# DPP - Daily Practice Problems

## Chapter-wise Sheets

**Date :** ____ **Start Time :** ____ **End Time :** ____

# CHEMISTRY (CC17)

**SYLLABUS :** Electrochemistry

**Max. Marks : 180** **Marking Scheme : + 4 for correct & (–1) for incorrect** **Time : 60 min.**

**INSTRUCTIONS** : This Daily Practice Problem Sheet contains 45 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.

1. A gas X at 1 atm is bubbled through a solution containing a mixture of 1 M $Y^-$ and 1 M $Z^-$ at 25°C. If the reduction potential of Z > Y > X, then,
   (a) Y will oxidize X and not Z
   (b) Y will oxidize Z and not X
   (c) Y will oxidize both X and Z
   (d) Y will reduce both X and Z
2. On the basis of the following E° values, the strongest oxidizing agent is:
   $[Fe(CN)_6]^{4-} \rightarrow [Fe(CN)_6]^{3-} + e^-$; $E° = -0.35$ V
   $Fe^{2+} \rightarrow Fe^{3+} + e^-$; $E° = -0.77$ V
   (a) $[Fe(CN)_6]^{4-}$ (b) $Fe^{2+}$
   (c) $Fe^{3+}$ (d) $[Fe(CN)_6]^{3-}$
3. Resistance of a conductivity cell filled with a solution of an electrolyte of concentration 0.1 M is 100 Ω. The conductivity of this solution is 1.29 S $m^{-1}$. Resistance of the same cell when filled with 0.2 M of the same solution is 520 Ω. The molar conductivity of 0.2 M solution of electrolyte will be
   (a) $1.24 \times 10^{-4}$ S $m^2$ $mol^{-1}$ (b) $12.4 \times 10^{-4}$ S $m^2$ $mol^{-1}$
   (c) $124 \times 10^{-4}$ S $m^2$ $mol^{-1}$ (d) $1240 \times 10^{-4}$ S $m^2$ $mol^{-1}$
4. For the electrochemical cell, $M | M^+ \| X^- | X$,
   $E°_{M^+/M} = 0.44$ V and $E°_{X/X^-} = 0.33$ V.
   From this data one can deduce that
   (a) $M + X \rightarrow M^+ + X^-$ is the spontaneous reaction
   (b) $M^+ + X^- \rightarrow M + X$ is the spontaneous reaction
   (c) $E_{cell} = 0.77$ V
   (d) $E_{cell} = -0.77$ V
5. What will be the emf for the given cell
   $Pt | H_2(P_1) | H^+(aq) || H_2(P_2) | Pt$
   (a) $\frac{RT}{F}\log_e\frac{P_1}{P_2}$ (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

| RESPONSE GRID | 1. ⓐⓑⓒⓓ | 2. ⓐⓑⓒⓓ | 3. ⓐⓑⓒⓓ | 4. ⓐⓑⓒⓓ | 5. ⓐⓑⓒⓓ |
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*Space for Rough Work*

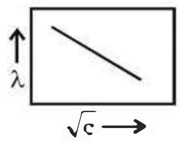
6. What is the standard cell potential E° for an electrochemical cell in which the following reaction takes place spontaneously ?

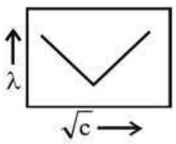
$Cl_2(g) + 2Br^- \rightarrow Br_2(aq) + 2Cl^-, \Delta G^\circ = -50.6$ kJ

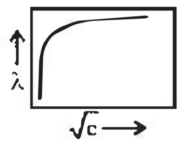
(a) 1.2 V (b) 0.53 V
(c) 0.26 V (d) –0.53 V

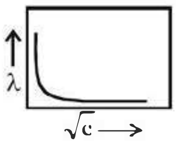
7. The unit of equivalent conductivity is
(a) ohm cm
(b) $ohm^{-1}\ cm^2$ (g equivalent)$^{-1}$
(c) ohm $cm^2$ (g equivalent)
(d) S $cm^{-2}$

8. The variation of equivalent conductance of strong electrolyte with (concentration)$^{1/2}$ is represented by

(a) 


(b) 


(c) 


(d) 


9. Consider the following cell reaction:

$2Fe(s) + O_2(g) + 4H^+(aq) \rightarrow 2Fe^{2+}(aq) + 2H_2O(l); E^\circ = 1.67$ V

