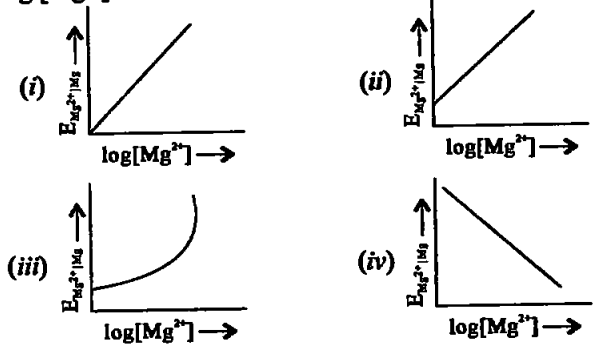
3 Electrochemistry

I. Multiple Choice Questions (Type-I)

1. Which cell will measure standard electrode potential of copper electrode?
   (*i*) Pt (s) | H_2 (g,0.1 bar) | H^+ (aq.,1 M) || Cu^{2+} (aq.,1M) | Cu
   (*ii*) Pt (s) | H_2 (g, 1 bar) | H^+ (aq.,1 M) || Cu^{2+} (aq.,2 M) | Cu
   (*iii*) Pt (s) | H_2 (g, 1 bar) | H^+ (aq.,1 M) || Cu^{2+} (aq.,1 M) | Cu
   (*iv*) Pt (s) | H_2 (g, 1 bar) | H^+ (aq.,0.1 M) || Cu^{2+} (aq.,1 M) | Cu

Ans. (*iii*)

2. Electrode potential for Mg electrode varies according to the equation $E_{Mg^{2+}|Mg} = E^{\ominus}_{Mg^{2+}|Mg} - \frac{0.059}{2} \log \frac{1}{[Mg^{2+}]}$. The graph of $E_{Mg^{2+}|Mg}$ vs log $[Mg^{2+}]$ is



Ans. (*ii*)

3. Which of the following statement is correct?
   (*i*) E_{Cell} and $\Delta_r G$ of cell reaction both are extensive properties.
   (*ii*) E_{Cell} and $\Delta_r G$ of cell reaction both are intensive properties.
   (*iii*) E_{Cell} is an intensive property while $\Delta_r G$ of cell reaction is an extensive property.
   (*iv*) E_{Cell} is an extensive property while $\Delta_r G$ of cell reaction is an intensive property.

Ans. (*iii*)

4. The difference between the electrode potentials of two electrodes when no current is drawn through the cell is called _____.
   (*i*) Cell potential (*ii*) Cell emf
   (*iii*) Potential difference (*iv*) Cell voltage

Ans. (*ii*)

5. Which of the following statement is **not** correct about an inert electrode in a cell?
   (*i*) It does not participate in the cell reaction.
   (*ii*) It provides surface either for oxidation or for reduction reaction.
   (*iii*) It provides surface for conduction of electrons
   (*iv*) It provides surface for redox reaction.

Ans. (*iv*)

6. An electrochemical cell can behave like an electrolytic cell when _____.
   (*i*) $E_{cell} = 0$ (*ii*) $E_{cell} > E_{ext}$
   (*iii*) $E_{ext} > E_{cell}$ (*iv*) $E_{cell} = E_{ext}$

Ans. (*iii*)

7. Which of the statements about solutions of electrolytes is **not** correct?
   (*i*) Conductivity of solution depends upon size of ions.
   (*ii*) Conductivity depends upon viscosiy of solution.
   (*iii*) Conductivity does not depend upon solvation of ions present in solution.
   (*iv*) Conductivity of solution increases with temperature

Ans. (*iii*)

8. Using the data given below find out the strongest reducing agent.
   $E^{\ominus}_{Cr_2O_7^{2-}/Cr^{3+}} = 1.33V$ $E^{\ominus}_{Cl_2/Cl^-} = 1.36V$
   $E^{\ominus}_{MnO_4^-/Mn^{2+}} = 1.51V$ $E^{\ominus}_{Cr^{3+}/Cr} = -0.74V$
   (*i*) Cl^- (*ii*) Cr
   (*iii*) Cr^{3+} (*iv*) Mn^{2+}

Ans. (*ii*)

Explanation: Out of four standard reduction potential, chromium has negative value. Hence, it is the stronget reducing agent.

