-}_{4\,(aq)}$ is 10^{10x} ; then x is ($Zn^{2+}{}_{(aq)} + 2e^- \rightarrow Zn_{(s)}$; $E^o = -0.76$ V , $Zn(OH)^{2-}_{4\,(aq)} + 2e^- \rightarrow Zn_{(s)} + 4OH^-{}_{(aq)}$; $E^o = -1.36$V)

30. Consider $H_2(g)$, $Pt/H^+_{(aq)}$; E = 0.1V; the pH of the solution is :

EXERCISE-IV

(Electro Chemical Series & Batteries)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. The metal that cannot displace hydrogen from dilute hydrochloric acid is
1) aluminium 2) iron 3) copper 4) zinc

2. A standard hydrogen electrode has zero electrode potential because
1) Hydrogen is easiest to oxidise
2) This electrode potential is assumed to be zero
3) Hydrogen atom has only one electron
4) Hydrogen is the lightest element

3. The correct statement among the following, about electrochemical series (S.R.P. increasing order) is
   1) the metals occupying top positions in the series do not liberate hydrogen with dilute acids
   2) the substances which are stronger reducing agents and stronger oxidising agents are placed below & top respectively
   3) a metal higher in the series will displace the metal from its solution which is lower in the series
   4) various electrodes are arranged in a series in the descending order of their potentials

4. The following are some statements about normal hydrogen electrode
   1) when a 'Zn' electrode is in combination of NHE, Zn electrode acts as cathode
   2) when a 'Cu' electrode is in combination with NHE, Cu electrode is the anode
   3) when a 'Ag' electrode is in combination with NHE, Ag electrode is the anode
   4) all are incorrect

5. Which defines the standard reduction electrode potential of Zn^{2+} ions?
   1) $Zn^{2+}_{(1M)} + 2e \rightarrow Zn_{(s)}$ 2) $Zn_{(g)} \rightarrow Zn^{2+}_{(1M)} + 2e$ 3) $Zn^{2+}_{(1M)} \rightarrow Zn_{(s)} + 2e$ 4) $Zn^{2+}_{(g,1M)} \rightarrow Zn_{(s)} - 2e$

6. **(A) :** Lithium has less electrode potential than cesium
   (R) : Hydration energy of lithium ion is high.
   1) Both (A) and (R) are true and (R) is the correct explanation of (A)
   2) Both (A) and (R) are true and (R) is not the correct explanation of (A)
   3) (A) is true but (R) is false
   4) (A) is false but (R) is true

7. The reference electrode is made by using
   1) $ZnCl_2$ 2) $CuSO_4$ 3) $HgCl_2$ 4) Hg_2Cl_2

8. The more electro positive element has
   1) positive reduction potential
   2) negative reduction potential
   3) tendency to gain electrons
   4) negative oxidation potential

9. Stronger the oxidising agent greater is the
   1) Oxidation potential 2) Reduction potential 3) Redox potential 4) Hydration potential

10. Standard reduction electrode potential of three metals A, B and C are respectively +0.05 V, –3.0 and –1.2 V. The reducing powers of
   1) B > C > A 2) A > B > C 3) C > B > A 4) A > C > B

11. Zn gives H_2 gas with H_2SO_4 and HCI but not with HNO_3 because
   1) Zn acts as OA when reacts with HNO_3
   2) HNO_3 is weaker acid than H_2SO_4 and HCI
   3) In electrochemical series Zn is above H_2
   4) NO_3^- is reduced in preference to H_3O^+

12. When Zn piece is kept in $CuSO_4$ solution, copper gets precipitated because : (Z = Atomic number)
   1) SRP = Zn > Cu 2) SRP = Zn < Cu 3) Z = Zn > Cu 4) Z = Zn < Cu

13. For $I_2 + 2e \rightarrow 2I^-$, standard reduction potential = +0.54 volt. For $2Br^- \rightarrow Br_2 + 2e^-$, standard oxidation potential = –1.09 volt. For $Fe \rightarrow Fe^{2+} + 2e^-$, standard oxidation potential = +0.44 volt. Which of the following reactions is non-spontaneous?
   1) $Br_2 + 2I^- \rightarrow 2Br^- + I_2$ 2) $Fe + Br_2 \rightarrow Fe^{2+} + 2Br^-$ 3) $Fe + I_2 \rightarrow Fe^{2+} + 2I^-$ 4) $I_2 + 2Br^- \rightarrow 2I^- + Br_2$

14. Be is placed above magnesium in the II group. When Be dust is added to $MgCl_2$ solution, it
   1) Has no effect
   2) Precipitates Mg metal
   3) Precipitates MgO
   4) Leads to dissolution of Be metal

15. When an electric cell is charged, then
1) voltage of cell increases 2) electrolyte of cell dilutes
3) resistance of cell increases 4) None of these

16. When lead storage battery is discharged
1) SO_2 is evolved 2) $PbSO_4$ is consumed 3) lead is formed 4) H_2SO_4 is consumed

17. When lead storage battery is charged
1) PbO_2 dissolves 2) Pb rod coated by $PbSO_4$
3) H_2SO_4 is regenerated 4) The amount of acid decreases

18. During the charging of lead storage battery, the reaction occuring at cathode is represented by
1) $Pb \rightarrow Pb^{2+} + 2e^-$ 2) $Pb^{2+} + 2e^- \rightarrow Pb$
3) $Pb^{2+} + SO_4^{2-} \rightarrow PbSO_4$ 4) $PbSO_4 + 2H_2O \rightarrow PbO_2 + 4H^+ + SO_4^{2-} + 2e^-$

19. With respect to fuel cell prepared from H_2 and O_2 gases, the false statement is
1) It is free from pollution
2) This is more efficient than conventional method of generating electricity
3) The reaction occuring at anode is $O_{2(g)} + 2H_2O + 4e^- \rightarrow 4OH^-$
4) These take little time to go into operation.

20. Corrosion is basically a/an
1) altered reaction in presence of H_2O 2) electrochemical phenomenon
3) interaction
4) union between two light metals and a heavy metal

21. In which of the following will the corrosion of iron be most rapid ?
1) In pure water 2) In pure oxygen 3) In air and moisture 4) In air and saline water

22. Which of the following metals acts as a sacrificial anode for iron articles ?
1) Cu 2) Zn 3) Ag 4) Sn

23. The composition of rust is
1) $Fe_2O_3 . xH_2O$ 2) $Fe_2O_3 . 2H_2O$ 3) $Fe_2O_3.6H_2O$ 4) Fe_2O_3

24. Zinc is used to protect corrosion of iron because
1) $E_{ox} = Zn < E_{ox}$ of Fe 2) $E_{red} = Zn < E_{red}$ of Fe 3) cost = Zn < Fe 4) Zn is most abundant

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. The blue colour of aq. $CuSO_4$ solution, dissappears, when 'x' is added, then x = ?
a) Ag b) Mg c) Au d) Hg

2. An aqueous solution containing one mole per litre of each dil H_2SO_4, $AgNO_3$, $Hg(NO_3)_2$, $Au(NO_3)_3$ is being electrolysed using inert electrodes, then the sequence of deposition of elements at cathode will be
a) Ag > Hg > H_2 > Au b) H_2 > Au > Hg > Ag c) Au > Ag > Hg > H_2 d) H_2 > Hg > Ag > Au

3. Given $E^0_{Ag^+/Ag} = 0.80\,V$. $E^0_{Mg^{2+}/Mg} = -2.37\,V$, $E^0_{Cu^{2+}/Cu} = 0.34\,V$ $E^0_{Hg^{2+}/Hg} = 0.79\,V$.
Which of the following statements is/are correct ?
a) $AgNO_3$ can be stored in copper vessel b) $Cu(NO_3)_2$ can be stored in magnesium vessel
c) $CuCl_2$ can be stored in silver vessel d) $HgCl_2$ can be stored in copper vessel

4. The half cell reactions for the corrosion are, $2H^+ + \frac{1}{2}O_2 + 2e^- \rightarrow H_2O; E^0 = 1.23V$ and $Fe^{2+} + 2e^- \rightarrow Fe(s); E^0 = -0.44\,V$. Find the ΔG^0 (in kJ) for the overall reaction

a) –76 K b) –322 kJ c) –161 kJ d) –152 kJ

5. The E^0 at 25^0C for the following reaction at the indicated concentrations is 1.50 V. Calculate the ΔG in kJ at 25^0C; $Cr(s) + 3Ag^+(aq, 0.1M) \rightarrow Ag(s) + Cr^{3+}(aq, 0.1M)$

a) –140.94 b) –295 c) –212 d) –422.83 kJ

6. A fuel cell develops an electrical potential from the combustion of butane at 1 bar and 298 K $C_4H_{10(g)} + 6.5O_{2(g)} \rightarrow 4CO_{2(g)} + 5H_2O_{(l)}$; $\Delta G^0 = -2746 kJ/mol$

a) 4.74 V b) 0.547 V c) 4.37 V d) 1.07 V

7. For a cell reaction $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(\ell)}$ $\Delta S^0_{298} = -0.32\,kJ/K$. What is the value $\Delta_f H^0_{298}(H_2O, \ell)$? Given : $O_{2(g)} + 4H^+_{(aq)} + 4e^- \rightarrow 2H_2O_{(\ell)}$; $E^0 = 1.23V$

a) –285.07 kJ/mol b) –570.14 kJ/mol c) 285.07 kJ/mol d) None of these

More than One correct answer Type Questions

8. Based on the data given below, the correct order of reduction power is : $Fe^{3+}_{(aq)} + e \rightarrow Fe^{2+}_{(aq)}$, $E^0 = +0.77V$; $Al^{3+}_{(aq)} + 3e \rightarrow Al_{(s)}$, $E^0 = -1.66V$; $Br_{2(aq)} + 2e \rightarrow 2Br^-_{(aq)}$; $E^0 = 1.08V$

a) $Br^- < Fe^{2+}$ b) $Fe^{2+} < Al$ c) $Al < Br^- < Fe^{2+}$ d) $Al < Fe^{2+} < Br^-$

9. If the half cell reaction $A + e^- \rightarrow A^-$ has a larger negative potential, it follows that :

a) A is not readily reduced b) A is readily oxidised

c) A^- is readily reduced d) A^- is readily oxidised

10. Which of the following facts are true?

a) If $E^0(M^{n+}/M)$ is negative, H^+ will be reduced to H_2 by the metal M.

b) If $E^0(M^{n+}/M)$ is positive, M^{n+} will be reduced to M by H_2

c) In a cell, M^{n+}/M assembly is attached to hydrogen - half cell. To produce spontaneous cell reaction, metal M will act as negative electrode if the potential M^{n+}/M is negative. It will serve as positive electrode, if M^{n+}/M has a positive cell potential.

d) Compounds of active metals (Zn, Na, Mg) are reducible by H_2 where as those of noble metals (Cu, Ag, Au) are not reducible.

11. Which of the following is/are correct ?

a) If the solutions pressure which is in contact with a metal rod is greater than osmotic pressure then such metal half cell behaves as anode.

b) Generally the solutions pressure tends to drive the ions into the solution.

c) If the solutions pressure which is in contact with a metal rod is lesser than the osmotic pressure the solution tries to acquire -ve charge with respect to the metal (or) such half cell behaves as cathode.

d) Solution's pressure has no contribution in deciding the nature of the electrode.

12. Identify the true ones

a) Daniel cell is a reversible cell b) Lead storage battery is a reversible cell

c) $Zn/H_2SO_4/Ag$ cell is reversible

d) Any reversible cell will receive current flow from the external source when connected if its emf is less than that of the source.

13. When a lead storage battery is discharged:

a) Weight of both electrodes decreases
b) $PbSO_4$ formed at both electrodes
c) H_2SO_4 consumed
d) H_2O is formed

14. In a lead storage battery,

a) increase the emf with increase in the % H_2SO_4
b) the emf decreases with increase in the % H_2SO_4
c) equivalent weight of H_2SO_4 is 98
d) equivalent weight of H_2SO_4 = 49

Linked Comprehension Type Questions

Passage-I :

Redox reactions play a pivotal role in chemistry and biology. The values of standard redox potential (E°) of two half-cell reactions decided which way the reaction is expected to proceed. A simple example is a Daniel cell in which zinc goes into solution and copper gets deposited. Given below are a set of half-cell reactions (acidic medium) along with their E^0 values (with respect to normal hydrogen electrode) Using this data : $I_2 + 2e^- \rightarrow 2I^-$, $E^0 = 0.54$; $Cl_2 + 2e^- \rightarrow 2Cl^-$, $E = 1.36V$; $Mn^{3+} + e^- \rightarrow Mn^{2+}$, $E^0 = 1.50$; $Fe^{3+} + e^- \rightarrow Fe^{2+}$, $E = 0.77V$; $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$, $E^\circ = 1.23$.

