ELECTROCHEMISTRY

Instructor: ER. S. K. SINGH (B. Tech, M.Tech) M.N.N.I.T. Alld.

1. Which of the following reaction is possible at anode?
   (a) $2Cr^{3+} + 7H_2O \rightarrow Cr_2O_7^{2-} + 14H^+$
   (b) $F_2 \rightarrow 2F^-$
   (c) $(1/2)O_2 + 2H^+ \rightarrow H_2O$
   (d) None of these
2. Emf of a cell in terms of reduction potential of its left and right electrodes is:
   (a) $E = E_{left} - E_{right}$ (b) $E = E_{left} + E_{right}$
   (c) $E = E_{right} - E_{left}$ (d) $E = -[E_{right} + E_{left}]$
3. Conductance (Siemens, S) is directly prportional to the area of the vessel and the concentration of solution in it and is inversely proportional to the length of the vessel, then the unit of constant of proportionality is
   (a) $S\,m\,mol^{-1}$ (b) $S\,m^2\,mol^{-1}$
   (c) $S^{-1}\,m\,l\,mol$ (d) $S^2\,m^2\,mol^{-2}$
4. The emf of given cell $Pt - \underset{P_1}{H_2} \left| \underset{1M}{H^+_{(aq)}} \right| \underset{P_2}{H_2} - Pt$ is:
   (a) $\frac{RT}{F}\log\frac{P_1}{P_2}$ (b) $\frac{RT}{2F}\log_e\frac{P_1}{P_2}$
   (c) $\frac{RT}{F} - \log_e\frac{P_2}{P_1}$ (d) None of these
5. For a cell given below
   $\underset{-}{Ag \mid Ag^+} \parallel \underset{+}{Cu^{2+} \mid Cu}$
   $Ag^+ + e^- \longrightarrow Ag;$ $E^0 = x$
   $Cu^{2+} + 2e^- \longrightarrow Cu;$ $E^0 = y$
   E^0_{cell} is
   (a) $x + 2y$ (b) $2x + y$
   (c) $y - x$ (d) $y - 2x$
6. Several blocks of magnesium are fixed to the bottom of a ship to
   (a) keep away the sharks
   (b) make the ship lighter
   (c) prevent puncturing by under sea rocks
   (d) prevent action of water and salt
7. In an electrolytic cell, the flow of electrons is from:
   (a) cathode to anode in solution
   (b) cathode to anode through external supply
   (c) cathode to anode through internal supply
   (d) anode to cathode through internal supply
8. The $E^0_{M^{3+}/M^{2+}}$ values for Cr, Mn, Fe and Co are -0.41, +1.57, +0.77 and +1.97V respectively. For which one of these metals the change in oxidation state from +2 to +3 is easiest?
   (a) Co (b) Mn
   (c) Fe (d) Cr
9. Standard reduction electrode potentials of three metals A, B and C are +0.5 V, -3.0 V, and - 1.2 V respectively. The reducing power of these metals are:
   (a) B > C > A (b) A > B > C
   (c) C > B > A (d) A > C > B
10. For a cell reaction involving a two electrons changes, the standard *e.m.f*, of the cell is found to be 0.295 V at 25^0 C. The equilibrium constant of the reaction at 25^0C will be:
   (a) 1×10^{-10} (b) 29.5×10^{-2}
   (c) 10 (d) 1×10^{10}
11. When during electrolysis of a solution of $AgNO_3$, 9650 coulombs of charge pass through the electroplating bath, the mass of silver deposited on the cathode will be:
   (a) 1.08 g (b) 10.08 g
   (c) 21.6 g (d) 108 g
12. For the redox change; $Zn(s) + \underset{0.1\,M}{Cu^{2+}} \longrightarrow \underset{1\,M}{Zn^{2+}} + Cu(s)$, taking place in a cell is 1.10 volt. E_{cell} for the cell will be:
   (a) 1.07 V (b) 0.82 V
   (c) 2.14 V (d) 180 V
13. In a hydrogen-oxygen fuel cell, combustion of hydrogen occurs to:
   (a) remove adsorbed oxygen from electrode surfaces
   (b) create potential difference between the two electrodes
   (c) produce high purity water
   (d) generate heat
14. Consider the following E^0 values. $E^0_{Fe^{3+}/Fe^{2+}} = +0.77V$, $E^0_{Sn^{2+}/Sn} = +0.14V$, . The E^0_{cell} for the reaction;
   $Sn(s) + 2Fe^{3+}(aq) \longrightarrow 2Fe^{2+}(aq) + Sn^{2+}(aq)$ is
   (a) 0.63 V (b) 1.40 V
   (c) 0.91 V (d) 1.68 V
15. The standard emf of a cell having one electron charge is found to be 0.591 V at 25^0C. The equilibrium constant of the reaction is:
   (a) 1.0×10^{30} (b) 1.0×10^5
   (c) 1.0×10^{10} (d) 1.0×10^1