At $[Fe^{2+}] = 10^{-3}$ M, $p(O_2) = 0.1$ atm and pH = 3, the cell potential at 25°C is
(a) 1.47V (b) 1.77V
(c) 1.87V (d) 1.57V

10. The electrical properties and their respective SI units are given below. Identify the wrongly matched pair.

| | Electrical property | SI unit |
|---|---|---|
| (a) | Specific conductance | $S\ m^{-1}$ |
| (b) | Conductance | S |
| (c) | Equivalent conductance | $S\ m^2\ g\ equiv^{-1}$ |
| (d) | Cell constant | m |

11. Limiting molar conductivity of $NH_4OH$ $\left(\text{i.e., } \Lambda^\circ_{m(NH_4OH)}\right)$ is equal to :
(a) $\Lambda^\circ_{m(NH_4Cl)} + \Lambda^\circ_{m(NaCl)} - \Lambda^\circ_{m(NaOH)}$
(b) $\Lambda^\circ_{m(NaOH)} + \Lambda^\circ_{m(NaCl)} - \Lambda^\circ_{m(NH_4Cl)}$
(c) $\Lambda^\circ_{m(NH_4OH)} + \Lambda^\circ_{m(NH_4Cl)} - \Lambda^\circ_{m(HCl)}$
(d) $\Lambda^\circ_{m(NH_4Cl)} + \Lambda^\circ_{m(NaOH)} - \Lambda^\circ_{m(NaCl)}$

12. A lead storage battery containing 5.0 L of (1N) $H_2SO_4$ solution is operated for $9.65 \times 10^5$ s with a steady current of 100 mA. Assuming volume of the solution remaining constant, normality of $H_2SO_4$ will
(a) remain unchanged (b) increases by 0.20
(c) increase by unity (d) decrease by 0.40

13. The electrode potential $E_{(Zn^{2+}/Zn)}$ of a zinc electrode at 25°C with an aqueous solution of 0.1 M $ZnSO_4$ is

$[E^\circ_{(Zn^{2+}/Zn)} = -0.76$ V. Assume $\frac{2.303RT}{F} = 0.06$ at 298K].
(a) +0.73 (b) –0.79
(c) –0.82 (d) –0.70

14. A battery is constructed of Cr and $Na_2Cr_2O_7$. The unbalanced chemical equation when such a battery discharges is following:

$Na_2Cr_2O_7 + Cr + H^+ \rightarrow Cr^{3+} + H_2O + Na^+$

If one Faraday of electricity is passed through the battery during the charging, the number of moles of $Cr^{3+}$ removed from the solution is
(a) $\frac{4}{3}$ (b) $\frac{1}{3}$
(c) $\frac{3}{3}$ (d) $\frac{2}{3}$

15. 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.

16. In a hydrogen-oxygen fuel cell, combustion of hydrogen occurs to
(a) produce high purity water
(b) create potential difference between two electrodes
(c) generte heat
(d) remove adsorbed oxygen from electron surfaces

| RESPONSE GRID | | | | | |
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| | 6. ⓐⓑⓒⓓ | 7. ⓐⓑⓒⓓ | 8. ⓐⓑⓒⓓ | 9. ⓐⓑⓒⓓ | 10. ⓐⓑⓒⓓ |
| | 11. ⓐⓑⓒⓓ | 12. ⓐⓑⓒⓓ | 13. ⓐⓑⓒⓓ | 14. ⓐⓑⓒⓓ | 15. ⓐⓑⓒⓓ |
| | 16. ⓐⓑⓒⓓ | | | | |

*Space for Rough Work*

17. $E^\circ$ for the cell,

$Zn \mid Zn^{2+}(aq) \mid\mid Cu^{2+}(aq) \mid Cu$ is 1.10 V at 25°C. The equilibrium constant for the cell reaction

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

is of the order of

(a) $10^{-37}$ (b) $10^{37}$

(c) $10^{-17}$ (d) $10^{17}$

18. The correct order of $E^\circ_{M^{2+}/M}$ values with negative sign for the four successive elements Cr, Mn, Fe and Co is

(a) Mn > Cr > Fe > Co (b) Cr < Fe > Mn > Co

(c) Fe > Mn > Cr > Co (d) Cr > Mn > Fe > Co

19. For a spontaneous reaction the $\Delta G$, equilibrium constant (K) and $E^\circ_{Cell}$ will be respectively

(a) –ve, >1, –ve (b) –ve, <1, –ve

(c) +ve, >1, –ve (d) –ve, >1, +ve

20. If the $E^\circ_{cell}$ for a given reaction has a negative value, then which of the following gives the correct relationships for the values of $\Delta G^\circ$ and $K_{eq}$?