15. Among the following, identify the correct statement :

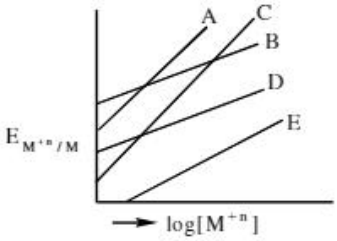
a) Chloride ion is oxidised by O_2
b) Fe^{2+} is oxidised by iodine
c) Iodide ion is oxidised by chlorine
d) Mn^{2+} is oxidised by chlorine

16. While Fe^{3+} is stable, Mn^{3+} is not stable in acid solution because :

a) O_2 oxidises Mn^{2+} to Mn^{3+}
b) O_2 oxidises both Mn^{2+} to Mn^{3+} and Fe^{2+} to Fe^{3+}
c) Fe^{3+} oxidises H_2O to O_2
d) Mn^{3+} oxidises H_2O to O_2

Passage-II :

Four metal electrodes show the variation in their reduction potential as shown.



17. Which is the most reactive metal ?

a) A
b) B
c) E
d) D

18. Which statement is true ?

a) B can reduce A^{+n} (1 M)
b) E cannot replace H^+ from acids
c) 'A-D' cell has maximum E^0 among the given
d) 'C' can reduce the ions of A, B and D

19. Which metal requires maximum voltage for deposition of one mole through electrolysis process?

a) A
b) B
c) C
d) D

Passage-III :

Hydrogen-oxygen fuel cell may have an acidic or alkaline electrolyte. The half-cell reactions are

$\frac{1}{2}O_2(g)+2H^+ +2e^- = H_2O(\ell)$ $\quad E^\circ = 1.22\ 88\ V$

$2H^+ + 2e^- = H_2(g)$ $\quad E^\circ = 0$

$H_2(g)+\frac{1}{2}O_2(g) = H_2O(\ell)$ $\quad E^\circ = 1.2288V$ *(or)*

$\frac{1}{2}O_2(g)+H_2O(\ell)+2e^- = 2OH^-$ $\quad E^\circ = 0.4009\ V$

$2H_2O(\ell)+2e^- = H_2(g)+2OH^-$ $\quad E^\circ = -0.8279\ V$

$H_2(g)+\frac{1}{2}O_2(g) = H_2O(\ell)$ $\quad E^\circ = 1.2288\ V$

20. If 560 mL of H_2 gas at STP is fed into and is consumed by the fuel cell in 10 minutes, then what is the current output of the fuel cell?

a) 4A b) 8A c) 16A d) 12A

21. For a Hydrogen-Oxygen fuel cell if $\Delta H_f^0 (H_2O, \ell) = -285$ kJ/mole, then what will be its thermodynamic efficiency under standard conditions

a) 0.91 b) 0.41 c) 0.63 d) 0.83

22. How much H_2O is produced in the cell if 2 Faradays of charge is derived from the fuel cells?

a) 18 g b) 36 g c) 42 g d) 9 g

Matrix Matching Type Questions

23.

Column-I	Column-II
A) Non spontaneous reaction is made to occur	p) Secondary voltaic cell
B) Spontaneous redox reaction occurs	q) Conductivity cell
C) No chemical reaction occurs	r) Dry cell
D) Reaction can be reversed	s) Nelson cell

24.

Column-I	Column-II
A) Primary cell	p) Lead storage cell
B) Secondary cell	q) Daniel cell
C) Calomel electrode	r) Secondary reference cell
D) Hydrogen electrode	s) Primary reference cell

KEY SHEET (LECTURE SHEET)

EXERCISE-I

LEVEL-I

1) **4**	2) **3**	3) **3**	4) **4**	5) **1**	6) **3**	7) **4**	8) **4**
9) **3**	10) **2**	11) **2**	12) **1**	13) **2**	14) **1**	15) **2**	16) **3**
17) **3**	18) **2**	19) **3**	20) **4**	21) **4**	22) **3**	23) **3.54**	24) **11.2**
25) **965**	26) **10**	27) **65**	28) **4.5**	29) **965**			

LEVEL-II

1) **d** 2) **d** 3) **c** 4) **d** 5) **a** 6) **abcd** 7) **ac** 8) **bc**
9) **ad** 10) **ac** 11) **bc** 12) **bc** 13) **d** 14) **b** 15) **b** 16) **d**
17) **a** 18) **d** 19) **A-pq; B-pq; C-rq; D-ps**
20) **A-r; B-s; C-p; D-q** 21) **2** 22) **4** 23) **6** 24) **8** 25) **2**
26) **1** 27) **3** 28) **1**

EXERCISE-II

LEVEL-I

1) **1** 2) **3** 3) **4** 4) **2** 5) **1** 6) **4** 7) **2** 8) **4**
9) **1** 10) **1** 11) **3** 12) **4** 13) **4** 14) **4** 15) **3** 16) **3**
17) **4** 18) **4** 19) **0.5** 20) **220** 21) **128** 22) **130** 23) **18.78**
24) **0.2** 25) **391** 26) **1.1** 27) **1**

LEVEL-II

1) **c** 2) **c** 3) **b** 4) **a** 5) **b** 6) **ad** 7) **c** 8) **a**
9) **a** 10) **b** 11) **a** 12) **c** 13) **b** 14) **b**
15) **A-p; B-q; C-s; D-r** 16) **A-qs; B-pr; C-qs; D-pr** 17) **6** 18) **2**
19) **1** 20) **8** 21) **9** 22) **5**

EXERCISE-III

LEVEL-I

1) **3** 2) **2** 3) **3** 4) **3** 5) **1** 6) **4** 7) **3** 8) **4**
9) **1** 10) **3** 11) **1** 12) **1** 13) **3** 14) **4** 15) **3** 16) **4**
17) **4** 18) **3** 19) **1** 20) **1** 21) **2** 22) **0.28** 23) **0.01** 24) **0.35**
25) **0.91** 26) **0.80** 27) **1.79** 28) **0.52**

LEVEL-II

1) **c** 2) **c** 3) **a** 4) **a** 5) **b** 6) **c** 7) **d** 8) **d**
9) **a** 10) **abc** 11) **ab** 12) **ad** 13) **bc** 14) **abc** 15) **acd** 16) **bcd**
17) **acd** 18) **abd** 19) **abcd** 20) **a** 21) **a** 22) **a** 23) **a** 24) **b**
25) **A-r; B-s; C-p; D-q** 26) **3** 27) **7** 28) **5** 29) **2** 30) **2**

EXERCISE-IV

LEVEL-I

1) **3** 2) **2** 3) **3** 4) **4** 5) **1** 6) **1** 7) **4** 8) **2**
9) **2** 10) **1** 11) **4** 12) **2** 13) **4** 14) **1** 15) **1** 16) **4**
17) **3** 18) **4** 19) **3** 20) **2** 21) **4** 22) **2** 23) **1** 24) **2**

LEVEL-II

1) **b** 2) **c** 3) **c** 4) **b** 5) **d** 6) **d** 7) **a** 8) **ab**
9) **ad** 10) **abc** 11) **abc** 12) **abd** 13) **acbd** 14) **ac** 15) **c** 16) **d**
17) **c** 18) **d** 19) **c** 20) **b** 21) **d** 22) **a**
23) **A-ps; B-pr; C-q; D-p** 24) **A-q; B-p; C-r; D-s**

PRACTICE SHEET

EXERCISE-I

(Electrolytic conductors, Electrolysis and Faraday Laws)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. Which of the following is a conductor of electricity
   1) diamond 2) graphite 3) carborundum 4) silica

2. In which of the following, HCl conducts electricity to a large extent?
   1) liquid HCl 2) HCl aq. solution 3) HCl solution in C_6H_6 4) gaseous HCl

3. What happens at infinite dilution in a given solution?
   1) $\alpha = 1$ for weak electrolytes 2) The electrolyte is 100% ionised
   3) All inter ionic attractions disappear 4) All the three

4. The following are some statements about electrolytic cell, the correct one is :
   1) in this cell, chemical energy is converted into electrical energy
   2) in this cell, electrons flow from cathode to anode
   3) in this cell, reduction takes place at cathode
   4) in this cell, cathode is a +ve electrode

5. When an aqueous solution of copper sulphate is electrolysed using copper electrodes the reaction at the anode is represented by
   1) $H^+ + e^- \rightarrow H$ 2) $Cu^{2+} + 2e^- \rightarrow Cu$ 3) $SO_4^{2-} \rightarrow SO_4 + 2e^-$ 4) $Cu(s) \rightarrow Cu^{2+} + 2e^-$

6. Aqueous solution of $CuSO_4$ is electrolysed using inert electrodes till the blue coloured solution becomes colourless. The colourless solution formed is
   1) $Cu(OH)_2$ 2) H_2SO_4 3) $CuSO_4$ 4) H_2O

7. At anode in the electrolysis of fused sodium chloride
   1) Na^+ is oxidised 2) Cl^- is oxidised 3) Cl is reduced 4) Na is reduced

8. In electrolysis of NaCl when Pt electode is taken then H_2 is liberated at cathode while with Hg cathode, it forms sodium amalgam. This is because
   1) Hg is more inert than Pt
   2) More voltage is required to reduce H^+ at Hg than at Pt
   3) Na is dissolved in Hg while it does not dissolve in Pt
   4) Conc. of H^+ ions is larger when Pt electrode is taken

9. During electrolysis of fused NaOH, which is liberated?
   1) H_2 (cathode) 2) O_2 (cathode) 3) H_2 (anode) 4) O_2 (anode)

10. Which of the following reaction is possible at anode ?
    1) $2Cr^{3+} + 7H_2O \rightarrow Cr_2O_7^{2-} + 14H^+$ 2) $F_2 \rightarrow 2F^-$
    3) $\frac{1}{2}O_2 + 2H^+ \rightarrow H_2O$ 4) None of these

11. In the electrolytic cell, flow of electrons is from
1) cathode to anode in the solution 2) cathode to anode through external circuit
3) anode to cathode through external circuit 4) all of these

12. In electrolysis of dilute H_2SO_4, what is liberated at anode in the presence of inert electrode ?
1) H_2 2) SO_2 3) SO_3 4) O_2

13. Find correct match.
1) Electronic conductor = Aqueous urea sol. 2) Non-electrolyte = Solid sodium
3) Electrolytic solution = Cond. raises with temp. 4) Arrhenius = Radioactivity

14. After the electrolysis of aqueous solution of NaCl using Pt electrodes, the pH of the solution
1) increases 2) decreases 3) remains constant 4) becomes zero

15. Which one of the following materials conducts electricity?
1) molten sulphur 2) barium sulphate 3) crystalline NaCl 4) fused KCl

16. As electrolysis is in progress, if the cathode plate is removed
1) the movement of ions stops 2) the ions move at random
3) all ions move towards anode 4) only anions move towards the anode

17. The metal that cannot be obtained by electrolysis of the aqueous solution of its salts is:
1) Ag 2) Cr 3) Cu 4) Al

18. In an electrolytic cell of $Ag|AgNO_3|Ag$, when current is passed the concentration of $AgNO_3$?
1) increases 2) decreases 3) remains same 4) none of these

19. At infinite dilution, the degree of dissociation of weak electrolyte in aqueous solution is
1) 1 2) 0.5 3) 0.99 4) 0

20. When the same charge is passed through the solutions of different electrolytes in a series, the amounts of elements deposited on the electrodes are in the ratio of their
1) atomic numbers 2) atomic weights 3) specific gravities 4) equivalent weights

21. One Faraday of electricity will liberate 1 gram atom of the metal from the solution of
1) $CuCl_2$ 2) $CuSO_4$ 3) $AgNO_3$ 4) $AuCl_3$

22. The amount of an ion discharged during electrolysis is not dependent of
1) resistance of sol. 2) time 3) current strength 4) equivalent weight

23. Faraday's laws hold good at
1) all pressures 2) only at 298K 3) in different solvents 4) all of these

24. The electrochemical equivalent of a metal is 'y' g. coulomb^{-1}. The equivalent weight of metal is
1) y 2) y × 96500 3) y/96500 4) $1.6 \times 10^{-19} \times y$

Numerical Value Type Questions

25. Weight of copper (atomic mass 63.5) deposited when 1 Faradays of electricity is passed through cuprous salt solution is

26. The number of coulombs required to deposit 5.4 g. of Aluminium when the given electrode reaction is represented as $Al^{3+} + 3e^- \longrightarrow Al$ is _____ $\times 10^5$.

