Unit

3

ELECTROCHEMISTRY

I. Multiple Choice Questions (Type-I)

1. Which cell will measure standard electrode potential of copper electrode?

(i) $Pt\,(s)\,|\,H_2\,(g,0.1\ bar)\,|\,H^+(aq.,1\ M)\,\|\,Cu^{2+}(aq.,1M)\,|\,Cu$

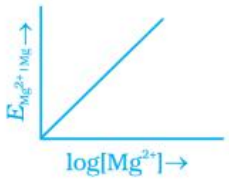
(ii) $Pt(s)\,|\,H_2\,(g,\ 1\ bar)\,|\,H^+(aq.,1\ M)\,\|\,Cu^{2+}(aq.,2\ M)\,|\,Cu$

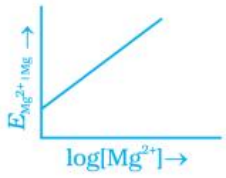
(iii) $Pt(s)\,|\,H_2\,(g,\ 1\ bar)\,|\,H^+(aq.,1\ M)\,\|\,Cu^{2+}(aq.,1\ M)\,|\,Cu$

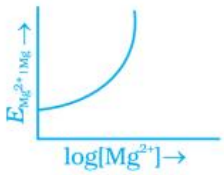
(iv) $Pt(s)\,|\,H_2\,(g,\ 1\ bar)\,|\,H^+(aq.,0.1\ M)\,\|\,Cu^{2+}(aq.,1\ M)\,|\,Cu$

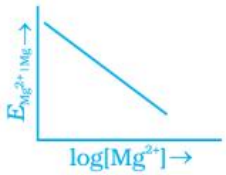
2. Electrode potential for Mg electrode varies according to the equation

$E_{Mg^{2+}|\,Mg} = E^{\ominus}_{Mg^{2+}|\,Mg} - \frac{0.059}{2}\log\frac{1}{[Mg^{2+}]}$. The graph of $E_{Mg^{2+}|\,Mg}$ vs $\log\,[Mg^{2+}]$ is

(i) 

(ii) 

(iii) 

(iv) 

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.

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

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.

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) $E_{cell} = E_{ext}$

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.

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+}

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+}

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) $Mn^{2+} < Cr^{3+} < Cl^- < Cr$

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+}

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+}

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

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.

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.

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

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

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

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

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

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

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

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

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

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

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.

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

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

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

(c) $2SO_4^{2-}\ (aq) \longrightarrow S_2O_8^{2-}\ (aq) + 2e^-$; $E^{\ominus}_{Cell} = 1.96\ V$

(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.

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) $\log K_c = 1.1$

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.

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

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.

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.

25. Conductivity κ, is equal to _____.

(i) $\frac{1}{R}\frac{l}{A}$

(ii) $\frac{G^*}{R}$

(iii) Λ_m

(iv) $\frac{l}{A}$

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.

27. For the given cell, $Mg|Mg^{2+}||Cu^{2+}|Cu$

(i) Mg is cathode

(ii) Cu is cathode

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

(iv) Cu is the oxidising agent

III. Short Answer Type

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

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

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

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

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.

33. Depict the galvanic cell in which the cell reaction is $Cu + 2Ag^{+} \longrightarrow 2Ag + Cu^{2+}$

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?