(a) $\Delta G^\circ > 0; K_{eq} > 1$ (b) $\Delta G^\circ < 0; K_{eq} > 1$

(c) $\Delta G^\circ < 0; K_{eq} < 1$ (d) $\Delta G^\circ > 0; K_{eq} < 1$

21. Which of the following expressions correctly represents the equivalent conductance at infinite dilution of $Al_2(SO_4)_3$, Given that $\Lambda^\circ_{Al^{3+}}$ and $\Lambda^\circ_{SO_4^{2-}}$ are the equivalent conductances at infinite dilution of the respective ions?

(a) $\frac{1}{3}\Lambda^\circ_{Al^{3+}} + \frac{1}{2}\Lambda^\circ_{SO_4^{2-}}$ (b) $2\Lambda^\circ_{Al^{3+}} + 3\Lambda^\circ_{SO_4^{2-}}$

(c) $\Lambda^\circ_{Al^{3+}} + \Lambda^\circ_{SO_4^{2-}}$ (d) $\left(\Lambda^\circ_{Al^{3+}} + \Lambda^\circ_{SO_4^{2-}}\right) \times 6$

22. Given : $E^\circ_{Cr^{3+}/Cr} = -0.74$ V; $E^\circ_{MnO_4^-/Mn^{2+}} = 1.51$ V

$E^\circ_{Cr_2O_7^{2-}/Cr^{3+}} = 1.33$ V; $E^\circ_{Cl/Cl^-} = 1.36$ V

Based on the data given above, strongest oxidising agent will be :

(a) Cl (b) $Cr^{3+}$

(c) $Mn^{2+}$ (d) $MnO_4^-$

23. The standard electrode potentials $\left(E^\circ_{M^+/M}\right)$ of four metals A, B, C and D are – 1.2 V, 0.6 V, 0.85 V and – 0.76 V, respectively. The sequence of deposition of metals on applying potential is:

(a) A, C, B, D (b) B, D, C, A

(c) C, B, D, A (d) D, A, B, C

24. Which of the following statements is correct?

(a) Oxidation number of oxygen in $KO_2$ is +1

(b) The specific conductance of an electrolyte solution decreases with increase in dilution

(c) $Sn^{2+}$ oxidises $Fe^{3+}$

(d) $Zn/ZnSO_4$ is a reference electrode

25. Molar ionic conductivities of a two-bivalent electrolytes $x^{2+}$ and $y^{2-}$ are 57 and 73 respectively. The molar conductivity of the solution formed by them will be

(a) 130 S cm$^2$ mol$^{-1}$ (b) 65 S cm$^2$ mol$^{-1}$

(c) 260S cm$^2$ mol$^{-1}$ (d) 187 S cm$^2$ mol$^{-1}$

26. The cell, $Zn \mid Zn^{2+}$ (1 M) $\mid\mid Cu^{2+}$ (1 M) $\mid$ Cu ($E^\circ_{cell} = 1.10$ V) 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) $9.65 \times 10^4$ (b) antilog (24.08)

(c) 37.3 (d) $10^{37.3}$.

27. Which of the following statements is true for an electrochemical cell?

(a) Reduction occurs at $H_2$ electrode

(b) $H_2$ is cathode and Cu is anode

(c) $H_2$ is anode and Cu is cathode

(d) Oxidation occurs at Cu electrode

28. Given

$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$; $E^\circ = +0.77$ V

$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$; $E^\circ = -1.66$ V

$Br_2(aq) + 2e^- \rightarrow 2Br^-$; $E^\circ = +1.09$ V

Considering the electrode potentials, which of the following represents the correct order of reducing power?