27. The no. of Faradays of electricity required to get 13.5g Al from molten $AlCl_3$, is ___

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. One Faraday charge was passed through the electrolytic cell placed in series containing solutions of Ag^+, Ni^{2+} and Cr^{3+}. Then Ag, Ni and Cr deposited will be, in order (Atomic masses ; Ag = 108, Ni = 59 and Cr = 52)
   a) 108g, 29.5g, 17.3g b) 108g, 59g, 52 g c) 108g, 108g, 108g d) 108g, 116g, 156g

2. Time required to deposit one millimole of aluminium metal by the passage of 9.65 amperes through aqueous solution of aluminium ions is
   a) 30 s b) 10 s c) 30,000 s d) 10,000 s

3. When an electric current is passed through acidulated water, 112 ml of hydrogen gas at NTP is collected at the cathode in 965 seconds. The current passed in amperes is
   a) 1.0 b) 0.5 c) 0.1 d) 2.0

4. The amount of chlorine evolved when 2 amperes of current is passed for 30 minutes in an aqueous solution of NaCl
   a) 66 g b) 1.32 g c) 33 g d) 99 g

5. Calculate the current (in ma) required to deposit 0.195 gm of platinum metal in 5.0 hours from aqueous solution of $PtCl_6^{-2}$ (Atomic weight of Pt = 195)
   a) 310 b) 31 c) 21.44 d) 5.36

More than One correct answer Type Questions

6. Which pair of electrolytes give different products at anode
   a) 1M $CuSO_4$ solution 1M $CuCl_2$ solution b) 1M KCl solution 1M $Cu(NO_3)_2$ solution
   c) 1M $AgNO_3$ solution 1M $CuSO_4$ solution d) 1M $CuBr_2$ solution 1M $CuSO_4$ solution

7. Electrolysis of dilute aqueous solution of KCl gives?
   a) O_2 at anode b) Cl_2 at anode c) K at cathode d) H_2 at cathode

8. Oxygen and hydrogen gases are produced at the anode and cathode during the electrolysis of fairly concentrate aqueous solution of :
   a) K_2SO_4 b) $AgNO_3$ c) H_2SO_4 d) NaOH

9. Select right statement(s) about electrolysis :
   a) depositing order $= Au^{+3} > Ag^+ > Hg^{+2} > Cu^{+2}$
   b) depositing order $= I^- > Br^- > Cl^- > OH^- > F^-$
   c) depositing order $= Na^+ > Al^{+3} > H^+$
   d) depositing order $= OH^- > NO_3^- > SO_4^{-2} > F^-$

10. Which of the following gives the charge of an electron ? ($N_A \rightarrow$ avagadro numbers)
    a) $\frac{1F}{1N_A}$ b) 1F c) $1F \times 1N_A$ d) $\frac{96500C}{1N_A}$

Linked Comprehension Type Questions

Passage-I :

A current of 15 ampere is used to plate Ni from $NiSO_4$ bath. Both H_2 and Ni are formed at cathode. The current efficiency of Ni formation is 60%. (atomic mass of Ni = 58.71)

11. The thickness of plating of the cathode which consists of a sheet of $4cm^2$ when it is coated on both sides for 1 hr (The density of Ni is 8.9 g mL^{-1})
a) 0.276 cm b) 0.272 cm c) 0.316 cm d) 0.138 cm

12. The volume of H_2 is formed per hr at STP:
a) 6.62 litre b) 6.26 litre c) 2.51 litre d) 5.02 litre

13. The volume of O_2 is formed per hr at STP:
a) 6.26 litre b) 3.13 litre c) 9.39 litre d) 2.51 litre

Passage-II :

A 4.0 molar aqueous solution of NaCl is prepared and 500 mL of this solution is electrolysed. This leads to the evolution of chlorine gas at one of the electrodes (atomic mass : Na = 23, Hg = 200; 1 Faraday = 96500 coulombs)

14. The total number of moles of chlorine gas evolved is:
a) 0.5 b) 1.0 c) 2.0 d) 3.0

15. If the cathode is a Hg electrode, the maximum mass (g) of amalgam formed from this solution is:
a) 200 b) 225 c) 400 d) 446

16. The total charge (coulomb) required for complete electrolysis is:
a) 24125 b) 48250 c) 96500 d) 193000

Matrix Matching Type Questions

17.

Column-I (Electrolysis of)	Column-II (Electrode products)
A) $AgNO_3$ between 'Pt' electrodes	p) H_2
B) $CuSO_4$ between 'Cu' electrodes	q) Peroxide
C) H_2SO_4 (50%) between 'Pt' electrodes	r) Electronegative gas
D) Aq. NaCl with 'Hg' electrodes	s) Dissolved metal ions

18.

Column-I (Conversion w.r.t. reactant)	Column-II (Faradays consumed/mole)
A) Nitrobenzne $\longrightarrow$ Aniline	p) 1
B) Glucose $\longrightarrow$ Gluconic acid	q) 4
C) $H_2O_2 \longrightarrow H_2O + 1/2\ O_2$	r) 2
D) HCHO $\longrightarrow$ CH_4	s) 6

Integer Type Questions

19. During electrolysis of one mole of aq HCOOK. How many moles of H_2 is formed overall?

20. During electrolysis of 1 litre of aq.$CuSO_4$, the P^H of the solution is changed from 5.0 to 4.3. Then the number of faradays consumed in the process is $(x \times 10^{-y})$, here, (x+y) =

21. 10^{-2}F can remove all Cl_2 from 100ml of a HCl solution. What is the P^H of the solution initially

22. How many faradays of charge is consumed during eletrolysis of acidified water producing 33.6 lt of gases at both electrodes.

23. 10 litres, 0.1M$AgNO_3$ is electrolysed with 2 F. '5.6*x*' litres O_2 is released at STP what is *x*?

24. How many faradays of charge is transfered during disproportionation of two moles of cuprous ion?

25. The element indium is to be obtained by electrolysis of a molten halide of the element. Passage of a current of 3.20 A for a period of 40.0 min results in formation of 3.05 g of In. What is the oxidation state of indium in the halide ? (At.wt of In = 114.81)

26. The quantity of charge (in Faraday) required to electrolyse 54g H_2O is

27. The charge required to deposites all Al from the electrolysis of 1 mol molten Al_2O_3.

EXERCISE-II

(Electrolytic Conductance)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. The minimum conductance in fused state is shown by
   1) $MgCl_2$ 2) $CaCl_2$ 3) $BaCl_2$ 4) $SrCl_2$

2. The $\wedge_m$ of HCl is greater than that of NaCl at a particular temperature because
   1) M.W = HCl > NaCl 2) Mobility of H^+ ions is more than that of Na^+ ions
   3) HCl is strongly acidic 4) Ionisation of HCl is larger than that of NaCl

3. The unit of specific conductivity is
   1) ohms cm^{-1} 2) ohms cm^{-2} 3) $ohms^{-1}$ cm 4) $ohms^{-1}$ cm^{-1}

4. The unit of equivalent conductivity is
   1) ohm cm 2) ohm^{-1} cm^2 $(g\ eq.)^{-1}$ 3) ohm cm^2 (g eq.) 4) S cm^{-2}

5. The equivalent conductance of 1N solution of an electrolyte is nearly
   1) Same as its specific conductance 2) 10^{-3} times its specific conductance
   3) 10^2 times more than its specific conductance 4) 10^3 times more than its specific conductance

6. **(A) :** The molar conductance of weak electrolytes is low as compared to that of strong electrolytes at moderate concentrations
   (R) : Weak electrolytes at moderate concentrations dissociate to a much greater extent when compared to strong electrolytes
   1) Both (A) and (R) are true and (R) is the correct explanation of (A)
   2) Both (A) and (R) are true and (R) is not the correct explanation of (A)
   3) (A) is true but (R) is false 4) (A) is false but (R) is true

7. The speed of ions during passage of current depends upon:
   1) nature of ion 2) potential gradient 3) dilution of solution 4) all of these

8. Which of the following is an additive property?
   1) Conductance 2) Viscosity 3) Surface tension 4) None of these

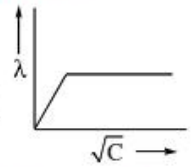
9. For which electrolyte, $\alpha = \lambda_v / \lambda_\infty$ does not hold good:
   1) CH_3COOH 2) HCOOH 3) CH_3NH_2 4) $HClO_4$

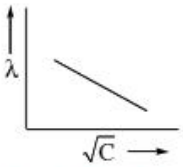
10. Which ion has exceptionally higher λ^∞ values :
    1) H^+ 2) K^+ 3) Co^{2+} 4) Ca^+

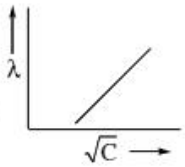
11. For which case λ values vs. $\sqrt{C}$ show a straight line?
    1) NaCl 2) HCOOH 3) CH_3NH_2 4) CH_3COOH

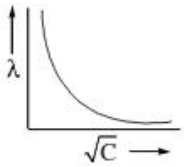
12. For which electrolyte the evaluation of λ_∞ is not possible by extrapolation of λ vs $\sqrt{C}$ curves to zero concentration?
    1) KCl 2) NH_4OH 3) NaCl 4) K_2SO_4

13. The variation of equivalent conductance of weak electrolyte with $\sqrt{\text{concentration}}$ is correctly shown in figure.

1) 

2) 

3) 

4) 

14. The best conductor of electricity in 1M solution of

1) CH_3COOH 2) HCl 3) H_3PO_4 4) boric acid

15. Which solution will show highest resistance during the passage of current?

1) 1N NaCl 2) 0.1 N NaCl 3) 2N NaCl 4) 0.05N NaCl

16. Mobility of H^+ (in aq. medium) is high because:

1) of the small size of H^+
2) of the high hydration energy of H^+
3) it exhibits a Grothus type of conduction
4) hydrogen is the lightest element

17. According to Kohlrausch law, the limiting value of molar conductivity of an electrolyte A_2B is

1) $\lambda^{\infty}_{A^+} + \lambda^{\infty}_{B^{2-}}$ 2) $(\lambda^{\infty}_{A^+}/2) + \lambda^{\infty}_{B^{2-}}$ 3) $2\lambda^{\infty}_{A^+} + (\lambda^{\infty}_{B^{2-}}/2)$ 4) $2\lambda^{\infty}_{A^+} + \lambda^{\infty}_{B^{2-}}$

18. The molar conductivities Λ^0_{KAc} and Λ^0_{HCl} at infinite dilution in water at 25^0C are 91.0 S cm^2/mol and 426.2 S cm^2/mol respectively. To caculate Λ^0_{HOAc} the additional value required is

1) Λ^0_{KCl} 2) $\Lambda^0_{H_2O}$ 3) Λ^0_{NaCl} 4) Λ^0_{NaOH}

Numerical Value Type Questions

19. Molar conductivity of a solution is $1.26 \times 10^2 \Omega^{-1}$ cm^2mol^{-1}. Its molarity is 0.01M. Its specific conductivity will be 1.26×10^x, x =

20. The values of equivalent conductivity at infinte dilutions for NH_4Cl, NaOH and NaCl are respectively 149.74, 248.1 and 126.4 ohm^{-1} cm^2 $equi^{-1}$. The value of λ^{∞}_{eq} of NH_4OH is

21. Specific conductance of 0.1 M Nitric acid is 6.3×10^{-2} ohm^{-1} $cm^{-1}mol^{-1}$. The molar conductance of the solution is

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. Equivalent conductivity of $BaCl_2$, H_2SO_4 and HCl, are x_1,x_2 and $x_3 scm^{-1}eq^{-1}$ at infinite dilution. If conductivity of saturated $BaSO_4$ solution is x Scm^{-1}, then Ksp of $BaSO_4$ is

a) $\frac{500x}{(x_1+x_2-2x_3)}$ b) $\frac{10^6 x^2}{(x_1+x_2-2x_3)^3}$ c) $\frac{2.5x10^5 x^2}{(x_1+x_2-x_3)^2}$ d) $\frac{0.25x^2}{(x_1+x_2-x_3)^2}$

2. The ionization constnat of a weak acid is 1.6×10^{-5} and the molar conductivity at infinite dilution is 380×10^{-4} sm^2mol^{-1}. If the cell constant is $0.01m^{-1}$, then conductance of 0.01M acid solution is

a) 1.52×10^{-5} s b) 1.52 s c) 1.52×10^{-3}s d) 1.52×10^{-4} s

3. Equivalent conductance of saturated $BaSO_4$ is 400 $Ohm^{-1}cm^2$ $equi^{-1}$ and specific conductance is 8×10^{-5} $ohm^{-1}cm^{-1}$. Hence K_{sp} of $BaSO_4$ is,

a) $4\times10^{-8}M^2$ b) $1\times10^{-8}M^2$ c) $2\times10^{-4}M^2$ d) $1\times10^{-4}M^2$

4. A big irregular shaped vessel (Volume = V) contained water, the conductivity of which was 2.56×10^{-5} S cm^{-1}. 500 g of NaCl was then added to the water and the conductivity after the addition of NaCl, was found to be 3.1×10^{-5} S cm^{-1}. ($\lambda^0_{NaCl} = 149.9$), V = ?

a) 2.373×10^6 L b) 4.133×10^5 L c) 2.373×10^5 L d) 4.133×10^6 L

5. The speed of migration of Ag^+ ion and NO_3^- ion are 0.00057 cm sec^{-1} and 0.00063 cm sec^{-1} at infinite dilution. The equivalent conductance of $AgNO_3$ at infinite dilution is

a) 140.2 b) 130.1 c) 120.8 d) 115.8

6. The ionic conductances of H^+ and OH^- at 298K are 349.8 and 198.5 mho cm^2 eq^{-1} respectively. The equivalent conductance of H_2O at infinite dilution is

a) 548.3 b) 151.3 c) 699.6 d) 54.83

More than One correct answer Type Questions

7. Identify the correct statements.

a) The conductance of $1cm^3$ of a conductor is called conductivity

b) $\wedge^0_m$ of a weak electrolyte can not be determined from the plot of λ_m against $\sqrt{C}$

c) Conductivity of an electrolyte increases with increase in concentration

d) Molar conductivity of an electrolyte increases with increase in concentration

8. The term infinite dilution refers to

a) $\alpha \to 1$ for weak electrolytes b) An electrolyte is 100% dissociated

c) All interionic effects disappears d) When $\wedge_{eq}$ of an electrolyte becomes constant

9. Which ions has exceptionally higher λ^∞ values?

a) H^+ b) K^+ c) OH^- d) NH_2^-

10.