35. What is 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?

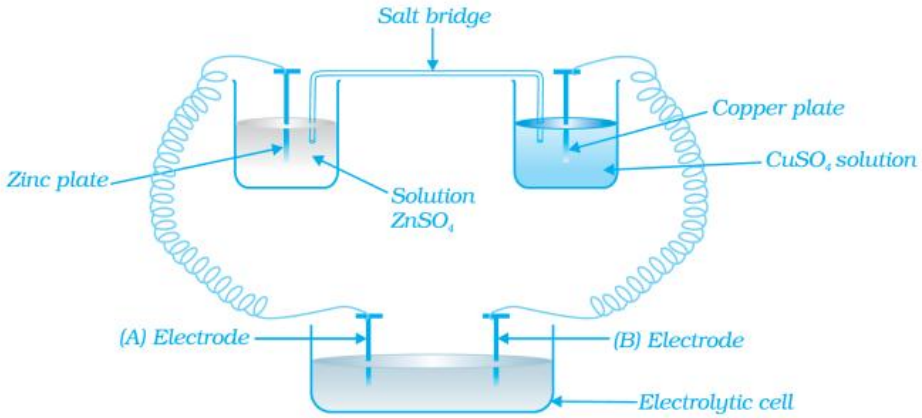


Fig. *3.1*

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

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?

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

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

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.

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

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

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

45. Consider a cell given below

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

Write the reactions that occur at anode and cathode

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?

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

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?

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

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

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

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

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

	Column I		**Column II**
(i)	κ	(a)	$I \times t$
(ii)	Λ_m	(b)	Λ_m / Λ_m^0
(iii)	α	(c)	$\frac{\kappa}{c}$
(iv)	Q	(d)	$\frac{G^*}{R}$

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

	Column I		**Column II**
(i)	Lechlanche cell	(a)	cell reaction $2H_2 + O_2 \longrightarrow 2H_2O$
(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, $Zn \longrightarrow Zn^{2+} + 2e^-$
		(e)	converts energy of combustion into electrical energy

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

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.

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

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

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

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

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.

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

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

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

Reason : Formation of oxygen at anode requires overvoltage.

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.

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

Reason : Equilibrium of the cell reaction is attained.

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

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

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

Reason : Zinc is less reactive than copper.

VI. Long Answer Type

66. Consider the Fig. 3.2 and answer the following questions.

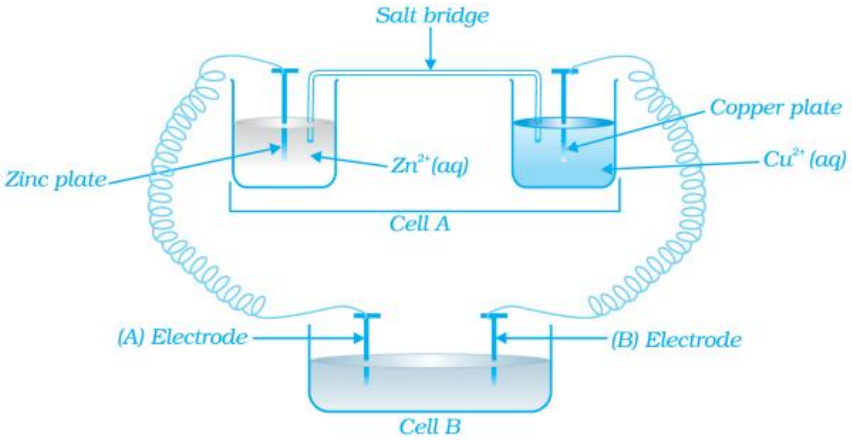


Fig. *3.2*

(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 reactions at anode and cathode?

67. Consider Fig. 3.2 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?

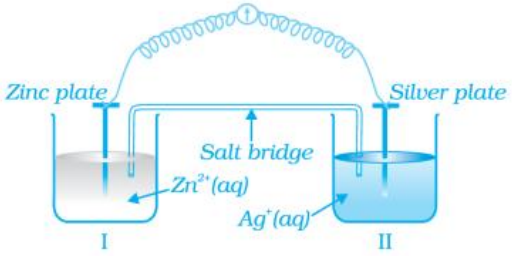


Fig. *3.3*

(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'?

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?