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

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

29. Standard free energies of formation (in kJ/mol) at 298 K are –237.2, –394.4 and –8.2 for $H_2O(l)$, $CO_2(g)$ and pentane $(g)$, respectively. The value $E^\circ_{cell}$ for the pentane-oxygen fuel cell is :

(a) 1.968V (b) 2.0968V (c) 1.0968V (d) 0.0968V

30. Given $E^\circ_{Cr^{3+}/Cr} = -0.72$ V, $E^\circ_{Fe^{2+}/Fe} = -0.42$ V. The potential for the cell

$Cr \mid Cr^{3+}$ (0.1M) $\mid\mid Fe^{2+}$ (0.01 M) $\mid$ Fe is

(a) 0.26V (b) 0.336V (c) –0.339V (d) 0.26V

| RESPONSE GRID | | | | | |
|---|---|---|---|---|---|
| | 17. ⓐⓑⓒⓓ | 18. ⓐⓑⓒⓓ | 19. ⓐⓑⓒⓓ | 20. ⓐⓑⓒⓓ | 21. ⓐⓑⓒⓓ |
| | 22. ⓐⓑⓒⓓ | 23. ⓐⓑⓒⓓ | 24. ⓐⓑⓒⓓ | 25. ⓐⓑⓒⓓ | 26. ⓐⓑⓒⓓ |
| | 27. ⓐⓑⓒⓓ | 28. ⓐⓑⓒⓓ | 29. ⓐⓑⓒⓓ | 30. ⓐⓑⓒⓓ | |

*Space for Rough Work*

31. Electrolysis of dilute aqueous NaCl solution was carried out by passing 10 milli ampere current. The time required to liberate 0.01 mole of $H_2$ gas at the cathode is
(1 Faraday=96500 C $mol^{-1}$)
(a) $9.65 \times 10^4$ sec (b) $19.3 \times 10^4$ sec
(c) $28.95 \times 10^4$ sec (d) $38.6 \times 10^4$ sec

32. Which of the following reaction occurs at the cathode during the charging of lead storage battery?
(a) $Pb^{2+} + 2e^- \longrightarrow Pb$
(b) $Pb^{2+} + SO_4^{2-} \longrightarrow PbSO_4$
(c) $Pb \longrightarrow Pb^{2+} + 2e^-$
(d) $PbSO_4 + 2H_2O \longrightarrow 2PbO_2 + 4H^+ + SO_4^{2-} + 2e^-$

33. Conductance of 0.1 M KCl (conductivity = X $ohm^{-1}cm^{-1}$) filled in a conductivity cell is Y $ohm^{-1}$. If the conductance of 0.1 M NaOH filled in the same cell is Z $ohm^{-1}$, the molar conductance of NaOH will be
(a) $10^3 \frac{XZ}{Y}$ (b) $10^4 \frac{XZ}{Y}$
(d) $10 \frac{XZ}{Y}$ (d) $0.1 \frac{XZ}{Y}$

34. How much charge is required, when 1 mole of $Cr_2O_7^{2-}$ reduce to form 1 mole of $Cr^{3+}$?
(a) 6F (b) 3F
(c) 1F (d) 2F

35. In electrolysis of dilute $H_2SO_4$ using platinum electrodes
(a) $H_2$ is evolved at cathode
(b) $NH_2$ is produced at anode
(c) $Cl_2$ is obtained at cathode
(d) $O_2$ is produced

36. The resistance of 0.1 N solution of a salt is found to be $2.5 \times 10^3$ ohm. The equivalent conductance of the solution is (cell constant = 1.15 $cm^{-1}$)
(a) 4.6 (b) 5.6 (c) 6.6 (d) 7.6

37. The highest electrical conductivity of the following aqueous solutions is of
(a) 0.1 M difluoroacetic acid
(b) 0.1 M fluoroacetic acid
(c) 0.1 M chloroacetic acid
(d) 0.1 M acetic acid

38. 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) 10.8 g (b) 21.6 g (c) 108 g (d) 1.08 g

39. 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

40. When electric current is passed through acidified water, 112 mL of hydrogen gas at STP 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

41. An electrolytic cell contains a solution of $Ag_2SO_4$ and has platinum electrodes. A current is passed until 1.6 g of $O_2$ has been liberated at anode. The amount of silver deposited at cathode would be
(a) 107.88g (b) 1.6 g
(c) 0.8g (d) 21.60g

42. Which of the following pair(s) is/are incorrectly matched?
(i) R (resistance) – ohm (Ω)
(ii) ρ (resistivity) – ohm metre (Ωm)
(iii) G (conductance) – seimens or ohm (S)
(iv) κ (conductivity) – seimens metre$^{-1}$ ($Sm^{-1}$)
(a) (i), (ii) and (iii) (b) (ii) and (iii)
(c) (i), (ii) and (iv) (d) (iii) only