16. In a cell that utilizes the reaction;
$Zn(s)+2H^+(aq)\longrightarrow Zn^{2+}(aq)+H_2(g)$, addition of H_2SO_4 to cathode compartment will:
(a) increase the E and shift equilibrium to the left
(b) lower the E and shift equilibrium to the right
(c) increase the E and shift equilibrium to the right
(d) lower the E and shift equilibrium to the left

17. The limiting molar conductivities Λ^0 for NaCl, KBr and KCl are 126, 152 and 150 S cm^2 mol^{-1} respectively. The Λ^0 for NaBr (S cm^2 mol^{-1}) is:
(a) 302 (b) 176
(c) 278 (d) 128

18. The highest electrical conductivity of the following aqueous solution is of:
(a) 0.1 M acetic acid
(b) 0.1 M chloroacetic acid
(c) 0.1 M fluoroacetic acid
(d) 0.1 M difuluoracetic acid

19. The molar conductance of acetic acid at infinite dilution if for CH_3COONa, NaCl and HCl are 91.0, 126.5 and 426.2 S cm^2 mol^{-1} respectively is,
(a) 517.2 (b) 552.7
(c) 390.7 (d) 217.5

20. For a spontaneous reaction ΔG^0 , equilibrium constant (K) and E^0_{cell} will be respectively
(a) $-ve, >1, +ve$ (b) $+ve, >1, -ve$
(c) $-ve, <1, -ve$ (d) $-ve, >1, -ve$

21. Given, $l/a = 0.5$ cm^{-1}, R = 50 ohm, N = 1.0, the equivalent conductance of electrolytic cell is:
(a) 10 ohm^{-1} cm^2 (gm equiv^{-1})
(b) 20 ohm^{-1} cm^2 (gm equiv^{-1})
(c) 300 ohm^{-1} cm^2 (gm equiv^{-1})
(d) 100 ohm^{-1} cm^2 (gm equiv^{-1})

22. Aluminium oxide may be electrolysed at 100^{0}C to furnish aluminium metal (atomic mass = 27 amu). The cathodic reaction is : $Al^3+3e^-\longrightarrow Al$
To prepare 5.12 kg of aluminium metal by this reaction would require:
(a) 549 × 10^7 C of electricity
(b) 1.83 × 10^7 C of electricity
(c) 5.49 × 10^7 C of electricity
(d) 5.49 × 10^{10} C of electricity

23.

Electrolyte	KCl	KNO_3	HCl	NaOAc	NaCl
Λ^0 (S cm^{2}mol^{-1})	149.9	145.0	426.2	91.0	126.5

Calculate Λ^0_{HOAc} using appropriate molar conductances of the electrolytes listed above at infinite dilution in H_2O at 25^{0}C.
(a) 217.5 (b) 390.7
(c) 552.7 (d) 517.2

24. Given the data at 25^{0}C,
$Ag+I^-\longrightarrow AgI+e^-$; $E^0=0.152$ V
$Ag\longrightarrow Ag^++e^-$; $E^0=-0.800$ V
What is the value of log K_{sp} for AgI?
(2.303 RT/F = 0.059 V)
(a) - 16.13 (b) - 8.12
(c) + 8.612 (d) - 37.83