Electrolyte	KCl	KNO_3	HCl	NaOAc	NaCl
λ^∞_m (S cm^2mol^{-1})	149.9	145.0	426.2	91.0	126.5

Which of the following is/are not correct?

a) $\Lambda^\infty_{HOAc} = 517.2$ b) $\Lambda^\infty_{HNO_3} = 450.0$ c) $\Lambda^\infty_{AcOH} = 309.7$ d) $\Lambda^\infty_{HNO_3} = 421.3$

11. Which modifications are necessary to determine resistance of solutions by usual method of conductance measurements?

a) A.C. should be used

b) A conductivity cell is used

c) Galvanometer is replaced by head phone or magic eye arrangement

d) None

12. Among the following, the intensive property is (properties are):

a) molar conductivity b) electromotive force c) resistance d) heat capacity

Linked Comprehension Type Questions

Passage-1 :

The partial dissociation appears to be a major factor in determining the properties of weak electrolytes and the degree of dissociation for weak electrolyte at dilution v is given by $\alpha = \frac{\Lambda_v}{\Lambda_\infty}$. ***The strong electrolytes on the otherhand do not obey this relation and the variation of molar conductivity for strong electrolytes is given by*** $\Lambda_v = \Lambda_\infty - bc^{1/2}$.

13. The slope of the graph $\frac{\Lambda_v^2}{\Lambda_\infty(\Lambda_\infty - \Lambda_v)}$ vs $\frac{1}{c}$, if Λ_v and Λ_∞ are molar conductivity of weak electrolyte having dissociation constant K_a at concentration c and zero respectively is:
a) concave downwards
b) concave upwards
c) straight line with intercept K_a
d) straight line with slope K_a

14. The numerical value of Λ^∞_{ion}:
a) is dependent of nature of ion
b) is called molar conductivity
c) is obtained by extrapolation of Λ_c vs $\sqrt{c}$ curves to zero concentration for all electrolytes
d) is equal to $\frac{\Lambda_v}{\alpha}$ for strong electrolytes

15. The van'ts Hoff factor for weak electrolyte A_xB_y, if (n = x + y) can be given as:
a) $i = 1 - \alpha + x\alpha + y\alpha$
b) $i = 1 + (x + y)$ at infinite dilution
c) $i = (n-1)\frac{\Lambda_v}{\Lambda_\infty} + 1$
d) either of these

16. The graph plotted for log (i – 1) vs. log Λ_v, where i is vant' Hoff factor for uni-univalent electrolyte and Λ_v is its molar conductivity at concentration c does not show the following characteristics :
a) straight line
b) slope equal to unity
c) intercept equal to log Λ_∞
d) intercept equal to – log Λ_∞

Passage-II :

The conductivity of water at 298K is 0.554 × 10⁻⁷ $\Omega^{-1} cm^{-1}$.

Answer the following, if $\Lambda^0_{(H^+)} = 349.8\Omega^{-1}cm^2mole^{-1}$ and $\Lambda^0_{(OH^-)} = 197.8\Omega^{-1}cm^2mole^{-1}$

17. The degree of dissociation of water is ____
a) 1.821×10^{-9}
b) 1.821×10^{-7}
c) 1.956×10^{-8}
d) 1.956×10^{-9}

18. The K_W of water is at that temperature is ____
a) 1.023×10^{-13}
b) 1.023×10^{-14}
c) 1.0038×10^{-14}
d) 1.0038×10^{-13}

19. The molar conductance of water is ___
a) $9.9 \times 10^{-8}\,\Omega^{-1}\,cm^2\,mole^{-1}$
b) $7.01 \times 10^{-7}\,\Omega^{-1}\,cm^2\,mole^{-1}$
c) $7.01 \times 10^{-8}\,\Omega^{-1}\,cm^2\,mole^{-1}$
d) $9.9 \times 10^{-7}\,\Omega^{-1}\,cm^2\,mole^{-1}$

Matrix Matching Type Questions

20.

Column-I (Property)	Column-II (Unit)
A) Conductance	p) Sm^{-1}
B) Conductivity	q) S^{-1}
C) Molar conductivity	r) $Sm^2\,mol^{-1}$
D) Ressistance	s) S

21.

Column-I (Substance)	Column-II (Molar conductance at 0.1M)
A) HCl	p) 40
B) NaOH	q) 120
C) NaCl	r) 240
D) HCN	s) 370

Integer Type Questions

22. The resistance of a conductivity cell containing 0.001M KC*l* solution at 298K is 1500 Ω. What is the cell constant (in mm^{-1}). If the conductivity of 0.001 M KC*l* solution is 2×10^{-3} S mm^{-1}.

23. The specific conductance of a saturated solution of AgCl at 25°C is 2.28×10^{-6} S cm^{-1}. If solubility of AgCl is 2.35×10^{-x} gL^{-1} ($\lambda^{o}_{AgCl} = 138.3$ S cm^2 mol^{-1}) then x is

24. For H^+, $\lambda^0 = 349.8$ S cm^2 mol^{-1}. Calculate the velocity of H^+ electrodes are 5 cm apart to which 1 volt of potential is applied. If the answer is 7.0×10^{-x} cm/s then x is ____

25. λ_{HCN} of 0.1M solution is 20S m^2 mol^{-1}, $\overset{0}{\lambda}_{HCN}$ is 200S m^2 mol^{-1}. The P^H of 0.1M HCN solution is

EXERCISE-III

(Galvanic cell & Nernst Equation)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. The difference of potential of two electrodes in a galvanic cell is known as
   1) EMF 2) Potential difference 3) Electrode difference 4) Ionic difference

2. The potential of single electrode depends upon
   1) the nature of the electrode 2) temperature
   3) conc. of the ion in solution 4) all the above

3. The Nernst equation giving dependence of electrode potential on concentration is
   1) $E = E^0 + \frac{2.303\ RT}{nF} \log \frac{[M]}{[M^{n+}]}$ 2) $E = E^0 + \frac{2.303\ RT}{nF} \log \frac{[M^{n+}]}{[M]}$
   3) $E = E^0 - \frac{2.303\ RT}{nF} \log \frac{[M^{n+}]}{[M]}$ 4) $E = E^0 - \frac{2.303\ RT}{nF} \log [M^{n+}]$

4. Consider the following four electrodes: A = Cu^{2+}(0.0001 M)/Cu(s); B = Cu^{2+}(0.1 M)/Cu(s) ; C = Cu^{2+}(0.01 M)/Cu(s); D = Cu^{2+}(0.001 M)/Cu(s). If the standard reduction potential of Cu^{+2} /Cu is +0.34V, the reduction potentials (in volts) of the above electrodes follow the order
   1) A > D > C > B 2) B > C > D > A 3) C > D > B > A 4) A > B > C > D

5. The e.m.f. of the following Daniell cell at 298 K is E_1; Zn /$ZnSO_4$(0.01M)//$CuSO_4$ (1.0M)/Cu When the concentration of $ZnSO_4$ is 1. 0 M and that of $CuSO_4$ is 0.01 M, the e.m.f. changed to E_2. What is the relationship between E_1 and E_2 ?
   1) $E_1 > E_2$ 2) $E_1 < E_2$ 3) $E_1 = E_2$ 4) $E_2 = 0 \neq E_1$

6. $Zn(s) + Cl_2(1atm) \rightarrow Zn^{2+} + 2Cl^-$, The E^0 of the cell is 2.12 V. To increase E
   1) Zn^{2+} concentration should be increased 2) Zn^{2+} concentration should be decreased
   3) Cl^- concentration should be increased 4) partial preassure of Cl_2 should be decreased.

7. In the cell $Zn/Zn^{2+}//Cu^{2+}/$ Cu, if 1F current is produced from the cell then
   1) $[Zn^{+2}]$ decrease 2) $[Cu^{+2}]$ decrease 3) $[Zn^{+2}]$ increase 4) $[Zn^{+2}]$ remains same

8. In a cell that utilises the reaction $Zn_{(s)} + 2H^+_{(aq)} \rightarrow Zn^{2+}_{(aq)} + H_{2(g)}$ addition of H_2SO_4 to cathode compartment, will (eq. = equilibrium)
   1) lower the E and shift eq. to the left 2) increase the E and shift eq. to the left
   3) increase the E and shift eq. to the right 4) lower the E and shift eq. to the right

9. For a cell reaction, $Cu^{2+}(C_1, aq)+Zn(s) \rightarrow Zn^{2+}(C_2, aq) + Cu(s)$ of an electro chemical cell, the change in standard free energy, ΔG^0 at a given temperature is
1) $\ln C_1$ 2) $-RT \ln(C_2/C_1)$ 3) $\ln C_2$ 4) $\ln(C_1 + C_2)$

10. The relationship between SRP of a cell and equilibrium constant is shown by
1) $E^0_{cell} = \frac{n}{0.059}\log K_c$ 2) $E^0_{cell} = \frac{0.059}{n}\log K_c$ 3) $E^0_{cell} = 0.059\ n \log K_c$ 4) $E^0_{cell} = \frac{\log K_c}{n}$

11. For the reaction $Pt/H_2(1atm)/H^+(aq)//Cl^-(aq)\ /AgCl/Ag$; K_c (equilibrium constant) is represented as
1) $K_c = \frac{[Cl^-][AgCl]}{[H^+][H_2]}$ 2) $K_c = [H^+][Cl^-]$ 3) $K_c = \frac{[H^+][H_2]}{[Cl^-][AgCl]}$ 4) $K_c = \frac{[H_2]}{[Ag]}$

12. The relationship between free energy and electrode potential is
1) $\Delta G = -nFE$ 2) $\Delta G = n\ FE$ 3) $\Delta G = nFE/R$ 4) $\Delta G = \Delta H/nFE$

13. EMF of a cell in terms of reduction potential of its left and right electrodes is
1) $E = E_{left} - E_{right}$ 2) $E = E_{left} + E_{right}$ 3) $E = E_{right} - E_{left}$ 4) $E = -(E_{right} + E_{left})$

14. The reaction, $\frac{1}{2}H_{2(g)} + AgCl_{(s)} = H^+_{(aq)} + Cl^-_{(aq)} + Ag_{(s)}$ occurs in the galvanic cell:
1) $Ag\left|AgCl_{(s)}\right|KCl(soln.)\left|AgNO_3(soln.)\right|Ag$ 2) $Pt\left|H_{2(g)}\right|HCl(soln.)\left|AgNO_3(soln.)\right|Ag$
3) $Pt\left|H_{2(g)}\right|HCl(soln.)\left|AgCl(s)\right|Ag$ 4) $Pt\left|H_{2(g)}\right|KCl(soln.)\left|AgCl(s)\right|Ag$

15. Regarding standard hydrogen electrode the correct one is
1) $E^\circ \neq \pm 0.00V$ 2) a reference electrode
3) apply at any pressure 4) apply at any temperature

16. The calomel electrode is reversible with respect to :
1) Hg_2^{2+} 2) H^+ 3) Hg^{2+} 4) Cl^-

17. The electrode potential of a glass electrode depends upon
1) concentration of chloride ions 2) concentration of hydrogen ions
3) concentration of KCl solution 4) none of these

18. A cell necessarily does not contain
1) Anode 2) Cathode 3) Electrolyte (fuel) 4) Porous diaphragm

19. Which is not 2nd reference electrode
1) calomel electrode 2) Ag/AgCl - electrode
3) Hg/Hg_2Cl_2-KCl electrode 4) SHE

20. E^0 for the reaction $Fe + Zn^{2+} \rightarrow Zn + Fe^{2+}$ is –0.35 V. The given cell reaction is
1) feasible 2) not feasible 3) explosive 4) slow

21. The solution of $NiSO_4$ in which nickel rod is dipped is diluted 10 times. The potential of nickel
1) decreases by 60mV 2) increases by 30V 3) decreases by 30mV 4) decreases by 60V