9. Use the data given in Q.8 and find out which of the following is the strongest oxidising agent.
   (*i*) Cl^- (*ii*) Mn^{2+}
   (*iii*) MnO_4^- (*iv*) Cr^{3+}

Ans. (*iii*)

Explanation: Highest positive value of standard reduction potential means strongest oxidising agent. Hence, MnO_4^- is the strongest oxidising agent.

10. Using the data given in Q.8 find out in which option the order of reducing power is correct.
    (*i*) $Cr^{3+} < Cl^- < Mn^{2+} < Cr$ (*ii*) $Mn^{2+} < Cl^- < Cr^{3+} < Cr$
    (*iii*) $Cr^{3+} < Cl^- < Cr_2O_7^{2-} < MnO_4^-$ (*iv*) $Mn^{2+} < Cr^{3+} < Cl^- < Cr$

Ans. (*ii*)

Explanation: Lower the value of standard reduction potential greater will be the reducing power.

11. Use the data given in Q.8 and find out the most stable ion in its reduced form.

(*i*) Cl^- (*ii*) Cr^{3+}

(*iii*) Cr (*iv*) Mn^{2+}

Ans. (*iv*)

Explanation: MnO_4^-/Mn^{2+} has highest standard reduction potential hence most stable form among four is Mn^{2+}.

12. Use the data of Q.8 and find out the most stable oxidised species

(*i*) Cr^{3+} (*ii*) MnO_4^-

(*iii*) $Cr_2O_7^{2-}$ (*iv*) Mn^{2+}

Ans. (*i*)

Explanation: Cr^{3+}/Cr has most negative value of standard reduction potential. Hence, Cr^{3+} is the most stable oxidised species.

13. The quantity of charge required to obtain one mole of aluminium from Al_2O_3 is _____.

(*i*) 1F (*ii*) 6F

(*iii*) 3F (*iv*) 2F

Ans. (*iii*)

Explanation: In Al_2O_3 oxidation state of Al is Al^{3+}.

14. The cell constant of a conductivity cell _____.

(*i*) changes with change of electrolyte.

(*ii*) changes with change of concentration of electrolyte.

(*iii*) changes with temperature of electrolyte.

(*iv*) remains constant for a cell.

Ans. (*iv*)

15. While charging the lead storage battery _____.

(*i*) $PbSO_4$ anode is reduced to Pb.

(*ii*) $PbSO_4$ cathode is reduced to Pb.

(*iii*) $PbSO_4$ cathode is oxidised to Pb.

(*iv*) $PbSO_4$ anode is oxidised to PbO_2.

Ans. (*i*)

Explanation: When the lead storage battery is on charging

$$2PbSO_4(s) + 2H_2O(l) \rightarrow Pb(s) + PbO_2(s) + 2H_2SO_4(aq)$$

16. $\Lambda^0_{m(NH_4OH)}$ is equal to _____.

(*i*) $\Lambda^0_{m(NH_4OH)} + \Lambda^0_{m(NH_4Cl)} - \Lambda^0_{(HCl)}$

(*ii*) $\Lambda^0_{m(NH_4Cl)} + \Lambda^0_{m(NH_4OH)} - \Lambda^0_{(NaCl)}$

(*iii*) $\Lambda^0_{m(NH_4Cl)} + \Lambda^0_{m(NaCl)} - \Lambda^0_{(NaOH)}$

(*iv*) $\Lambda^0_{m(NaOH)} + \Lambda^0_{m(NaCl)} - \Lambda^0_{m(NH_4Cl)}$

Ans. (*ii*)

Explanation: Since we require only sum of molar conductivity of NH_4^+ and OH^-.

17. In the electrolysis of aqueous sodium chloride solution which of the half cell reaction will occur at anode?

(*i*) $Na^+(aq) + e^- \rightarrow Na(s)$; $E^\ominus_{Cell} = -2.71V$

(*ii*) $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$; $E^\ominus_{Cell} = 1.23V$

(*iii*) $H^+(aq) + e^- \rightarrow \frac{1}{2}H_2(g)$; $E^\ominus_{Cell} = 0.00V$

(*iv*) $Cl^-(aq) \rightarrow \frac{1}{2}Cl_2(g) + e^-$; $E^\ominus_{Cell} = 1.36V$

Ans. (*ii*) and (*iv*)

Explanation: At the anode the following oxidation reactions are possible:

$$Cl^-(aq) \rightarrow \frac{1}{2}Cl_2(g) + e^-; \quad E^\ominus_{Cell} = 1.36V$$

$$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-; \quad E^\ominus_{Cell} = 1.23V$$

lower value of $E^\ominus$ is preferred and therefore, water should get oxidised in preference to $Cl^-(aq)$. However, on account of overpotential of oxygen, reaction $Cl^-(aq) \rightarrow \frac{1}{2}Cl_2(g) + e^-$ is preferred.