ANSWERS

I. Multiple Choice Questions (Type-I)

1. (iii)	2. (ii)	3. (iii)	4. (ii)	5. (iv)	6. (iii)
7. (iii)	8. (ii)	9. (iii)	10. (ii)	11. (iv)	12. (i)
13. (iii)	14. (iv)	15. (i)	16. (ii)	17. (ii)	

II. Multiple Choice Questions (Type-II)

18. (ii), (iv)	19. (i), (iii)	20. (ii), (iii)	21. (i), (ii)
22. (i), (iv)	23. (i), (iii)	24. (i), (ii)	25. (i), (ii)
26. (i), (iii)	27. (ii), (iii)		

III. Short Answer Type

28. No

29. No

30. When the cell reaction reaches equilibrium.

31. It means that Zn is more reactive than hydrogen. When zinc electrode will be connected to SHE, Zn will get oxidised and H^+ will get reduced.

32. Different, see the NCERT textbook, page no. 84.

33. $Cu \mid Cu^{2+} \mid\mid Ag^+ \mid Ag$

34. Under the conditions of electrolysis of aqueous sodium chloride, oxidation of water at anode requires overpotential hence Cl^- is oxidised instead of water.

35. See NCERT textbook, page no. 65

36. 'A' will have negative polarity

    'B' will have positive polarity

37. Alternating current is used to prevent electrolysis so that concentration of ions in the solution remains constant.

38. See NCERT textbook, page no. 64

39. The pH of the solution will rise as NaOH is formed in the electrolytic cell.

40. Ions are not involved in the overall cell reaction of mercury cells.

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41. Electrolyte 'B' is strong as on dilution the number of ions remains the same, only interionic attraction decreases therefore increase in $\wedge_m$ is small.

42. pH of the solution will not be affected as $[H^+]$ remains constant.

At anode : $2H_2O \longrightarrow O_2 + 4H^+ + 4e^-$

At cathode $4H^+ + 4e^- \longrightarrow 2H_2$

43. Conductivity decreases because number of ions per unit volume decreases.

44. Standard hydrogen electrode is the reference electrode whose electrode potential is taken to be zero. The electrode potential of other electrodes is measured with respect to it.

45. Anode : $Cu \longrightarrow Cu^{2+} + 2e^-$

Cathode : $Cl_2 + 2e^- \longrightarrow 2Cl^-$

Cu is anode as it is getting oxidised.

Cl_2 is cathode as it is getting reduced.

46. $Zn + Cu^{2+} \longrightarrow Zn^{2+} + Cu$

$$E_{Cell} = E^{\ominus}_{Cell} - \frac{0.059}{2}\log\frac{[Zn^{2+}]}{[Cu^{2+}]}$$

E_{Cell} decreases when concentration of Zn^{2+} ions, $[Zn^{2+}]$ increases.

47. Primary batteries contain a limited amount of reactants and are discharged when the reactants have been consumed. Secondary batteries can be recharged but take a long time to recharge. Fuel cell runs continuously as long as the reactants are supplied to it and products are removed continuously.

48. $Pb + PbO_2 + 2H_2SO_4 \longrightarrow 2PbSO_4 + 2H_2O$

Density of electrolyte decreases as water is formed and sulphuric acid is consumed as the product during discharge of the battery.

49. In the case of CH_3COOH, which is a weak electrolyte, the number of ions increase on dilution due to an increase in degree of dissociation.

$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$

In the case of strong electrolyte the number of ions remains the same but the interionic attraction decreases.

IV. Matching Type

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

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

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

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

54. (i) → (d) (ii) → (c) (iii) → (a), (e) (iv) → (b)

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

V. Assertion and Reason Type

56. (iii) 57. (iii) 58. (i) 59. (i) 60. (v)

61. (i) 62. (i) 63. (i) 64. (ii) 65. (iv)

VI. Long Answer Type

66. (i) Cell 'B' will act as electrolytic cell as it has lower emf

∴ The electrode reactions will be:

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

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

(ii) Now cell 'B' acts as galvanic cell as it has higher emf and will push electrons into cell 'A'.

The electrode reaction will be:

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

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

67. **Hint :** (i) Electrons move from Zn to Ag.

(ii) Ag is the cathode.

(iii) Cell will stop functioning.

(iv) When $E_{Cell} = 0$.

(v) Concentration of Zn^{2+} ions will increase and concentration of Ag^+ ions will decrease

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