22. The value of the reaction quotient, Q for the cell $Zn(s)\left|Zn^{2+}(0.01M)\right|\left|Ag^+(1.25M)\right|Ag(s)$ is :
1) 156 2) 125 3) 1.25×10^{-2} 4) 6.40×10^{-3}

Numerical Value Type Questions

23. E^0 for the half cell Zn^{2+}/Zn is –0.76V. Emf of the cell $Zn/Zn^{2+}(1M)//H^+(1M)/H_2$ at 1 atm is
24. E^0 for $F_2 + 2e^- \rightarrow 2F^-$ is 2.8 V; E^0 for $1/2\ F_2 + e^- \rightarrow F^-$ is
25. Aluminium displaces hydrogen from dilute HCl whereas silver does not. The e.m.f. of a cell prepared by combining Al/Al^{3+} and Ag/Ag^+ is 2.46 V. If $E^0_{Ag} = +0.80V$, $E^0_{Al} = ?$
26. A cell constructed by coupling a standard copper electrode and a standard magnesium electrode has emf of 2.7 volts. If the SRP of copper electrode is +0.34 volt, that of magnesium electrode is
27. Normal aluminium electrode coupled with NHE gives an emf of 1.66V. So the SRP of aluminium is
28. Consider the following cell reaction : $2Fe_{(s)} + O_{2(g)} + 4H^+_{(aq)} \rightarrow 2Fe^{2+}_{(aq)} + 2H_2O_{(l)}$; $E^0 = 1.67$ V
At $[Fe^{2+}] = 10^{-3}$ M, $P_{(O_2)} = 0.1$ atm and pH = 3, the cell potential at 25°C is

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. For the cell $Zn(s)\left|Zn^{2+}\right\|\left|Cu^{2+}\right|Cu(s)$, the standard cell voltage, E^0_{cell} is 1.10V. When a cell using these reagents was prepared in the lab, the measured cell voltage was 0.98 V. One possible explanation for the observed voltage is

   a) there was 2.00 mol of Cu^{2+} but only 1.00 mol of Zn^{2+}

   b) the Zn electrode had twice the surface of the Cu electrode

   c) the $[Zn^{2+}]$ was larger than the $[Cu^{2+}]$

   d) the volume of the Zn^{2+} solution was larger than the volume of the Cu^{2+} solution

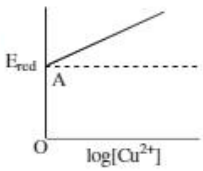
2. The standard oxidation potentials of Zn and Ag in water at 25°C are,

   $Zn_{(s)} \rightarrow Zn^{2+} + 2e$; $E^0 = 0.76V$; $Ag_{(s)} \rightarrow Ag^+ + e$; $E^0 = -0.80V$. Which reaction actually takes place?

   a) $Zn_{(s)} + 2Ag^+_{(aq)} \rightarrow Zn^{2+} + 2Ag_{(s)}$ b) $Zn^{2+} + 2Ag^+_{(s)} \rightarrow 2Ag^+_{(aq)} + Zn_{(s)}$

   c) $Zn_{(s)} + 2Ag_{(s)} \rightarrow Zn^{2+}_{(aq)} + Ag^+_{(aq)}$ d) $Zn^{2+}_{(aq)} + Ag^+_{(aq)} \rightarrow Zn_{(s)} + Ag_{(s)}$

3. $Cu^{2+} + 2e \rightarrow Cu$; $\log[Cu^{2+}]$ vs E graph is of the type as shown in figure where OA = 0.34 V, then electrode potential of the half-cell of $Cu\left|Cu^{2+}\right.(0.1M)$ will be



   a) $-0.34 + \frac{0.0591}{2}$ V b) 0.34 + 0.0591V

   c) 0.34 V d) none of these

4. The cell reaction for the given cell is spontaneous if : $PtCl_2\left|Cl^-(1M)\right\|\left|Cl^{-1}(1M)\right|PtCl_2$ (P_1, P_2)

   a) $P_1 > P_2$ b) $P_1 < P_2$ c) $P_1 = P_2$ d) $P_2 = 1$ atm

5. If a salt bridge is removed from the two half-cells, the voltage:

   a) drops to zero b) does not change c) increases gradually d) increases rapidly

6. For the cell given below. $Zn\left|Zn^{2+}\right\|\left|Cu^{2+}\right|Cu$, $(E_{cell} - E^0_{cell})$ is –0.12V. It will be when:

   a) $[Zn^{2+}]/[Cu^{2+}] = 10^2$ b) $[Zn^{2+}]/[Cu^{2+}] = 10^{-2}$ c) $[Zn^{2+}]/[Cu^{2+}] = 10^4$ d) $[Zn^{2+}]/[Cu^{2+}] = 10^{-4}$

7. E^0 for two reactions are given below: $Cr^{+3} + 3e^- \rightarrow Cr$, $E^0 = -0.74V$; $OCl^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^{-1}$, $E^0 = 0.94V$. What will be the E^0 for $3OCl^- + 2Cr + 3H_2O \rightarrow 2Cr^{+3} + 3Cl^- + 6OH^-$

   a) –1.68 V b) 1.68 V c) –0.20V d) +0.20 V

8. The emf of the cell in which of the following reaction, $Zn_{(s)} + Ni^{2+}(0.1M) \rightarrow Zn^{2+}(1.0M) + Ni_{(s)}$ occurs is found to 0.5105 V at 298 K. The standard emf of the cell is

a) 0.4810 V b) 0.5696 V c) –0.5105 V d) 0.5400 V

9. The hydrogen electrode when placed in a buffer solution of CH_3COONa and CH_3COOH in the ratio *x*:*y* and *y*:*x* has oxidation electrode potential E_1 and E_2 volts respectively at 25^0C (pH_2 = 1 atm). pK_a for CH_3COOH will be :

a) $E_1 + E_2$ b) $E_1 - E_2$ c) $(E_1 + E_2)/0.0591 \times 2$ d) $(E_1 - E_2)/0.0591 \times 2$

10. A 1.0 M solution of Cd^{+2} is added to excess iron and the system is allowed to reach equilibrium. What is the concentration of Cd^{+2} ? $Cd^{2+}(aq) + Fe(s) \rightarrow Cd(s) + Fe^{2+}(aq); E^0 = 0.037$

a) 0.195 b) 0.097 c) 0.053 d) 0.145

11. The standared electrode potential for the following reaction is +1.33 V. What is potential at pH=2.0?
$Cr_2O_7^{2-}(aq,1M) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq,1M) + 7H_2O(l)$

a) +1.820V b) +1.990 V c) +1.608 V d) +1.0542V

12. Copper reduces NO_3^- into NO and NO_2 depending upon concentration of HNO_3 in solution. Assuming $[Cu^{2+}]$ = 0.1M, and $P_{NO} = P_{NO_2} = 10^{-3}$ bar. At which concentration of HNO_3 , thermo-dynamic tendency for reduction of NO_3^- into NO and NO_2 by copper is same ?
Given : $E^0_{Cu^{2+}|Cu} = +0.34$ V, $E^0_{NO_3|NO} = +0.96$ V, $E^0_{NO_3|NO_2} = +0.79$ V

a) $10^{1.32}$ M b) $10^{0.56}$ M c) $10^{0.66}$ M d) None

13. The standard electrode potential of a metal - metal ion (Ag/Ag^+) and metal - sparingly soluble salt anion ($Ag|AgCl|Cl^-$) are related as:

a) $E^o_{Ag^+|Ag} = E^o_{Cl^-|AgCl|Ag} + \frac{RT}{F}\ln K_{sp}$ b) $E^o_{Cl^-|AgCl|Ag} = E^o_{Ag^+|Ag} + \frac{RT}{F}\ln K_{sp}$

c) $E^o_{Cl^-|AgCl|Ag} = E^o_{Ag^+|Ag} - \frac{RT}{F}\ln\frac{[Cl^-]}{K_{sp}}$ d) $E^o_{Cl^-|AgCl|Ag} = E^o_{Ag^+|Ag} - \frac{RT}{F}\ln\frac{K_{sp}}{[Cl^-]}$

14. In the following concentration cell. Ag(s) / AgCl (saturated) // $AgNO_3$(aq) (0.1M) / $Ag_{(s)}$; K_{SP} of AgCl = 1×10^{-10}. The cell potential will be

a) E_{cell} = 0.295 V b) E_{cell} = + 0.586V

c) $E_{cell} = \frac{0.059}{1}\log\frac{[Ag^+]_{cathode}}{\sqrt{K_{SP}\text{ of AgCl}}}$ d) $E_{cell} = E^o_{cell} + \frac{0.059}{1}\log\frac{\sqrt{K_{SP}\text{ of AgCl}}}{[Ag^+]_{cathode}}$

15. Calculate the potential of a half cell having reaction : $Ag_2S(s) + 2e^- \rightleftharpoons 2Ag(S) + S^{2-}(aq)$ in a solution buffered at p^H=3 and which is also saturated with $0.1M H_2S(aq)$
[Given : $K_{sp}(Ag_2S) = 2\times10^{-49}; K_{a1}.K_{a2} = 1.1\times10^{-21}; E^0_{As^+/Ag} = 0.8$V]

a) – 0.19V b) 0.19 c) 1.18V d) –0.166V

16. For a Ag-Zn button cell, net reaction is : $Zn_{(s)} + Ag_2O_{(s)} \rightarrow ZnO_{(s)} + 2Ag_{(s)}$; $\Delta G^0 f(Ag_2O) = -11.21\,kJ\,mol^{-1}$ $\Delta G^0 f(ZnO) = -318.3\,kJ\,mol^{-1}$ Hence E^0_{cell} of the button cell is :

a) 3.182 V b) 1.71 V c) -1.591 V d) 1.591 V

More than One correct answer Type Questions

17. Which of the following changes will increase the emf of the cell :
$Co(s)|CoCl_2(M_1)||HCl(M_2)|Pt(H_2,g)$
a) increase the volume of $CoCl_2$ solution from 100 mL to 200 ml
b) increase M_2 from 0.01 M to 0.50 M
c) increase the pressure of the $H_2(g)$ from 1.00 to 2.00 atm
d) increase M_1 from 0.01 M to 0.50 M

18. The cell emf in a cell with cell reaction $Cr_2O_7^{2-} + 14H^+ + 6Fe^{+2} \rightarrow 2Cr^{+3} + 6Fe^{+3} + 7H_2O$ could be increased above the standard emf by
a) Increasing $[Cr^{+3}]$
b) Decreasing $[Fe^{+3}]$
c) Decreasing $[Cr_2O_7^{2-}]$
d) Decreasing the pH

19. If the e.m.f of a galvanic cell is negative, it implies that :
a) the cell reaction is spontaneous
b) the cell reaction is non - spontaneous
c) the cell reaction is exothermic
d) the cell is working in reverse direction

20. Which is/are correct among the following, the half cell emf's $E^0\,Cu^{+2}/Cu = 0.337V$ and $E^0{}_{Cu^{+1}/Cu} = 0.521V$
a) Cu^{+1} disproportionates
b) Cu and Cu^{+2} comproportionates
c) $E^0_{Cu/Cu^{+2}} + E^0_{Cu^+/Cu}$ is positive
d) $E^0_{Cu/Cu^{+2}} + E^0_{Cu^+/Cu}$ is negative

21. For the cell (at 298 K) $Ag_{(g)}/AgCl_{(s)}/Cl^-{}_{(aq)} \| AgNO_{3(aq)}/Ag_{(s)}$.
Which of the following is correct?
a) The cell emf will be zero when $[Ag^+]_a = [Ag^+]_c$
b) The amount of $AgCl_{(s)}$ ppt in anodic compartment will decrease the working of the cell.
c) The $[Ag^+]$=constant in the anodic compartment during the working of the cell.
d) Anode is metal - sparingly soluble salt, half cell.

22. For the electrochemical cell $M/M^+ // X^-/X$, $E^0M^+/M = 0.44V$ and $E^0(x/x^-) = 0.33V$. From the data one can deduce that
a) $M + X \rightarrow M^+ + X^-$ (spontaneous)
b) $M^+ + X \rightarrow M + X$ (spontaneous)
c) E_{cell} for this couple = 0.77 V
d) E_{cell} for this couple = –0.11V

23. Consider the cell Ag | AgBr| KBr||KCl | AgCl | Ag with EMF 0.059 V. Assume that $[Br^-] = [Cl^-]$, Here, conclusion inferred may be
a) The ratio of the simultaneous solubilities of AgCl and AgBr in pure water is 1000
b) It is concentration cell
c) Change in conc. of KCl will not effect EMF
d) K_{sp} (AgCl) > K_{sp} (AgBr)

24. E^0_{red} (standard reduction potential) of different half-cells are given, $E^0_{Cu^{+2}/Cu} = +0.34V$
$E^0_{Zn^{+2}/Zn} = -0.76V, E^0_{Ag^+/Ag} = 0.80V$, $E^0_{Mg^{2+}/Mg} = -2.37V$ In which cell ΔG^o is most negative ?
a) $Zn/Zn^{2+}(1M)//Mg^{2+}(1M)/Mg$
b) $Zn/Zn^{2+}(1M)//Ag^+(1M)/Ag$
c) $Cu/Cu^{2+}(1M)//Ag^+(1M)/Ag$
d) $Ag/Ag^+(1M)//Mg^{+2}(1M)/Mg$

Linked Comprehension Type Questions

Passage-I :

Nernst equation gives the variation of potential of an electrode based on activity of ions temperature and pressure. The equation is $E = E^0 - (2.303RT/nF)\log Q$ *(or)* $E = E^0 - (0.0591/n)\log Q$.