43. One Faraday of electricity is passed through molten $Al_2O_3$, aqueous solution of $CuSO_4$ and molten NaCl taken in three different electrolytic cells connected in series. The mole ratio of Al, Cu and Na deposited at the respective cathode is
(a) 2 : 3 : 6 (b) 6 : 2 : 3
(c) 6 : 3 : 2 (d) 1 : 2 : 3

44. If ρ is the resistance in ohm of a centimeter cube, generally called the specific resistance of the substance constituting the conductor, the resistance r of the layer containing "a" cubes is given by
(a) $\frac{1}{r} = \frac{1}{\rho} + \frac{1}{\rho} + \ldots$ (b) $\frac{1}{r} = \frac{1}{\rho a} + \frac{1}{\rho a} + \ldots$
(c) $r = a/\rho$ (d) $r = \rho + \rho + \ldots$

45. Which of the following statements is wrong ?
(a) Electrolysis of an aqueous sodium hydroxide solution liberates $H_2$ gas at the cathode and $O_2$ gas at the anode.
(b) Electrolysis of dil. $H_2SO_4$ liberates $H_2$(g) at cathode and $O_2$ (g) at the anode
(c) $\Delta G° = nFE°$ for a spontaneous reaction
(d) $E = E° - \frac{0.059}{n} \log Q$, Where Q = reaction quotient.

| RESPONSE GRID | | | | | |
|---|---|---|---|---|---|
| | 31. ⓐⓑⓒⓓ | 32. ⓐⓑⓒⓓ | 33. ⓐⓑⓒⓓ | 34. ⓐⓑⓒⓓ | 35. ⓐⓑⓒⓓ |
| | 36. ⓐⓑⓒⓓ | 37. ⓐⓑⓒⓓ | 38. ⓐⓑⓒⓓ | 39. ⓐⓑⓒⓓ | 40. ⓐⓑⓒⓓ |
| | 41. ⓐⓑⓒⓓ | 42. ⓐⓑⓒⓓ | 43. ⓐⓑⓒⓓ | 44. ⓐⓑⓒⓓ | 45. ⓐⓑⓒⓓ |

*Space for Rough Work*

1. **(a)** The given order of reduction potentials (or tendencies) is Z > Y > X. A spontaneous reaction will have the following characteristics
Z reduced and Y oxidised
Z reduced and X oxidised
Y reduced and X oxidised
Hence, Y will oxidise X and not Z.

2. **(c)** From the given data we find $Fe^{3+}$ is strongest oxidising agent. More the positive value of $E^\bullet$, more is the tendency to get oxidized. Thus correct option is (c).

3. **(b)** $R = 100\,\Omega,\ \kappa = \frac{1}{R}\left(\frac{l}{A}\right),$

$\frac{l}{A}$ (cell constant) $= 1.29 \times 100\ m^{-1}$
Given, $R = 520\,\Omega$, $C = 0.2$ M,
$\mu$ (molar conductivity) = ?

$\mu = \kappa \times V$ ($\kappa$ can be calculated as $\kappa = \frac{1}{R}\left(\frac{l}{A}\right)$ now cell constant is known.)
Hence,

$$\mu = \frac{1}{520} \times 129 \times \frac{1000}{0.2} \times 10^{-6}\ m^3$$
$$= 12.4 \times 10^{-4}\ S\ m^2\ mol^{-1}$$

4. **(b)** For, $M^+ + X^- \longrightarrow M + X$, $E^o_{cell} = 0.44 - 0.33 = 0.11\,V$ is positive, hence reaction is spontaneous.

5. **(b)** RHS : $2H^+ + 2e^- \rightleftharpoons H_2(P_2)$
LHS : $H_2(P_1) \rightleftharpoons 2H^+ + 2e^-$
overall reaction : $H_2(P_1) \rightleftharpoons H_2(P_2)$

$$E \bullet E^\bullet \bullet \frac{RT}{nF} \ln \frac{P_2}{P_1} \bullet 0 \bullet \frac{RT}{nF} \ln \frac{P_2}{P_1} \bullet \frac{RT}{nF} \ln \frac{P_1}{P_2}$$

6. **(c)** $\Delta G^\circ = -nFE^\circ;\ E^\circ = \frac{-\Delta G^\circ}{nF};$

$$E^\circ = \frac{-(-50.61J)}{2 \times 96500 \times 10^{-3}} = 0.26\ V$$

7. **(b)** $Ohm^{-1}\ cm^2\ (g\ eq)^{-1}$

8. **(a)** In case of equivalent conductance of strong electrolyte there is little increase with dilution.