25. Resistance of a conductivity cell filled with a solution of an electrolyte of concentration 0.1 M is 100Ω. The conductivity of this solution is 1.29 S m^{-1}. Resistance of the same cell when filled with 0.02 M of the same solution is 520Ω. The molar conductivity of 0.02 M solution of the electrolyte will be:
(a) 124×10^{-4} S m^2 mol^{-1} (b) 1240×10^{-4} S m^2 mol^{-1}
(c) 1.24×10^{-4} S m^2 mol^{-1} (d) 12.4×10^{-4} S m^2 mol^{-1}

26. The molar conductivities Λ^0_{NaOAc} and Λ^0_{HCl} at infinite dilution in water at 25^{0}C are 91.0 and 426.2 S cm^2/mol respectively. To calculate Λ^0_{HOAc}, the additional value required is:
(a) $\Lambda^0_{H_2O}$ (b) Λ^0_{KCl}
(c) Λ^0_{NaOH} (d) Λ^0_{NaCl}

27. The cell, $Zn|Zn^{2+}(1M)||Cu^{2+}(1M)|Cu\left(E^0_{cell}=1.10\text{ V}\right)$, was allowed to be completely discharged at 298 K. The relative concentration of 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

28. Given $E^0_{Cr^{3+}/Cr}=-0.72V$, $E^0_{Fe^{2+}/Fe}=-0.42V$. The potential for the cell
$Cr|Cr^{3+}(0.1M)||Fe^{2+}(0.01M)|Fe$ is
(a) 0.26 V (b) 0.339 V
(c) -0.399 V (d) -0.26 V

29. Given $E^0_{Fe^{3+}/Fe}=-0.036V$, $E^0_{Fe^{2+}/Fe}=-0.439V$
The value of standard electrode potential for the change, $Fe^{3+}(aq)+e\longrightarrow Fe^{2+}(aq)$ will be:
(a) -0.072 V (b) 0.385 V
(c) 0.770 V (d) -0.270 V

30. In a fuel cell, methanol is used as fuel and oxygen gas is used as an oxidizer. The reaction is
$$CH_3OH(l)+\frac{3}{2}O_2(g)\longrightarrow CO_2(g)+2H_2O(l)$$
At 298 K, standard Gibbs energies of formation for $CH_3OH(l)$, $H_2O(l)$ and $CO_2(g)$ are -166.2, -237.2 and -394.4 kJ mol^{-1} respectively. If standard enthalpy of combustion of methanol is -726 kJ mol^{-1}, efficiency of the fuel cell will be:
(a) 80% (b) 87%
(c) 90% (d) 97%

31. The Gibbs energy for the decomposition of Al_2O_3 at 500^{0}C is as follows
$$\frac{2}{3}Al_2O_3\longrightarrow\frac{4}{3}Al+O_2,\ \Delta_rG=+966\text{ kJ mol}^{-1}$$
The potential difference needed for electrolytic reduction of Al_2O_3 at 500^{0}C is at least

(a) 4.5 V (b) 3.0 V
(c) 2.5 V (d) 5.0 V

32. The reduction potential of hydrogen half-cell will be negative if
(a) $p(H_2) = 1$ atm and $(H^+) = 2.0$ M
(b) $p(H_2) = 1$ atm and $(H^+) = 1.0$ M
(c) $p(H_2) = 2$ atm and $(H^+) = 1.0$ M
(d) $p(H_2) = 2$ atm and $(H^+) = 2.0$ M

33. Resistance of 0.2 M solution of an electrolyte is 50Ω. The specific conductance of the solution is 1.3 S m^{-1}. If resistance of the 0.4 M solution of the same electrolyte is 260Ω, its molar conductivity is:
(a) 6250 S m^2 mol^{-1} (b) 6.25×10^{-4} S m^2 mol^{-1}
(c) 625×10^{-4} S m^2 mol^{-1} (d) 62.5×10^{-4} S m^2 mol^{-1}