II. Multiple Choice Questions (Type-II)

Note: In the following questions two or more than two options may be correct.

18. The positive value of the standard electrode potential of Cu^{2+}/Cu indicates that _____.

(*i*) this redox couple is a stronger reducing agent than the H^+/H_2 couple.

(*ii*) this redox couple is a stronger oxidising agent than H^+/H_2.

(*iii*) Cu can displace H_2 from acid.

(*iv*) Cu cannot displace H_2 from acid.

Ans. (*ii*) and (*iv*)

Explanation: Lower the value of standard reduction potential higher will be the reducing power.

19. $E^\ominus_{Cell}$ for some half cell reactions are given below. On the basis of these mark the correct answer.

(*a*) $H^+(aq) + e^- \rightarrow \frac{1}{2}H_2(g)$; $E^\ominus_{Cell} = 0.00V$

(*b*) $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$; $E^\ominus_{Cell} = 1.23V$

(*c*) $2SO_4^{2-}(aq) \rightarrow S_2O_8^{2-}(aq) + 2e^-$; $E^\ominus_{Cell} = 1.96\ V$

(*i*) In dilute sulphuric acid solution, hydrogen will be reduced at cathode.

(*ii*) In concentrated sulphuric acid solution, water will be oxidised at anode.

(*iii*) In dilute sulphuric acid solution, water will be oxidised at anode.
(*iv*) In dilute sulphuric acid solution, SO_4^{2-} ion will be oxidised to tetrathionate ion at anode.

Ans. (*i*) and (*iii*)

Explanation: In the electrolysis of dil. H_2SO_4 above three reaction takes place.

Oxidation half reaction occurs at anode, lower value of standard reduction potential will be preferred. At cathode hydrogen ion will be converted into hydrogen.

20. $E^{\ominus}_{Cell} = 1.1V$ for Daniel cell. Which of the following expressions are correct description of state of equilibrium in this cell?

(*i*) $1.1 = K_C$ (*ii*) $\frac{2.303RT}{2F}\log K_C = 1.1$

(*iii*) $\log K_C = \frac{2.2}{0.059}$ (*iv*) $\log K_C = 1.1$

Ans. (*ii*) and (*iii*)

Explanation: $\Delta_r G_0 = -2.303\ RT \log K_C$

$$E^{\ominus}_{Cell} = \frac{2.303RT}{2F}\log K_C = 1.1$$

21. Conductivity of an electrolytic solution depends on _____.

(*i*) nature of electrolyte. (*ii*) concentration of electrolyte.
(*iii*) power of AC source. (*iv*) distance between the electrodes.

Ans. (*i*) and (*ii*)

Explanation: Conductivity or specific conductance κ (kappa): It is the conductance of solution kept between two electrodes with 1 m^2 area of cross section and distance of 1 m. It is the reciprocal of resistivity (ρ).

$\kappa = 1/\rho$.

S.I unit of $\kappa = Sm^{-1}$

It depends on the nature of the electrolyte and concentration of the electrolyte .

22. $\Lambda^0_{m(H_2O)}$ is equal to

(*i*) $\Lambda^0_{m(HCl)} + \Lambda^0_{m(NaOH)} - \Lambda^0_{m(NaCl)}$

(*ii*) $\Lambda^0_{m(HNO_3)} + \Lambda^0_{m(NaNO_3)} - \Lambda^0_{m(NaOH)}$

(*iii*) $\Lambda^0_{(HNO_3)} + \Lambda^0_{m(NaOH)} - \Lambda^0_{m(NaNO_3)}$

(*iv*) $\Lambda^0_{m(NH_4OH)} + \Lambda^0_{m(HCl)} - \Lambda^0_{m(NH_4Cl)}$

Ans. (*i*) and (*iv*)