9. **(d)** Here $n = 4$, and $[H^+] = 10^{-3}$ (as pH = 3)
Applying Nernst equation

$$E = E^\bullet - \frac{0.059}{n} \log \frac{[Fe^{2+}]^2}{[H^+]^4 (p_{O_2})}$$

$$= 1.67 - \frac{0.059}{4} \log \frac{(10^{-3})^2}{(10^{-3})^4 \times 0.1}$$

$$\bullet\ 1.67 \bullet \frac{0.059}{4} \log 10^7 = 1.67 - 0.103 = 1.567\,V$$

10. **(d)** Cell constant = $l/a$
Unit = $m/m^2 = m^{-1}$.

11. **(d)** $\Lambda^\circ_{m(NH_4Cl)} = \Lambda^\circ_{m_{NH_4^+}} + \Lambda^\circ_{m_{Cl^-}}$

$\Lambda^\circ_{m(NaOH)} = \Lambda^\circ_{m_{Na^+}} + \Lambda^\circ_{m_{OH^-}}$

$\Lambda^\circ_{m(NaCl)} = \Lambda^\circ_{m_{Na^+}} + \Lambda^\circ_{m_{Cl^-}}$

$\therefore\ \Lambda^\circ_{m(NH_4^+)} + \Lambda^\circ_{m(OH^-)}$

$= \Lambda^\circ_{m(NH_4^+)} + \Lambda^\circ_{m(Cl^-)} + \Lambda^\circ_{m(Na^+)}$

$+ \Lambda^\circ_{m(OH^-)} - \left[\Lambda^\circ_{m(Na^+)} + \Lambda^\circ_{m(Cl^-)}\right]$

$\Lambda^\circ_{m(NH_4OH)} = \Lambda^\circ_{m(NH_4Cl)} + \Lambda^\circ_{m(NaOH)} - \Lambda^\circ_{m(NaCl)}$

12. **(d)**
$$Pb + SO_4^{2-} \longrightarrow PbSO_4 + 2e^-$$
$$PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \longrightarrow PbSO_4 + 2H_2O$$
$$Pb + PbO_2 + 2H_2SO_4 \longrightarrow 2PbSO_4 + 2H_2O$$
The reaction indicates that 2 moles of $H_2SO_4$ corresponds to $2 \times 96500$ C and 2 moles $H_2SO_4 \equiv 4$ equiv. of $H_2SO_4$.
$2 \times 96500$ C consumed 4 equiv. of $H_2SO_4$
and $100 \times 10^{-3} \times 9.65 \times 10^5$ C consumed

$$= \frac{4 \times 100 \times 10^{-3} \times 9.65 \times 10^5}{2 \times 96500} = 2 \text{ equiv. } H_2SO_4$$

$\therefore$ Decrease in normality $= \frac{2}{5} = 0.40$

13. **(b)** For $Zn^{2+} \rightarrow Zn$

$$E_{Zn^{2+}/Zn} = E^\circ_{Zn^{2+}/Zn} - \frac{2.303RT}{nF} \log \frac{[Zn]}{[Zn^{2+}]}$$

$$= -0.76 - \frac{0.06}{2} \log \frac{1}{[0.1]} = -0.76 - 0.03$$

$$E_{Zn^{2+}/Zn} = -0.79V$$

14. (c) Reduction half reaction :

$$Cr_2O_7^{2-} + 6e^- + 14H^+ \longrightarrow 2Cr^{3+} + 7H_2O$$

Oxidation half reaction :

$$Cr \longrightarrow Cr^{3+} + 3e^-$$

Overall reaction :

$$Cr_2O_7^{2-} + Cr + 14H^+ + 3e^- \longrightarrow 3Cr^{3+} + 7H_2O$$

3F of electricity = 3 moles of $Cr^{3+}$

1F of electricity = $\frac{3}{3}$ moles of $Cr^{3+}$

15. (a) $2Cr^{3+} + 7H_2O \rightarrow Cr_2O_7^{2-} + 14H^+$

O.S. of Cr changes from +3 to +6 by loss of electrons. At anode oxidation takes place.

16. (b) In $H_2 - O_2$ fuel cell, the combustion of $H_2$ occurs to create potential difference between the two electrodes.