25. By what margin the potential of an aluminium electrode decreases if the activity of the ions is decreased by 10 times ?
    a) 0.02 V b) 0.03 V c) 0.06 V d) 0.01 V

26. What is the RP of a hydrogen electrode in an aq. solution containing 0.1 M NH_4OH, ($Kb=10^{-5}$) ?
    a) –0.45 V b) –0.85 V c) –0.9V d) –0.6501V

27. Which cell has least potential ?
    a) $Zn/\underset{1M}{Zn^{+2}}//\underset{1M}{Cu^{+2}}/Cu$ b) $Zn/\underset{0.1M}{Zn^{+2}}//\underset{0.1M}{Cu^{+2}}/Cu$ c) $Zn/\underset{0.1M}{Zn^{+2}}//\underset{1M}{Cu^{+2}}/Cu$ d) $Zn/\underset{1M}{Zn^{+2}}//\underset{0.1M}{Cu^{+2}}/Cu$

Passage-II :

The electrochemical cell shown below is a concentration cell. $M \mid M^{2+}$ (saturated solution of a sparingly soluble salt, MX_2) $\| M^{2+}$ (0.001 mol dm^{-3}) $\mid M$. The emf of the cell depends on the difference in concentration of M^{2+} ions at the two electrodes. The emf of the cell at 298 is 0.059 V.

28. The solubility product (K_{sp}; mol^3dm^{-9}) of MX_2 at 298 based on the information available the given concentration cell is (take $2.303 \times R \times 298/F = 0.059$ V)
    a) 1×10^{-15} b) 4×10^{-15} c) 1×10^{-12} d) 4×10^{-12}

29. The value of ΔG (kJ mol^{-1}) for the given cell is (take 1F = 96500 C mol^{-1})
    a) –5.7 b) 5.7 c) 11.4 d) –11.4

Matrix Matching Type Questions

30.

Column - I	Column - II
A) $Pt\vert Fe^{3+}, Fe^{2+}$	p) Metal-metal ion half-cell
B) $Pt\vert H_2\vert H^+$	q) Gas-gas ion half cell
C) $Pt\vert Hg\vert Hg_2^{2+}$	r) Oxidation - reduction half-cell
D) $Pb\vert PbSO_4\vert SO_4^{2-}$	s) Metal Sparinglysoluble salt half-cell

31.

Column - I	Column - II
A) Hg_2Cl_2	p) Salt bridge
B) Agar-agar	q) Calomel electrode
C) 0.1 N KCl	r) Used in ice cream
D) Quinhydrone	s) Redox electrode

Integer Type Questions

32. The no. of cells which may be constructed with different E^0_{cell} values for the reaction :
    $Fe + 2Fe^{3+} \rightarrow 3Fe^{2+}$.

33. $E_{MnO_4^-/Mn^{+2},H^+}$ can be 0.48V greater than from E^0 value if the $[MnO_4^-]$ is equal to $[Mn^{+2}]$ at a P^H of

34. Potential of a hydrogen electrode at one atmosphere in 0.48V if the P^H value is

35. The anodic solution of standard "Al–Ag" voltaic cell is diluted by 100 times. The potential of the cell is increased by '0.01x' volts what is x ?

36. $Ag/AgBr(s), \underset{0.1M}{KBr}//\underset{0.1M}{KCl}, \underset{(s)}{AgCl}/Ag$ the cell potential is 0.1x V. (Ksp AgBr=10^{-16}, AgCl=10^{-11}), x=?

EXERCISE-IV

(Electro Chemical Series & Batteries)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. E° for $Fe^{2+} + 2e \rightarrow Fe$ is –0.44 V ; E° for $Zn^{2+} + 2e \rightarrow Zn$ is –0.76 V. Then
   1) Zn is more electropositive than Fe
   2) Fe is more electropositive than Zn
   3) Zn is more electronegative
   4) None of the above

2. Based on the data given below, the correct order of reducing power is : $Fe^{3+}_{(aq)} + e \rightarrow Fe^{2+}_{(aq)}$, $E^\circ = 0.77V$; $Al^{3+}_{(aq)} + 3e \rightarrow Al_{(s)}$, $E^\circ = -1.66V$; $Br_{2(aq)} + 2e \rightarrow 2Br^-_{(aq)}$; $E^\circ = +1.08V$
   1) $Br^- < Fe^{2+} < Al$ 2) $Fe^{2+} < Al < Br^-$ 3) $Al < Br^- < Fe^{2+}$ 4) $Al < Fe^{2+} < Br^-$

3. For the cell prepared from electrode A : $Cr_2O_7^{2-}/Cr^{3+}$, $E^\circ_{red} = +1.33V$ and electrode B : $Fe^{3+} \mid Fe^{2+}$, $E^\circ_{red} = 0.77V$. Which of the following stament is correct?
   1) The e^- flows from B to A
   2) The e.m.f. of the cell will be 0.56V
   3) A will be positive electrode
   4) All of the above

4. The S.R.Ps of Cu^{2+}/Cu, Hg^{2+}/Hg and Zn^{2+}/Zn are respectively 0.34V, 0.85 V and –0.76 V. The wrong statement is
   1) Cu reduces Hg^{2+} 2) Zn reduces Cu^{2+} 3) Hg reduces Zn^{2+} 4) Zn reduces Cu^{2+}, Hg^{2+}

5. The $E^\circ_{M^{3+}|M^{2+}}$ values for Cr, Mn, Fe and Co are –0.41, +1.57V, + 0.77 and +1.97V respectively. For which one of these metals the change in oxidation state from +2 to +3 is easiest?
   1) Co 2) Mn 3) Fe 4) Cr

6. **(A) :** A blue colour is obtained when a copper wire is immersed in $AgNO_3$ solution
   (R) : Silver reduces Cu^{2+} to copper
   1) Both (A) and (R) are true and (R) is the correct explanation of (A)
   2) Both (A) and (R) are true and (R) is not the correct explanation of (A)
   3) (A) is true but (R) is false
   4) (A) is false but (R) is true

7. The half cell reaction, with its SRPs are: I) $Pb^{2+} + 2e^- \rightarrow Pb$ ($E^0 = -0.13$ V) II) $Ag^+ + e^- \rightarrow Ag$ ($E^0 = +0.80$ V). Which of the following reactions will occur ?
   1) $Pb^{2+} + 2Ag \rightarrow 2Ag^+ + Pb$ 2) $Pb^+ + H_2 \rightarrow 2H^+ + Pb$
   3) $2H^+ + 2Ag \rightarrow 2Ag^+ + H_2$ 4) $2Ag^+ + Pb \rightarrow Pb^{2+} + 2Ag$

8. A student made the following observations in the laboratory,
   A) Clean copper metal did not react with 1 molar $Pb(NO_3)_2$ solution
   B) Clean lead metal dissolved in a 1 molar $AgNO_3$ solution and crystals of Ag metal appeared
   C) Clean silver metal did not react with 1 molar $Cu(NO_3)_2$ solution.
   The order of decreasing reducing character of the three metals is :
   1) Cu, Pb, Ag 2) Cu, Ag, Pb 3) Pb, Cu, Ag 4) Pb, Ag, Cu

9. Four colourless salt solutions are placed in separate test tubes and a strip of copper is placed in each. Which solution finally turns blue?
   1) $Pb(NO_3)_2$ 2) $Zn(NO_3)_2$ 3) $AuCl_3$ 4) $Cd(NO_3)_2$

10. Red hot carbon will remove oxygen from the oxides XO and YO but not from ZO, Y will remove oxygen from XO, then order of reactivity (the most reactive first)
1) X, Y, Z 2) Z, Y, X 3) Y, X, Z 4) Z, X, Y

11. The position of some metals in the electro-chemical series in decreasing electropositive character is given as Mg > Al > Zn > Cu > Ag. What will happen if a copper spoon is used to stir a solution of aluminium nitrate?
1) The spoon will get coated with aluminium 2) An alloy of copper and aluminium is formed
3) The solution becomes blue 4) There is no reaction

12. The metal that cannot be produced on reduction of its oxide by aluminium is:
1) K 2) Mn 3) Cr 4) Fe

13. Which of the following salt solution cannot be stored in copper vessel
1) $Pb(NO_3)_2$ 2) $Zn(NO_3)_2$ 3) $AgNO_3$ 4) $Cd(NO_3)_2$

14. Silver spoon cannot be used to stirr which of the following salt solution
1) $ZnSO_{4(aq)}$ 2) $CuSO_{4(aq)}$ 3) $AuCl_{3(aq)}$ 4) $NaCl_{(aq)}$

15. On the basis of position in the electrochemical series, the metal which does not displace hydrogen from water and acids is :
1) Hg 2) Al 3) Pb 4) Ba

16. In an aqueous solution, hydrogen (H_2) will not reduce:
1) Fe^{2+} 2) Cu^{2+} 3) Zn^{2+} 4) Ag^{+}

17. The standard reduction potential values of three metallic cations, X, Y, Z are 0.52, –3.03 and –1.18 V respectively. The order of reducing power of the corresponding metals is :
1) Y > Z > X 2) X > Y > Z 3) Z > Y > X 4) Z > X > Y

18. Among Na, Hg, S, Pt and graphite which can be used as electrodes in electrolytic cells having aqueous solution?
1) Na and S 2) Hg and Pt 3) Na, Hg and S 4) Hg, Pt and graphite

19. **(A) :** In the construction of Galvanic cell, lithium electrode can not be used as cathode
(R) : Lithium has the highest negative S.R.P value.
1) Both (A) and (R) are true and (R) is the correct explanation of (A)
2) Both (A) and (R) are true and (R) is not the correct explanation of (A)
3) (A) is true but (R) is false 4) (A) is false but (R) is true

20. Hydrogen - oxygen fuel cells are used in space programs to supply
1) Power 2) drinking water 3) oxygen 4) Both (1) and (2)

21. In a hydrogen - oxygen fuel cell, combustion of hydrogen occurs to
1) generate heat 2) produce high purity water
3) remove adsorbed oxygen from electrode surfaces
4) create potential difference between the two electrodes

22. Which of the following reactions is used to make a fuel cell ?
1) $Cd_{(s)}+2Ni(OH)_{3(s)} \rightarrow CdO(s)+2Ni(OH)_{2(s)} + H_2O_{(l)}$
2) $Pb_{(s)}+PbO_{2(s)}+2H_2SO_{4(aq)} \rightarrow 2PbSO_4(s) + 2H_2O_{(l)}$
3) $2\ H_{2(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(l)}$ 4) $2Fe_{(s)}+O_{2(g)}+ 4H^{+}_{(aq)} \rightarrow 2Fe^{2+}_{(aq)} + 2H_2O_{(l)}$

23. The Zn acts as sacrificial anode or cathodic protection to prevent rusting of iron because :
1) E°_{OP} of Zn < E°_{OP} of Fe
2) E°_{OP} of Zn > E°_{OP} of Fe
3) E°_{OP} of Zn = E°_{OP} of Fe
4) Zn is cheaper than iron

24. The corrosion of iron object is favoured by
1) Presence of H^+ ion
2) Presence of moisture in air
3) Presence of impurities in iron object
4) All of the above

25. Galvanization includes plating iron with
1) zinc 2) tin 3) copper 4) aluminium

26. The electroplating with chromium is undertaken because:
1) electrolysis of chromium is easier
2) chromium can form alloys with other metals
3) chromium gives a protective and decorative coating to the base metal
4) of high reactivity of chromium metal

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. Is the reaction ; $2Al + 3Fe^{2+} \rightarrow 2Al^{3+} + 3Fe$, possible:
a) No, because SOP of Al < Fe
b) Yes, because SOP of Al > Fe
c) Neither (a) nor (b)
d) Data are unpredictable

2. Standard electrode potential (E^0) for OCl^- / Cl^- and $Cl^-/\frac{1}{2}Cl_2$ are respectively 0.94 V and –1.36V. The E^0 value for OCl^-/Cl_2 will be
a) – 0.42 V b) – 2.20 V c) 0.52 V d) 1.04 V