Explanation: This problem is based on the concept of Kohlrausch law of independent migration of ions: (Λ^0_m) is the sum of limiting molar conductivities of cation (λ^0_+) and anion (λ^0_-). $\Lambda^0_m = \nu^+\lambda^0_+ + \nu^-\lambda^0_-$

23. What will happen during the electrolysis of aqueous solution of $CuSO_4$ by using platinum electrodes?
(*i*) Copper will deposit at cathode.
(*ii*) Copper will deposit at anode.
(*iii*) Oxygen will be released at anode.
(*iv*) Copper will dissolve at anode.

Ans. (*i*) and (*iii*)

Explanation: During electrolysis following reaction takes place at cathode:

$$Cu^{2+} + 2e^- \rightarrow Cu$$

$$H^+ + e^- \rightarrow \frac{1}{2}H_2$$

Standard electrode potential of Cu^{2+}/Cu is greater than $H^+/\frac{1}{2}H_2$ therefore Cu will deposite at cathode.

24. What will happen during the electrolysis of aqueous solution of $CuSO_4$ in the presence of Cu electrodes?
(*i*) Copper will deposit at cathode.
(*ii*) Copper will dissolve at anode.
(*iii*) Oxygen will be released at anode.
(*iv*) Copper will deposit at anode.

Ans. (*i*) and (*ii*)

25. Conductivity κ, is equal to _____.
(*i*) $\frac{1}{R}\frac{1}{A}$ (*ii*) $\frac{G^*}{R}$
(*iii*) Λ_m (*iv*) $\frac{l}{A}$

Ans. (*i*) and (*ii*)

Explanation: $R = \rho L/A$ $1/\rho = \frac{1}{R}\frac{1}{A}$

Conductivity κ = Conductance (G) × Cell constant (G^*)

26. Molar conductivity of ionic solution depends on _____.
(*i*) temperature
(*ii*) distance between electrodes.
(*iii*) concentration of electrolytes in solution.
(*iv*) surface area of electrodes.

Ans. (*i*) and (*iii*)

Explanation: Λ_m ($S\ cm^2\ mol^{-1}$) = K

On increasing the temperature molar conductivity increases whereas molar conductivity decreases on increasing the concentration.

27. For the given cell, $Mg|Mg^{2+} || Cu^{2+}|Cu$
(*i*) Mg is cathode
(*ii*) Cu is cathode

(*iii*) The cell reaction is $Mg + Cu^{2+} \rightarrow Mg^{2+} + Cu$

(*iv*) Cu is the oxidising agent

Ans. (*ii*) and (*iii*)

Explanation: Left side of the cell represent oxidation half cell and right side represent reduction half cell.

III. Short Answer Type

28. Can absolute electrode potential of an electrode be measured?

Ans. No only the difference in potential between two electrode can be measured.

29. Can $E^{\ominus}_{Cell}$ or $\Delta_r G$ for cell reaction ever be equal to zero?

Ans. At equilibrium $G = 0$ $E_{cell} = 0$

30. Under what condition is $E_{Cell} = 0$ or $\Delta_r G = 0$?

Ans. $E_{Cell} = 0$ at equilibrium $\Delta_r G = -nF E_{Cell}$

$\Delta_r G = 0$

31. What does the negative sign in the expression $E^{\ominus}_{Zn^{2+}/Zn} = -0.76$ V mean?

Ans. A negative *E*.means that the redox couple is a stronger reducing agent than the H^+/H^2 couple.

32. Aqueous copper sulphate solution and aqueous silver nitrate solution are electrolysed by 1 ampere current for 10 minutes in separate electrolytic cells. Will the mass of copper and silver deposited on the cathode be same or different? Explain your answer.

Ans. It will be different. According to Faraday's second law, the amounts of different substances liberated by the same quantity of electricity passing through the electrolytic solution are proportional to their chemical equivalent weights $\frac{\text{Atomic mass of metal}}{\text{No. of electrons}}$ electrons required to reduce the cation.

Here, for the electrode reactions:

$$Cu^{2+} + 2e^- \rightarrow Cu(s)$$

$$Ag^+ + e^- \rightarrow Ag(s)$$

Hence, one mole of Cu^{2+} and Ag^{3+} require 2 mol of electron (2F) and 1 mol of electrons (F_1) respectively.