17. (b) $E^o_{cell} = \frac{0.059}{2}\log K_C$ or $\frac{1.10\times 2}{0.059} = \log K_C$

$\therefore K_C = 1.9\times 10^{37}$

18. (a) The value of $E^o_{M^{2+}/M}$ for given metal ions are

$E^o_{Mn^{2+}/Mn}$ • • 1.18 V,

$E^o_{Cr^{2+}/Cr}$ • • 0.9 V,

$E^o_{Fe^{2+}/Fe}$ • • 0.44 V and $E^o_{Co^{2+}/Co}$ • • 0.28 V.

The correct order of $E^o_{M^{2+}/M}$ values without considering negative sign would be

$Mn^{2+} > Cr^{2+} > Fe^{2+} > Co^{2+}$.

19. (d) For spontaneous reaction ΔG should be negative. Equilibrium constant should be more than one ($\Delta G = -2.303\ RT \log K_c$, If $K_c = 1$ then $\Delta G = 0$; If $K_c < 1$ then ΔG = +ve). Again $\Delta G = -nFE^o_{cell}$.

$E^o_{cell}$ must be +ve to have ΔG –ve.

20. (d) Standard Gibbs free energy is given as $\Delta G^o = -nE^oF$

If $E^o_{cell} < 0$ i.e., –ve

$\Delta G^o > 0$

Further $\Delta G^o = -RT \ln K_{eq}$

$\therefore \Delta G^o > 0$ and $K_{eq} < 0$

21. (c) Conductivity of an electrolyte depends on the mobility of ions and concentration of ions. The motion of an ionic species in an electric field is retarded by the oppositely charged ions due to their interionic attraction. On dilution, concentration of electrolyte decreases and the retarding influence of oppositely charged ions decreases. Therefore mobility of ions increases.

22. (d) Higher the value of standard reduction potential, stronger is the oxidising agent, hence $MnO_4^-$ is the strongest oxidising agent.

23. (c) As the value of reduction potential decreases the reducing power increases i.e.

C < B < D < A

(0.85). (0.6). (–0.76) (– 1.2)

24. (b) Specific conductance decreases with dilution.

25. (a) $\Lambda^{\infty}_m = 57 + 73 = 130\ S cm^2 mol^{-1}$

26. (d) $E_{cell} = 0$; when cell is completely discharged.

$$E_{cell} = E^o_{cell} - \frac{0.059}{2}\log\left(\frac{[Zn^{2+}]}{[Cu^{2+}]}\right)$$

$$\text{or } 0 = 1.1 - \frac{0.059}{2}\log\left(\frac{[Zn^{2+}]}{[Cu^{2+}]}\right)$$

$$\log\left(\frac{[Zn^{2+}]}{[Cu^{2+}]}\right) = \frac{2\times 1.1}{0.059} = 37.3$$

$$\therefore \left(\frac{[Zn^{2+}]}{[Cu^{2+}]}\right) = 10^{37.3}$$

27. (c) Reduction potential of Cu is more than $H_2$.

28. (d) Reducing character decreases down the series. Hence the correct order is

$Al < Fe^{2+} < Br^-$

29. (c) Writing the equation for pentane-oxygen fuel cell at respective electrodes and overall reaction, we get

At Anode:

$$\underset{(pentane)}{C_5H_{12}} + 10H_2O \rightarrow 5CO_2 + 32H^+ + 32e^-$$

At Cathode:

$$8O_2 + 32H^+ + 32e^- \rightarrow 16H_2O$$

$$\text{Overall}: C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$$

Calculation of $\Delta G^o$ for the above reaction

$\Delta G^o = [5\times(-394.4) + 6\times(-237.2)] - [-8.2]$

$= -1972.0 - 1423.2 + 8.2 = -3387.0$ kJ

$= -3387000$ Joules.

From the equation we find n = 32

Using the relation, $\Delta G^o = -nFE^o_{cell}$ and substituting various values, we get

$-3387000 = -32\times 96500\times E^o_{cell}$ (F = 96500C)

$$\text{or } E^o_{cell} = \frac{3387000}{32\times 96500}$$

$= \frac{3387000}{3088000}$ or $\frac{3387}{3088}$ V = 1.0968 V

Thus option (c) is correct answer.