3. Cu^+ ion is not stable in aqueous solution because of disproportionation reaction. E^0 value for the disproportionation of Cu^+ is : $(E^\circ_{cu^{2+}/cu^+} = +0.15V, E^\circ_{cu^+/cu} = +0.34\ V)$
a) –0.19V b) –0.38 V c) + 0.19 V d) + 0.38 V

4. The SRPs $Fe \xrightarrow{+0.4V} Fe^{2+}(aq) \xrightarrow{-0.8V} Fe^{3+}(aq)$; $Fe \xrightarrow{+0.9V} Fe(OH)_2 \xrightarrow{0.6V} Fe(OH)_3$
It is easier to oxidize Fe^{2+} to Fe^{3+} in ____ medium
a) Acid b) Alkaline c) Neutral d) Acidic and alkaline

5. If $E^\circ_{Au^+/Au}$ is 1.69 V and $E^\circ_{Au^{3+}/Au}$ is 1.40 V, Then $E^\circ_{Au^+/Au^{3+}}$ will be :
a) 0.19 V b) 2.945 V c) 1.255 V d) None of these

6. Let a fully charged lead-storage battery contains 1.5 L of $5MH_2SO_4$. What will be the concentration of H_2SO_4 in the battery after 2.5 ampere current is drawn from the battery for 6 hour?
a) 4.626M b) 0.1865M c) 0.373M d) 9.627M

7. The rusting of iron takes place as follows, $2Fe_{(s)} + O_{2(g)} + 4H^+_{(aq)} \rightarrow 2Fe^{+2} + 2H_2O$, if E^0 for $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$ is 1.23V and $E^0_{Fe/Fe^{-2}} = 0.44V$. Then the correct one is
a) $E^0_{cell} = +1.67V$; $K_C = 2.63 \times 10^{56}$
b) $E^0_{cell} = +0.34V$; $K_C = 1.54 \times 10^{26}$
c) $E^0_{cell} = 1.16V$; $K_C = 8 \times 10^{-5}$
d) $E^0_{cell} = 1.67V$; $K_C = 2.85 \times 10^{-56}$

8. For a reaction in a galvanic cell the value of $-\Delta G^\circ$ at certain temperature is not necessarily equal to
a) nFE^0 b) RT ln K_{eq} c) $T.\Delta S^\circ - \Delta H^\circ$ d) zero

More than One correct answer Type Questions

9. Consider the reactions, $PbO_2 \rightarrow PbO, \Delta G_{298} < 0$; $SnO_2 \rightarrow SnO, \Delta G_{298} > 0$ the most probable oxidation state of Pb and Sn will be
   a) Pb^{+4} b) Sn^{+4} c) Sn^{+2} d) Pb^{+2}

10. The element that is easiest to be reduced is :
   a) Fe b) Cu c) Ag d) Hg

11. The correct order of chemical reactivity with water according to electrochemical series is :
   a) K > Mg b) Zn > Cu c) K > Zn d) Mg > Zn

12. For the reduction of NO_3^- ion in an aqueous solution, E^0 is + 0.96 V, the values of E^0 for some metal ions are given below : (i) $V^{+2}_{(aq)} + 2e^- \rightarrow V; E^0 = -1.19V$ (ii) $Fe^{+3}_{(aq)} + 3e^- \rightarrow Fe; E^0 = -0.04V$ (iii) $Au^{+3}_{(aq)} + 3e^- \rightarrow Au; E^0 = +1.40V$ (iv) $Hg^{+2}_{(aq)} + 2e^- \rightarrow Hg; E^0 = +0.86V$
   The pair(s) of metals that is/are oxidized by NO_3^- in aqueous solution is/are
   a) Fe and Au b) Hg and Fe c) V and Hg d) Fe and V

13. Which of the following statements are correct regarding to galvanic cell?
   a) A reaction is spontaneous from left to right if $E_{cell} > 0$
   b) A reaction occurs from right to left if $E_{cell} < 0$
   c) If the system is at equilibrium no net reaction occurs
   d) E_{cell} is temperature-independent

14. The correct statements among the following are
   a) The potential of metallic electrode increases with increase in conc. of metal ions
   b) The potential of metallic electrode decreases with increase in conc. of metal ions
   c) The potential of non-metallic electrode increases with increase in conc. of non-metal ions
   d) The potential of non-metallic electrode decreases with increase in conc.of non-metal ions

15. Given $E^0_{Ag^+/Ag} = 0.80\,V, E^0_{Mg^{2+}/Mg} = -2.37\,V, E^0_{Cu^{2+}/Cu} = 0.34\,v\; E^0_{Hg^{2+}/Hg} = 0.79\,v$
   Which of the following statements is/are not correct ?
   a) $AgNO_3$ can be stored in copper vessel b) $Cu(NO_3)_2$ can be stored in magnesium vessel
   c) $CuCl_2$ can be stored in silver vessel d) $HgCl_2$ can be stored in copper vessel

16. Standard electrode potential of two half-reactions are given below : $Fe^{2+} \rightleftarrows Fe, E^0 = -0.44V$; $Fe^{3+} \rightleftarrows Fe^{2+}, E^0 = +0.77V$. If Fe^{2+}, Fe^{3+} and Fe are kept together:
   a) The concentration of Fe^{3+} increases b) The concentration of Fe^{3+}decreases
   c) The mass of Fe increases d) The concentration of Fe^{2+} increases

Linked Comprehension Type Questions

Passage-I :

Electrochemical series is series of elements arranged in increasing order of their reduction potiential $E^0_{H^+/H_2} = 0$. The metals above H_2 have –ve reduction potential, they are more reactive than hydrogen whereas metals below hydrogen are less reactive than H_2. Reduction potential of metal depends upon (i) sublimation energy, (ii) ionization energy (iii) hydration energy of ions.

17. Which of the following is best reducing agent?
   a) Li b) Na c) K d) Cs

18. Which of the following metal can be extracted by chemical reduction?
   a) Al b) Mg c) Na d) Fe

19. Which of the following is best oxidising agent?
a) Cu^{2+} b) Na^{+} c) Ag^{+} d) Al^{3+}

20. Which one of the following is weakest reducing agent among alkali metals?
a) Na b) K c) Rb d) Cs

21. Which of the following cannot displace H_2 from dil. acid?
a) Pt b) Zn c) Mg d) Pb

Passage-II :

The cell potential (E_{cell}) of a reaction is related as $\Delta G = -nF\ E_{cell}$, where ΔG represents max. useful electrical work; n = no. of moles of electrons exchanged during the reaction for reversible cell reaction $d(\Delta G) = (\Delta V)dP - (\Delta S).dT$, at constant pressure $d(\Delta G) = -(\Delta S).dT$ $\because$ At constant pressure $\Delta G = \Delta H - T.\Delta S$ .....(1) $\therefore \Delta G = \Delta H + T\left(d(\Delta G)/dT\right)_p$ .....(2) $\left(dE_{cell}/dT\right)_p$ is known as temperature coefficient of the e.m.f of the cell

22. When ΔS increases, temperature coefficient of the emf of cell
a) Constant b) Decreases c) Suddenly decreases d) Increases

23. At 300 K, ΔH for the reaction $Zn_{(s)} + 2AgCl_{(s)} \rightarrow ZnCl_{2(aq)} + 2Ag_{(s)}$ is $-218\,kJ/mol$ while the e.m.f. of the cell was 1.015V. $(dE/dT)_p$ of the cell is :
a) $-4.2\times10^{-4}\,VK^{-}$ b) $-3.81\times10^{-4}\,VK^{-1}$ c) $0.11\,VK^{-1}$ d) $7.62\times10^{-4}\,VK^{-1}$

24. Calculate ΔS for the given cell reaction in the previous question:
a) $-73.53\,J/K\,mol$ b) $83.53\,J/K\,mol$ c) $100\,J/K\,mol$ d) none of these

Integer Type Questions

25. In rusting of iron, iron is oxidised and O_2 is reduced. The no. of electrons used during reduction of O_2 are ____

KEY SHEET (PRACTICE SHEET)

EXERCISE-I

LEVEL-I

1) **2** 2) **2** 3) **4** 4) **3** 5) **4** 6) **2** 7) **2** 8) **2**
9) **4** 10) **1** 11) **3** 12) **4** 13) **3** 14) **1** 15) **4** 16) **2**
17) **4** 18) **3** 19) **1** 20) **4** 21) **3** 22) **1** 23) **1** 24) **2**
25) **63.5** 26) **0.58** 27) **1.5**

LEVEL-II

1) **a** 2) **a** 3) **a** 4) **b** 5) **c** 6) **abd** 7) **ad** 8) **acd**
9) **abd** 10) **ad** 11) **d** 12) **c** 13) **b** 14) **b** 15) **d** 16) **d**
17) **A-r; B-s; C-pq; D-r** 18) **A-s; B-r; C-p; D-q** 19) **2** 20) **9**
21) **1** 22) **2** 23) **2** 24) **2** 25) **3** 26) **6** 27) **6**

EXERCISE-II

LEVEL-I

1) **3** 2) **2** 3) **4** 4) **2** 5) **4** 6) **3** 7) **4** 8) **1**
9) **4** 10) **1** 11) **1** 12) **2** 13) **4** 14) **2** 15) **3** 16) **3**
17) **4** 18) **1** 19) **–3** 20) **271.44** 21) **630**

LEVEL-II

1) **c** 2) **b** 3) **b** 4) **c** 5) **d** 6) **a** 7) **abc** 8) **abcd**
9) **ac** 10) **abc** 11) **abc** 12) **ab** 13) **d** 14) **a** 15) **d** 16) **c**
17) **a** 18) **b** 19) **d** 20) **A-s; B-p; C-r; D-q**
21) **A-s; B-r; C-q; D-p** 22) **3** 23) **3** 24) **4** 25) **2**

EXERCISE-III

LEVEL-I

1) **1** 2) **4** 3) **2** 4) **2** 5) **1** 6) **2** 7) **3** 8) **3**
9) **2** 10) **2** 11) **2** 12) **1** 13) **3** 14) **3** 15) **2** 16) **4**
17) **2** 18) **4** 19) **4** 20) **2** 21) **3** 22) **4** 23) **0.76** 24) **2.8**
25) **–1.66** 26) **–2.36** 27) **–1.66** 28) **1.57**

LEVEL-II

1) **c** 2) **a** 3) **a** 4) **b** 5) **a** 6) **c** 7) **b** 8) **d**
9) **c** 10) **c** 11) **d** 12) **d** 13) **b** 14) **c** 15) **d** 16) **d**
17) **ab** 18) **bd** 19) **bd** 20) **ac** 21) **ad** 22) **bd** 23) **bd** 24) **b**
25) **a** 26) **d** 27) **d** 28) **b** 29) **d** 30) **A-r; B-q; C-p; D-s**
31) **A-qs; B-pr; C-p; D-s** 32) **3** 33) **5** 34) **8** 35) **4** 36) **3**

EXERCISE-IV

LEVEL-I

1) **1** 2) **1** 3) **4** 4) **3** 5) **4** 6) **3** 7) **4** 8) **3**
9) **3** 10) **2** 11) **4** 12) **1** 13) **3** 14) **3** 15) **1** 16) **3**
17) **1** 18) **4** 19) **1** 20) **4** 21) **4** 22) **3** 23) **2** 24) **4**
25) **1** 26) **3**

LEVEL-II

1) **b** 2) **c** 3) **c** 4) **b** 5) **d** 6) **a** 7) **a** 8) **d**
9) **bd** 10) **cd** 11) **bcd** 12) **bcd** 13) **abc** 14) **ad** 15) **abd** 16) **bd**
17) **a** 18) **d** 19) **c** 20) **a** 21) **a** 22) **d** 23) **b**
24) **a** 25) **4**

ADDITIONAL PRACTICE EXERCISE

LEVEL-I (MAIN)

Straight Objective Type Questions

1. A current of 9.65 A is passed for 3 hours between platinum electrodes immersed in 0.5 dm^3 solution of concentration 2 mol dm^{-3} $Cd(NO_3)_2$. The molarity of solution after electrolysis would be
   1) 0.46 M 2) 0.91 M 3) 1.25 M 4) 0.625 M
2. When an aqueous concentrate solution of lithium chloride is electrolysed using inert electrodes:
   1) Cl_2 is liberated at the anode 2) Li is deposited at the cathode
   3) As the current flows, pH of the solution around the cathode remains constant
   4) As the current flows, pH of the solution around the cathode increases
3. The thermodynamic efficiency of cell is given by:
   1) $\Delta H/\Delta G$ 2) $nFE/\Delta G$ 3) $nFE/\Delta H$ 4) nFE^0
4. In a salt bridge, KCl is used because :
   1) It is an electrolyte
   2) It is cood conductor of electricity
   3) The transport number of K^+ and Cl^- ions are nearly same or both have same ionic mobility
   4) It is ionic compound