33. Depict the galvanic cell in which the cell reaction is

$Cu + 2Ag^+ \rightarrow 2Ag + Cu^{2+}$

Ans. $Cu + 2Ag^+ \rightarrow 2Ag + Cu^{2+}$ cell can be represented is $Cu \mid Cu^{2+} \parallel Ag^+ \mid Ag$

34. Value of standard electrode potential for the oxidation of Cl^- ions is more positive than that of water, even then in the electrolysis of aqueous sodium chloride, why is Cl^- oxidised at anode instead of water?

Ans. At the anode the following oxidation reactions are possible:

$$Cl^-(aq) \rightarrow \frac{1}{2} Cl_2(g) + e^-$$

$E^{\ominus}_{Cell} = 1.36$ V

$2H_2O\ (l) \rightarrow O_2\ (g) + 4H^+(aq) + 4e^-$

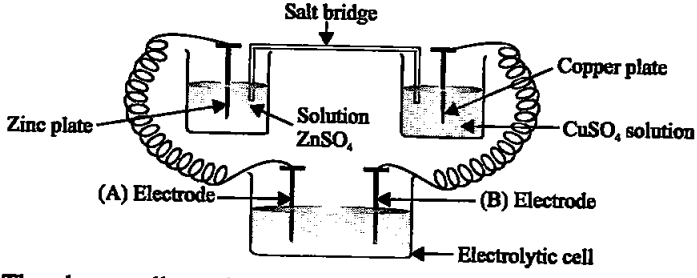
$E^{\ominus}_{Cell} = 1.23\ V$

The reaction at anode with lower value of $E^{\ominus}$ is preferred and therefore, water should get oxidised in preference to $Cl^-(aq)$. However, on account of overpotential of oxygen, oxidation of cl^- is preferred.

35. What is electrode potential?

Ans. A potential difference developing between the electrode and the electrolyte is known as electrode potential.

36. Consider the following diagram in which an electrochemical cell is coupled to an electrolytic cell. What will be the polarity of electrodes 'A' and 'B' in the electrolytic cell?



Ans. The above cell can be represented as $Zn \mid Zn^{2+} \parallel Cu^{2+} \mid Cu$ Zinc is oxidized at anode and copper is reduced at cathode.

A has negative polarity and B has positive polarity.

37. Why is alternating current used for measuring resistance of an electrolytic solution?

Ans. Alternating current is used for measuring the resistance of an electrolytic solution because DC current can change the composition of the solution and the concentration will not remain constant.

38. A galvanic cell has electrical potential of 1.1V. If an opposing potential of 1.1V is applied to this cell, what will happen to the cell reaction and current flowing through the cell?

Ans. When $E_{cell} = E_{ext}$ current will stop flowing.

39. How will the pH of brine (aq. NaCl solution) be affected when it is electrolysed?

Ans. As the product of electrolysis NaOH will be formed which will increase the pH of the solution. The net reaction in the electrolysis.

$NaCl\ (aq) + H_2O\ (l) \rightarrow Na^+(aq) + OH^-(aq) + \frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g)$

40. Unlike dry cell, the mercury cell has a constant cell potential throughout its useful life. Why?

Ans. Ions are not involved in the overall reaction of the mecury cell. Thus the mercury cell has constant voltage through out the life.

41. Solutions of two electrolytes 'A' and 'B' are diluted. The Λ_m of 'B' increases 1.5 times while that of A increases 25 times. Which of the two is a strong electrolyte? Justify your answer.

Ans. 'B' is strong electrolyte. For strong electrolyte Λ_m increases slowly with dilution since the number of ions remains the same only the interionic attraction decrease thus the molar conductivity increases slightly.

42. When acidulated water (dil. H_2SO_4 solution) is electrolysed, will the pH of the solution be affected? Justify your answer.

Ans. pH of the solution remains constant as H^+ remains same during the whole reaction.

At anode: $2H_2O\,(l) \rightarrow O_2\,(g) + 4H^+ + 4e^-$

At cathode: $4H^+ + 4e^- \rightarrow 2H_2\,(g)$

43. In an aqueous solution how does specific conductivity of electrolytes change with addition of water?

Ans. Conductivity always decreases with decrease in concentration for both, weak and strong electrolytes. This can be explained by the fact that the number of ions per unit volume that carry the current in a solution decreases on dilution.