30. (d) From the given representation of the cell, $E_{cell}$ can be found as follows.

$$E_{cell} = \left(E^o_{Fe^{2+}/Fe} - E^o_{Cr^{3+}/Cr}\right) - \frac{0.059}{6}\log\frac{[Cr^{3+}]^2}{[Fe^{2+}]^3}$$

[Nernst -Equ.]

$$= -0.42 - (-0.72) - \frac{0.059}{6}\log\frac{(0.1)^2}{(0.01)^3}$$

$$= -0.42 + 0.72 - \frac{0.059}{6}\log\frac{0.1\times0.1}{0.01\times0.01\times0.01}$$

$$= 0.3 - \frac{0.059}{6}\log\frac{10^{-2}}{10^{-6}} = 0.3 - \frac{0.059}{6}\times4$$

$= 0.30 - 0.0393 = 0.26$ V

Hence option (d) is correct answer.

31. (b) $H_2O \rightleftharpoons H^+ + OH^-$

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

∴ 0.5 mole of $H_2$ is liberated by 1 F = 96500 C

0.01 mole of $H_2$ will be liberated by

$= \frac{96500}{0.5} \times 0.01 = 1930$C

$Q = I \times t$

$t = \frac{Q}{I} = \frac{1930\ C}{10 \times 10^{-3}\ A} = 19.3 \times 10^4$ sec

32. (d)

33. (b) Conductivity (X) = conductance (c) × cell constant

∴ Cell constant $= \frac{X}{Y}$

Conductivity of NaOH $= \frac{X}{Y}.Z$

$\Delta m\ (NaOH) = \frac{X}{Y}.Z\times\frac{1000}{0.1} = \frac{XZ}{Y}10^4$

34. (b) Total of 6 electrons are required to form 2 moles of $Cr^{3+}$ therefore to form 1 mole of $Cr^{3+}$ 3F of charge is required.

35. (a) When platinum electrodes are dipped in dilute solution $H_2SO_4$ than $H_2$ is evolved at cathode.

36. (a) Specific conductance = Conductance × Cell constant

$k = \frac{1}{2.5\times10^3}\times1.15$;

$\Lambda_{eq} = \frac{1.15}{2.5\times10^3}\times\frac{1000}{0.1} = 4.6$

37. (a) Thus difluoro acetic acid being strongest acid will furnish maximum number of ions showing highest electrical conductivity. The decreasing acidic strength of the carboxylic acides given is difluoro acetic acid > fluoro acetic acid > chloro acetic acid > acetic acid.

38. (a) No. of moles of silver $= \frac{9650}{96500} = \frac{1}{10}$ moles

∴ Mass of silver deposited $= \frac{1}{10}\times108 = 10.8$ g

39. (c) $H^+ + e^- \longrightarrow \frac{1}{2}H_2$

$$E = E^o - \frac{0.059}{1}\log\frac{[P(H_2)]^{1/2}}{[H^+]}$$

Now if $p_{H_2} = 2$ atm and $[H^+] = 1M$

then $E = 0 - \frac{0.059}{1}\log\frac{2^{1/2}}{1} = \frac{-0.059}{2}\log2$

40. (a) 112 mL of $H_2$ at STP $= \frac{2\times112g}{22400}$

(Since 22400 mL at STP = M.wt)

Amount deposited $= \frac{Eq.wt\times i\times t}{96500}$

∴ $\frac{2\times112}{22400} = \frac{1\times965\times i}{96500}$;

i = 1 amp

41. (d) $\frac{W_A}{E_A} = \frac{W_B}{E_B}$; $\frac{1.6}{8} = \frac{Wt.\ of\ Ag}{108}$

∴ Wt. of Ag = 21.6 g

42. (d) Correct matching for pair (iii) will be [G (conductance) – siemens or $ohm^{-1}$(S).]

43. (a) The charge carried by 1 mole of electrons is one faraday. Thus for a reaction

$M^{n+} + ne^- \longrightarrow M$

nF = 1 mole of M

$Al^{3+} + 3e^- \longrightarrow Al$
3F — 1 mole
1F — 1/3 mole

$Cu^{2+} + 2e^- \longrightarrow Cu$
2F — 1 mole
1F — 1/2 mole

$Na^+ + e^- \longrightarrow Na$
1F — 1 mole

The mole ratio of Al, Cu and Na deposited at the respective cathode is $\frac{1}{3}:\frac{1}{2}:1$ or 2 : 3 : 6.

44. (a) Reciprocal of resistance is conductance. We can add the conductance and not resistance.

Hence $\frac{1}{r} = \frac{1}{\rho} + \frac{1}{\rho} + ........$

45. (c) The correct relation is $\Delta G^o = -nFE^o$