5. Which does not get oxidised by bromine water?
   1) Fe^{2+} to Fe^{3+} 2) Cu^{+} to Cu^{2+} 3) Mn^{2+} to MnO_4^- 4) Sn^{2+} to Sn^{4+}

6. The approximate EMF of a dry cell is
   1) 2.0V 2) 1.2V 3) 6V 4) 1.5V

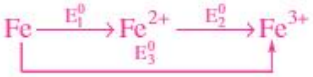
LEVEL-II

LECTURE SHEET (ADVANCED)

Straight Objective Type Questions

1. At 27^0C, $\left(\frac{\partial E^0}{\partial T}\right)_p = -1.25\times10^{-3}\,VK^{-1}$ and $E^0 = 1.36$ V for the cell, $Pt/H_{2(g)} \rightleftharpoons HCl_{(aq)}/Cl_2/Pt$
   Then the enthalpy change in the standard state is:
   a) –335 KJ b) –117 KJ c) 335 KJ d) –293 KJ

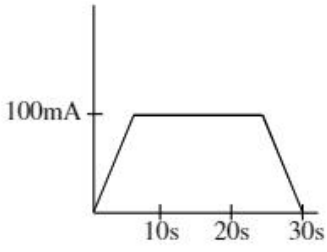
2. Value of E_3^0 may be calculated from



   a) $\frac{E_1^0}{E_2^0}+1$ b) $\frac{E_2^0+2E_1^0}{3}$ c) $\frac{E_1^0+E_2^0}{2}$ d) $\frac{E_1^0+2E_2^0}{2}$

3. Consider the following electrolytic reactions
   $CH_3COONa_{(aq)} \xrightarrow{Pt}$ Products ... (i) ; $CH_3CH_2CH_2COONa_{(aq)} \xrightarrow{Pt}$ Products ... (ii)
   In the first reaction, the ratio of gaseous products obtained at anode and cathode is 3:1 respectively. In second reaction this ratio is :
   a) 3:1 b) 1:3 c) 1:1 d) 2:1

4. In a Cu voltameter, mass deposited in 30 seconds is 100g. Carefully analyse the current-time graph shown below and identify the incorrect statement.
   a) Electrochemical equivalent for Cu is 50
   b) A constant current of 66.66 mA would also discharge the same amount in the same time
   c) 33.33 g got discharged in 10 seconds
   d) 50g got discharged in 15 seconds



5. At 25^0C, $Ag + I^- \rightarrow AgI + e$; $E^0 = 0.152$ V ; $Ag \rightarrow Ag^+ + e$; $E^0 = -0.80$ V
   The $\log K_{sp}$ of AgI is : $\left(\frac{2.303RT}{F} = 0.059V\right)$
   a) –8.12 b) +8.612 c) –37.83 d) –16.13

6. The cell, $Zn\left|Zn^{2+}(1M)\right\|Cu^{2+}(1M)Cu(E^0_{cell} = 1.10V)$, was allowed to be completely discharged at 298K. The relative concentration Zn^{2+} to Cu^{2+}, $\left[\frac{Zn^{2+}}{Cu^{2+}}\right]$ is:
   a) antilog (24.08) b) 37.3 c) $10^{37.3}$ d) 9.65×10^4

7. The EMF of the cell $Zn\underset{(0.01M)}{|Zn^{2+}|}\ \underset{(0.001M)}{|Fe^{2+}|}Fe$ at 298K is 0.2905, then the value of equilibrium constant for the cell reaction is :

a) $e^{0.32/0.0295}$ b) $10^{0.32/0.0295}$

c) $10^{0.26/0.0295}$ d) $10^{0.32/0.0591}$

More than One correct answer Type Questions

8. Which of the following are correct?

a) Chloride liberates Cl_2 but O_2 is also liberated as the solution is diluted which is due to over voltage.

b) Soluble iodides always liberate iodine at anode

c) Water is reduced in preference to cations having more negative reduction potential than –0.828V

d) Cation having less negative potential than –0.828 V are reduced in preference to water.

9. In hydrogen fuel cell _____

a) H_2 and O_2 are consumed in 1:8 mass ratio

b) H_2 and O_2 are consumed in 1:8 volume ratio

c) H_2 and O_2 are consumed in 2:1 mole ratio

d) 18gms of water is formed on producing 2 faradays of current

10. Which of the following is/are correct ?

a) IA group metals are extracted by the electrolysis their fused salts

b) F_2 is only extracted by electrolysis method

c) Li can be extracted by chemical and electrolytic methods

d) Cu, Ag, metals are purified by electrolytic method

11. Which statements is/are correct ?

a) In voltaic cell oxidation occurs at anode

b) In an electrolytic cell reduction occurs at cathode

c) In a conductivity cell electrolysis does not take place

d) H^+ has greater conductance than OH^-

PRACTICE SHEET (ADVANCED)

Matrix Matching Type Questions

1.

Column-I	Column-II
A) If SOP of substance is exist between –1.23 to – 0.81V	p) Oxidation of substance is not possible
B) If SOP of substance is exist between –0.81V to – 0.40V	q) Possible only in acidic medium
C) If SOP is less than –1.23 V	r) Possible in any medium
D) If SOP is greater than –0.40 V	s) Oxidation easily takes place

2. $E^0_{Ag^+/Ag} = 0.8V$ $K_{sp}AgCl = 10^{-10}$. Match the following Column-I with Column-II.

Column-I	Column-II
A) $Pt H_2(0.1\ Bar) \mid H^+(0.1M) \mid H^+(1M) \mid H_2(0.01\ Bar)\ Pt$	p) Concentration cell
B) $Ag \mid AgCl$ (KCl 0.1 M) $\mid Ag^+$ (0.01M) $\mid Ag$	q) $E_{cell} > 0$
C) $Cu \mid Cu^{2+}(0.1\ M) \parallel Cu^{2+}$ (0.01 M) $\mid Cu$	r) $E^0_{cell} = 0$ but cell is working
D) Pt / Cl_2(1bar) HCl(0.1M) $\parallel$ NaCl(0.1M) $\mid Cl_2$(1 bar) pt	s) non working condition

3.

Column-I	Column-II
A) Electrode reversible with respect to cation	p) $Pt/Fe^{2+}, Fe^{3+}$
B) Electrode reversible with respect to anion	q) Pt, H_2(1atm)/H^+ (a = 1)
C) Redox electrode	r) $Ag/AgCl_{(g)}; HCl_{(aq)}$
D) Reference electrode	s) $Ag/AgNO_3$

4.

Column-I	Column-II
A) $Pt\left\vert H_2(1atm)\right\vert ; H^+(3\times10^{-4}M)\left\Vert H^+(M)\right\vert$ $H_2(1atm)\vert Pt, E = 0.154V$	p) M' = 0.121
B) $Ni\left\vert Ni^{2+}(M')\right\vert ; \left\vert Cu^{2+}(1M)\right\vert Cu$, $E = 0.59V$ $E^0_{Ni^{2+}\mid Ni} = -0.25V$, $E^0_{Cu^{2+}\mid Cu} = 0.34V$	q) M' = 1M
C) $Zn_{(s)} + Ag_2O_{(s)} + H_2O_{(l)} \rightarrow 2Ag_{(s)} + Zn^{2+}_{(aq)} + 2OH^-_{(aq)}$ When $E^0_{cell} = 1.11V$ at 298K	r) $K \approx 10^{37}$
D) $2Fe^{3+} + Sn^{2+} \rightarrow 2Fe^{2+} + Sn^{4+}$; $E^0_{Sn^{4+}/Sn^{2+}} = 0.15V$; $E^0_{Fe^{3+}/Fe^{2+}} = 0.771V$	s) $K = 10^{21}$

5.

Column-I	Column-II
A) Cathode in electrolytic cell	p) Negative polarity
B) Anode in electrolytic cell	q) Positive polarity
C) $Cu_{(s)}\left\vert Cu^{2+}(0.01M)\right\Vert Ag^+(0.1M)\left\vert Ag\right.$ $[Ag^+] = 10^{-3}$ M; $[Cu^{2+}] = 10^{-4}$ M	r) $E_{cell} = E^0_{cell}$
D) $2Ag^+ + Cu \rightarrow 2Ag + Cu^{2+}$	s) $E_{cell} \neq E^0_{cell}$

6.

Column-I	Column-II
A) $Pt\left\vert H_2(1atm)\right\vert H^+(1M)$	p) Wrong representation
B) $Pt\left\vert Cl^-\right\vert Cl_2$	q) Electrolyte concentration cell
C) $Pt\left\vert H_2(1atm)\right\vert H^+(C_1)\left\Vert H^+(C_2)\right\vert H_2(1atm)\vert Pt$	r) Standard hydrogen electrode
D) $Pt\left\vert H_2(P_1\ atm)\right\vert H^+(1M)\left\Vert H^+(1M)\right\vert H_2(P_2\ atm)\vert\ Pt$	s) Electrode concentration cell

7.

Column-I	Column-II (SRP)
A) $F_2 + 2e^- \rightleftharpoons 2F^-$	p) 0.54 V
B) $Cl_2 + 2e^- \rightleftharpoons 2Cl^-$	q) 1.09 V
C) $Br_2 + 2e^- \rightleftharpoons 2Br^-$	r) 1.36 V
D) $I_2 + 2e^- \rightleftharpoons 2I^-$	s) 2.87 V

Integer Type Questions

8. The e.m.f of the cell : $H_2(g)$ |Buffer| |Normal calomel electrodes is 0.6885 volt at 25°C, when barometric pressure is 760 mm Hg. What is the pH of the buffer solution? Given $E^0_{calomel} = 0.28$ volt
9. The standard oxidation potential of Ni/Ni^{2+} electrode is 0.236 V. If this is combined with a hydrogen electrode in acid solution, at what pH of this solution will be measured e.m.f be zero at 25°C? Assume that $[Ni^{2+}] = 1M$ and $P_{H_2} = 1$ atm
10. Calculate the cell potential (in V) if $\Delta G = -96.5$ kJ/mol and n = 1.
11. If K_c for the reaction $Cu^{2+}_{(aq)} + Sn^{2+}_{(aq)} \rightarrow Sn^{4+}_{(aq)} + Cu_{(s)}$ at 25°C is represented as $y \times 10^6$ then find the value of y. (Given : $E^0_{Cu^{2+}|Cu} = 0.34V$; $E^0_{Sn^{4+}|Sn^{2+}} = 0.15V$)
12. The equilibrium constant of the reaction
$Cu_{(s)} + 2Ag^+_{(aq)} \rightleftharpoons Cu^{+2}_{(aq)} + 2Ag_{(s)}$; is $x \times 10^{15}$; 'x' is ($E^0 = 0.46$ V at 298 K)
13. 10800C of electricity causes the deposition of 2.977 g of metal with atomic mass 106.4 g mol^{-1}. Find the charge on the metal cations.
14. What is the quantity of charge needed for the reduction of 1 mole of MnO_4^- ion to Mn^{2+} ion ?
15. 3 ampere current was passed through an aqueous solution of an unknown salt of Pd for 1 hr 2.977 g of Pd^{n+} was deposited at cathode. Find the value of n. (atomic weight of Pd is 106.4)
16. The half cell potential of a half cell $A^{(x+n)+}, A^{x+}|Pt$ were found to be as follows:

% of reduced form	24.4	48.8
Half cell potential (V)	0.101	0.115

The value of 'n' is
17. An alloy of Pb-Ag weighing 1.08 g was dissolved in dilute HNO_3 and the volume made to 100 mL. A silver electrode was dipped in the solution and EMF of the cell set up
$Pt_{(s)}, H_{2(g)} \left| H^+(1M) \right\| Ag^+_{(aq)} \left| Ag_{(s)} \right.$ was 0.62V. The percentage of Ag in the alloy is :
18. How many electrons would reflect in the nernst equation of the conversion of one mole of Mn_3O_4 in the MnO_2?
19. How many kJ of energy is expected during the passage of 1 ampere current for 90 sec under a potential of 100 V?

KEY SHEET (ADDITIONAL PRACTICE EXERCISE)

LEVEL-I (MAIN)

1) **2** 2) **1,4** 3) **3** 4) **3** 5) **3** 6) **4**

LEVEL-II

LECTURE SHEET (ADVANCED)

1) **a** 2) **b** 3) **d** 4) **c** 5) **d** 6) **c** 7) **b** 8) **abcd** 9) **acd** 10) **abd**
11) **abcd**

PRACTICE SHEET (ADVANCED)

1) **A-q; B-r; C-p D-s** 2) **A-pqr; B-pqr; C-ps D-ps** 3) **A-s; B-r; C-p D-q**
4) **A-p; B-q; C-r D-s** 5) **A-p; B-q; C-r D-s** 6) **A-r; B-p; C-q D-s**
7) **A-s; B-r; C-q D-p** 8) **7** 9) **4** 10) **1** 11) **6** 12) **4** 13) **4** 14) **5**
15) **4** 16) **2** 17) **1** 18) **4** 19) **9**