34. The incorrect expression among the following is
(a) $\frac{\Delta G_{system}}{\Delta S_{total}} = -T$
(b) In spontaneous process, $W_{reversible} = nRT\ln\frac{V_f}{V_i}$
(c) $\ln K = \frac{\Delta H^0 - T\Delta S^0}{RT}$
(d) $K = e^{-\Delta G^0/RT}$

35. The standard reduction potentials for Zn^{2+}/Zn, Ni^{2+}/Ni and Fe^{2+}/Fe are -0.76, -0.23 and -0.44 V, respectively. The reaction $X + Y^{2+} \longrightarrow Y + X^{2+}$ will be spontaneous when
(a) X = Ni, Y = Fe (b) X = Ni, Y = Zn
(c) X = Fe, Y = Zn (d) X = Zn, Y = Ni

36. Given, $E^0_{Cr^{3+}/Cr} = -0.74V$; $E^0_{MnO_4^-/Mn^{2+}} = 1.51V$
$E^0_{Cr_2O_7^{2-}/Cr^{3+}} = 1.33V$; $E^0_{Cl/Cl^-} = 1.36V$;
Based on the data given above, strongest oxidising agent will be
(a) Cl (b) Cr^{3+}
(c) Mn^{2+} (d) MnO_4^-

37. Resistance of 0.2 M solution of an electrolyte is 50Ω. The specific conductance of the solution is 1.4 S m^{-1}. The resistance of 0.5 M solution of the same electrolyte is 280Ω. The molar conductivity of 0.5 M solution of the electrolyte is S mol^{-1} is
(a) 5×10^{-4} (b) 5×10^{-3}
(c) 5×10^{3} (d) 5×10^{2}

38. The equivalent conductance of NaCl at concentration C and at infinite dilution are λ_c and λ_∞ respectively. The correct relationship between λ_c and λ_∞ is given as
(a) $\lambda_c = \lambda_\infty + (B)C$ (b) $\lambda_c = \lambda_\infty - (B)C$
(c) $\lambda_c = \lambda_\infty - (B)\sqrt{C}$ (d) $\lambda_c = \lambda_\infty + (B)\sqrt{C}$

39. The metal that cannot be obtained by the electrolysis of an aqueous solution of its salts is
(a) Ag (b) Ca
(c) Cu (d) Cr

40. Given below are the half-cell reactions
$Mn^{2+} + 2e^- \longrightarrow Mn$, $E^0 = -1.18V$
$2(Mn^{3+} + e^- \longrightarrow Mn^{2+})$, $E^0 = +1.51V$
The E^0 for $3Mn^{2+} \longrightarrow Mn + 2Mn^{3+}$ will be
(a) -2.69 V, the reaction will not occur
(b) -2.69 V, the reaction will occur
(c) -0.33 V, the reaction will not occur
(d) -0.33 V, the reaction will occur

41. Two Faraday of electricity is passed through a solution of $CuSO_4$. The mass of copper deposited at the cathode is: (at. mass of Cu = 63.5 amu)
(a) 0 g (b) 63.5 g
(c) 2 g (d) 127 g

42. Galvanization is applying a coating of:
(a) Zn (b) Pb
(c) Cr (d) Cu

43. Given, $E^0_{Cl_2/Cl} = 1.36$ V; $E^0_{Cr^{3+}/Cr} = -0.74$ V
$E^0_{Cr_2O_7^{2-}/Cr^{3+}} = 1.33V$; $E^0_{MnO_4^-/Mn^{2+}} = 1.51V$
Among the following the strongest reducing agent is:
(a) Cr (b) Mn^{2+}
(c) Cr^{3+} (d) Cl

44. How long (approximate) should water be electrolysed by passing through 100 amperes current so that the oxygen released can completely burn 27.66 g of diborane? (Atomic weight of B = 10.8 u)
(a) 6.4 hours (b) 0.8 hour
(c) 3.2 hours (d) 1.6 hours

45. Consider the statements S1 and S2:
S1: Conductivity always increases with decrease in the concentration of electrolyte.
S2: Molar conductivity always increases with decrease in the concentration of electrolyte.
The correct option among the following is:
(a) S1 is wrong and S2 is correct
(b) S1 is correct and S2 is wrong
(c) Both S1 and S2 are wrong
(d) Both S1 and S2 are correct