44. Which reference electrode is used to measure the electrode potential of other electrodes?

Ans. SHE (standard hydrogen electrode) is used as a reference electrode to measure the standard electrode potential of the other electrode by assigning standard electrode potential of SHE as zero. [$E^0\,H^+$ = zero].

45. Consider a cell given below:

$Cu \mid Cu^{2+} \parallel Cl^- \mid Cl_2, Pt.$

Write the reactions that occur at anode and cathode.

Ans. Two half cell of the cell reaction can be represented as:

At anode: $Cu \rightarrow Cu^{2+} + 2e^-$

At cathode: $Cl_2 + 2e^- \rightarrow 2Cl^-$

46. Write the Nernst equation for the cell reaction in the Daniel cell. How will the E_{Cell} be affected when concentration of Zn^{2+} ions is increased?

Ans. $E_{(cell)} = E^0_{Cell} - \frac{0.059}{2}\log\frac{[Zn^{2+}]}{[Cu^{2+}]}$.

E_{cell} will decrease when the concentration of Zn^{2+} increases.

47. What advantage do the fuel cells have over primary and secondary batteries?

Ans. Advantages:

(*a*) High efficiency (*b*) Continuous source of energy

(*c*) Pollution free.

48. Write the cell reaction of a lead storage battery when it is discharged. How does the density of the electrolyte change when the battery is discharged?

Ans. $Pb(s) + PbO_2(s) + 2H_2SO_4 \rightarrow 2PbSO_4(s) + 2H_2O(l)$
Density of the electrolyte will decrease as water is formed and sulphuric acid is consumed.

49. Why on dilution the Λ_m of CH_3COOH increases drastically, while that of CH_3COONa increases gradually?

Ans. **For weak electrolyte(CH_3COOH):** Λ_m increases steeply on dilution due to increase in the number of ions (or the degree of dissociation). For strong electrolytes (CH_3COONa): Λ_m increases as number of ions remains the same but the interionic attraction decreases.

IV. Matching Type

Note: Match the items of Column I and Column II in the following questions.

50. Match the terms given in Column I with the units given in Column II.

Column I	Column II
(*i*) Λ_m	(*a*) $S\ cm^{-1}$
(*ii*) E_{Cell}	(*b*) m^{-1}
(*iii*) κ	(*c*) $S\ cm^2\ mol^{-1}$
(*iv*) G^*	(*d*) V

Ans. (*i*) → (*c*) (*ii*) → (*d*)
(*iii*) → (*a*) (*iv*) → (*b*)

51. Match the terms given in Column I with the items given in Column II.

Column I	Column II
(*i*) Λ_m	(*a*) intensive property
(*ii*) $E^{\ominus}_{Cell}$	(*b*) depends on number of ions/volume
(*iii*) κ	(*c*) extensive property
(*iv*) $\Delta_r G_{Cell}$	(*d*) increases with dilution

Ans. (*i*) → (*d*) (*ii*) → (*a*)
(*iii*) → (*b*) (*iv*) → (*c*)

52. Match the items of Column I and Column II.

Column I	Column II
(*i*) Lead storage battery	(*a*) maximum efficiency
(*ii*) Mercury cell	(*b*) prevented by galvanisation
(*iii*) Fuel cell	(*c*) gives steady potential
(*iv*) Rusting	(*d*) Pb is anode, PbO_2 is cathode

Ans. (*i*) → (*d*) (*ii*) → (*c*)
(*iii*) → (*a*) (*iv*) → (*b*)

53. Match the items of Column I and Column II.

Column I	Column II
(*i*) κ	(*a*) I × t
(*ii*) Λ_m	(*b*) Λ_m / Λ_m^0
(*iii*) α	(*c*) κ / c
(*iv*) Q	(*d*) G*/ R

Ans. (*i*) → (*d*) (*ii*) → (*c*)
(*iii*) → (*b*) (*iv*) → (*a*)