46. The decreasing order of electrical conductivity of the following aqueous solutions is:
0.1 M Formic acid (A),
0.1 M Acetic acid (B),
0.1 M Benzoic acid (C),
(a) A > B > C (b) A > C > B
(c) C > B > A (d) C > A > B

47. Given;
$Co^{3+} + e^- \rightarrow Co^{2+}$; $E^0 = +1.81V$
$Pb^{4+} + 2e^- \rightarrow Pb^{2+}$; $E^0 = +1.67V$

$Ce^{4+} + e^- \rightarrow Ce^{3+};\ E^0 = +1.61\,V$

$Bi^{3+} + 3e^- \rightarrow Bi;\ E^0 = +0.20\,V$

Oxidizing power of the species will increase in the order:

(a) $Co^{3+} < Ce^{4+} < Bi^{3+} < Pb^{4+}$

(b) $Co^{3+} < Pb^{4+} < Ce^{4+} < Bi^{3+}$

(c) $Ce^{4+} < Pb^{4+} < Bi^{3+} < Co^{3+}$

(d) $Bi^{3+} < Ce^{4+} < Pb^{4+} < Co^{3+}$

48. Calculate the standard cell potential (in V) of the cell in which following reaction takes place:

$$Fe^{2+}(aq) + Ag^{+}(ag) \longrightarrow Fe^{3+}(aq) + Ag(s)$$

Given that

$E^0_{Ag^+/Ag} = xV$ $\quad E^0_{Fe^{2+}/Fe} = yV$

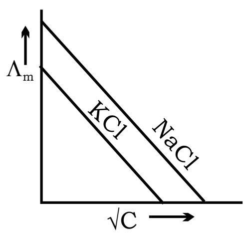
$E^0_{Fe^{3+}/Fe} = zV$

(a) $x - y$ (b) $x + y - z$

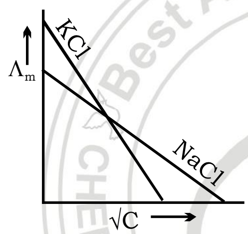
(c) $x + 2y - 3z$ (d) $x - z$

49. Which one of the following graphs between molar conductivity (Λ_m) versus $\sqrt{C}$ is correct?

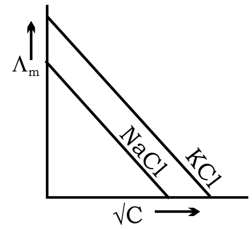
(a)



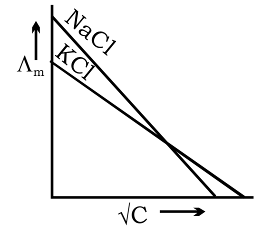
(b)



(c)



(d)



50. A solution of $Ni(NO_3)_2$ is electrolysed between platinum electrodes using 0.1 Faraday electricity. How many mole of Ni will be deposited at the cathode?

(a) 0.20 (b) 0.15

(c) 0.10 (d) 0.05

51. The standard Gibbs energy for the given cell reaction in kJ mol^{-1} at 298 K is

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

$E^0 = 2$ V at 298 K

(Faraday's constant. F = 96000 C mol^{-1})

(a) 192 (b) 384

(c) -384 (d) -192

ANSWER

1. (a)	2. (c)	3. (b)	4. (b)	5. (c)
6. (d)	7. (c)	8. (d)	9. (a)	10. (d)
11. (b)	12 (a)	13. (b)	14. (c)	15. (c)
16. (c)	17. (d)	18. (d)	19. (c)	20. (a)
21. (a)	22. (c)	23. (b)	24. (a)	25. (a)
26. (d)	27. (c)	28. (a)	29. (c)	30. (d)
31. (c)	32. (c)	33. (b)	34. (c)	35. (d)
36. (d)	37. (a)	38. (c)	39. (b)	40. (a)
41. (b)	42. (a)	43. (a)	44. (c)	45. (a)
46. (b)	47. (d)	48. (c)	49. (c)	50. (d)
51. (c)				