54. Match the items of Column I and Column II.

Column I	Column II
(*i*) Lechlanche cell	(*a*) cell reaction $2H_2 + O_2 \rightarrow 2H_2O$
(*ii*) Ni–Cd cell	(*b*) does not involve any ion in solution and is used in hearing aids.
(*iii*) Fuel cell	(*c*) rechargeable
(*iv*) Mercury cell	(*d*) reaction at anode, $Zn \rightarrow Zn^{2+} + 2e^-$
	(*e*) converts energy of combustion into electrical energy

Ans. (*i*) → (*d*) (*ii*) → (*c*)
(*iii*) → (*e*) (*iv*) → (*b*)

55. Match the items of Column I and Column II on the basis of data given below:

$E^{\ominus}_{F_2/F^-} = 2.87V, E^{\ominus}_{Li^+/Li} = -3.5V, E^{\ominus}_{Au^{3+}/Au} = 1.4V, E^{\ominus}_{Br_2/Br} = 1.09V$

Column I	Column II
(*i*) F_2	(*a*) metal is the strongest reducing agent
(*ii*) Li	(*b*) metal ion which is the weakest oxidising agent
(*iii*) Au^{3+}	(*c*) non metal which is the best oxidising agent
(*iv*) Br^-	(*d*) unreactive metal
(*v*) Au	(*e*) anion that can be oxidised by Au^{3+}
(*vi*) Li^+	(*f*) anion which is the weakest reducing agent
(*vii*) F^-	(*g*) metal ion which is an oxidising agent

Ans. (*i*) → (*c*) (*ii*) → (*a*) (*iii*) → (*g*)
(*iv*) → (*e*) (*v*) → (*d*) (*vi*) → (*b*)
(*vii*) → (*f*)

V. Assertion and Reason Type

Note: In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(*i*) Both assertion and reason are true and the reason is the correct explanation of assertion.

(*ii*) Both assertion and reason are true and the reason is not the correct explanation of assertion.

(*iii*) Assertion is true but the reason is false.

(*iv*) Both assertion and reason are false.

(*v*) Assertion is false but reason is true.

56. Assertion: Cu is less reactive than hydrogen.

Reason: $E^{\ominus}_{Cu^{2+}/Cu}$ is negative

Ans. (*iii*)

Explanation: Standard electrode potential of $E^{\ominus}_{Cu^{2+}/Cu}$ = 0.34V and $E^{\ominus}_{H^+/H}$ = 0.00V. This shows that copper is less reactive than hydrogen.

57. Assertion: E_{Cell} should have a positive value for the cell to function.

Reason: $E_{cathode} < E_{anode}$

Ans. (*iii*)

Explanation: For the cell reaction to be feasible $E_{cathode}$ should be positive. $\Delta_r G^0 = -$ nF E^0 cell for the value of E^0 cell to be positive $E_{cathode} > E_{anode}$

58. Assertion : Conductivity of all electrolytes decreases on dilution.

Reason : On dilution number of ions per unit volume decreases.

Ans. (*i*)

Explanation: Conductivity always decreases with decrease in concentration both, for weak and strong electrolytes. This can be explained by the fact that the number of ions per unit volume that carry the current in a solution decreases on dilution

59. Assertion : Λ_m for weak electrolytes shows a sharp increase when the electrolytic solution is diluted.

Reason : For weak electrolytes degree of dissociation increases with dilution of solution.

Ans. (*i*)

Explanation: For weak electrolyte: Λ_m increases steeply on dilution due to increase in the number of ions (or the degree of dissociation).

60. Assertion : Mercury cell does not give steady potential.

Reason : In the cell reaction, ions are not involved in solution.

Ans. (*v*)

Explanation: Correct assertion is mercury cell gives steady potential.

61. Assertion : Electrolysis of NaCl solution gives chlorine at anode instead of O_2.

Reason : Formation of oxygen at anode requires overvoltage

Ans. (*i*)

Explanation: At the anode the following oxidation reactions are possible:

$$Cl^-(aq) \rightarrow \frac{1}{2}Cl_2(g) + e^-;\ E = 1.36\ V$$

$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$; E = 1.23 V

Lower value of E_{cell} is preferred but due to overvoltage chlorine is liberated at anode.

62. Assertion : For measuring resistance of an ionic solution an AC source is used.

Reason : Concentration of ionic solution will change if DC source is used.

Ans. (*i*)

Explanation: DC current can change the composition of electrolytic solution.

63. Assertion : Current stops flowing when $E_{Cell} = 0$.

Reason : Equilibrium of the cell reaction is attained.

Ans. (*i*)

Explanation: At equilibrium $E_{cell} = 0$ and therefore current stops flowing.

64. Assertion : $E_{Ag^+/Ag}$ increases with increase in concentration of Ag^+ ions.

Reason : $E_{Ag^+/Ag}$ has a positive value.

Ans. (*ii*)

Explanation: $E_{cell} = E^0_{cell} - 0.059 \log 1/[Ag^+]$ therefore $E_{Ag^+/Ag}$ increases with increase in concentration of Ag^+

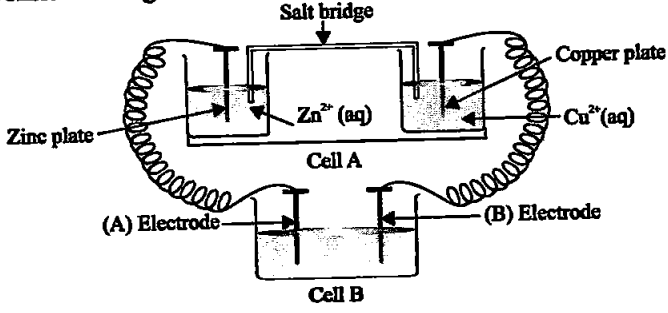
65. Assertion : Copper sulphate can be stored in zinc vessel.

Reason : Zinc is less reactive than copper.

Ans. (*iv*)

VI. Long Answer Type

66. Consider the figure and answer the following questions.



(*i*) Cell 'A' has $E_{Cell} = 2V$ and Cell 'B' has $E_{Cell} = 1.1V$ which of the two cells 'A' or 'B' will act as an electrolytic cell. Which electrode reactions will occur in this cell?

(*ii*) If cell 'A' has $E_{Cell} = 0.5V$ and cell 'B' has $E_{Cell} = 1.1V$ then what will be the reaction at cathode and anode.

Ans. (*i*) Cell 'B' will act as an electrolytic cell following reaction can take place at cathode and anode.

At cathode : $Zn^{2+} + 2e^- \longrightarrow Zn$

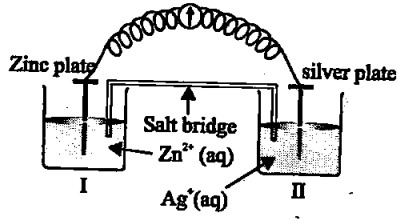
At anode : $Cu \longrightarrow Cu^{2+} + 2e^-$

(*ii*) Now the cell 'B' has higher e.m.f and it will act as an electrochemical cell.

At cathode : $Cu^{2+} + 2e^- \longrightarrow Cu$

At anode : $Zn \longrightarrow Zn^{2+} + 2e^-$

67. Consider the figure and answer the questions (*i*) to (*vi*) given below:



(*i*) Redraw the diagram to show the direction of electron flow.

(*ii*) Is silver plate the anode or cathode?

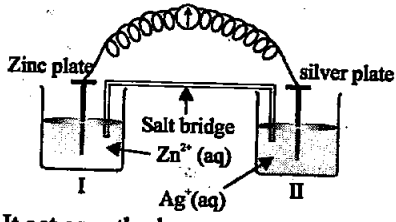
(*iii*) What will happen if salt bridge is removed?

(*iv*) When will the cell stop functioning?

(*v*) How will concentration of Zn^{2+} ions and Ag^+ ions be affected when the cell functions?

(*vi*) How will the concentration of Zn^{2+} ions and Ag^+ ions be affected after the cell becomes 'dead'?

Ans. (*i*)



(*ii*) It act as cathode.

(*iii*) Cell will stop functioning.

(*iv*) When equilibrium is attained i.e., $E_{cell} = 0$

(*v*) Concentration of Zn^+ will increase and Ag^+ will decrease.

(*vi*) When $E_{cell} = 0$ (equlibrium is reached), concentration of Zn^{2+} ions Ag^+ ions will not change.

68. What is the relationship between Gibbs free energy of the cell reaction in a galvanic cell and the emf of the cell? When will the maximum work be obtained from a galvanic cell?

Ans. The reversible work done by the galvanic cell is equal to decrease in gibbs free energy.

$$\Delta_r G = -nF E_{0\,cell}$$

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