CBSE Test Paper-05

Class 12 Chemistry (Electrochemistry)

1. The standard emf of galvanic cell involving 3 moles of electrons in its redox reaction is 0.59 V. The equilibrium constant for the reaction of the cell is
   a. 10^{25}
   b. 10^{30}
   c. 10^{15}
   d. 10^{20}
2. The standard reduction potential E_o for half reactions are
   $E^0_{cell} = E^0_{cathode} - E^0_{anods}$
   The EMF of the cell reaction Fe^{2+} + Zn = Zn^{2+} + Fe is--- [Given $E^0 Zn^{2+}/Zn$ = -0.76V; $E^0 Fe^{2+}/Fe$ = -0.44V]
   a. -1.17 V
   b. -0.32 V
   c. + 0.32 V
   d. +1.17 V
3. An increase in equivalent conductance of a strong electrolyte with dilution is mainly due to
   a. increase in concentration of electrolyte
   b. decrease in ionic mobility
   c. increase in ionic mobility and number of ions
   d. decrease in both i.e. number of ions and mobility of ions
4. Electrolytic conduction is due to the movement of:
   a. molecules
   b. ions
   c. atoms
   d. electrons
5. Relationship between equilibrium constant of the reaction and standard electrode potential of electrochemical cell in which that reaction takes place is
   a. $E^0_{cell} = \frac{2.303RT}{nF} \log K_c$

b. $E^0_{cell} = \frac{2.03RT}{nF} \log K_c$
c. $E^0_{cell} = \frac{2.230RT}{nF} \log K_c$
d. $E^0_{cell} = \frac{2.303RT}{F} \log K_c$

6. What do you understand by corrosion?

7. Two metals A and B have reduction potential values -0.76 V and +0.34 V respectively. Which of these will liberate H_2 from dil H_2SO_4?

8. Define the term specific resistance and give its SI unit.

9. The resistance of a conductivity cell containing 0.001 M KCl solution at 298 K is $1500\,\Omega$. What is the cell constant if conductivity of 0.001 M KCl solution at 298 K is $0.146 \times 10^{-3}\,S\,cm^{-1}$.

10. How much electricity in terms of Faraday is required to produce
    i. 20.0 g of Ca from molten $CaCl_2$.
    ii. 40.0 g of Al from molten Al_2O_3.

11. Calculate E_{cell} for following:
    $2Cr(s) + 3Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 3Fe(s)$
    $Cr(s)|Cr^{3+}(aq)(0.1M)||Fe^{2+}(aq)(0.01M)|Fe(s)$
    $E^{\ominus}_{(Cr^{3+}/Cr)} = -0.74\ V$
    $E^{\ominus}_{(Fe^{2+}/Fe)} = -0.44\ V$

12. What type of a cell is the lead storage battery? Write the anode and cathode reactions and the overall reaction occurring in a lead storage battery while operating.

13. Write mathematical expression for Kohlrausch's law.

14. What is a salt bridge? What is it used for?

15. Calculate the standard cell potentials of galvanic cells in which the following reactions take place:
    i. $2Cr(s) + 3Cd^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 3Cd$
    ii. $Fe^{2+}(aq) + Ag^{+}(aq) \rightarrow Fe^{3+}(aq) + Ag(s)$
    Calculate the $\Delta_r G^{\Theta}$, and equilibrium constant of the reactions.

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Solutions

1. b. 10^{30}

   Explanation: $E^0 = \left(\frac{0.0591}{n}\right)\log k$

   0.59 = 0.0591/3 log K

   log K = 3 × 0.59/0.0591 = 30

   K = AL 30 = 10^{30}

2. c. + 0.32 V

   Explanation: $E^0_{cell} = E^0_{cathods} - E^0_{anods}$

   E^0cell = E^0Fe^{2+}/Fe - E^0Zn^{2+}/Zn

   = -0.44-(-0.76)= +0.32V.

3. a. increase in ionic mobility and number of ions

   Explanation: Equivalent conductance increases on dilution for a strong electrolyte as interionic attraction also decreases along with dilution. So ionic mobility increases which in turn increases the equivalent conductance.

4. c. atoms

   Explanation: atoms

5. a. $E^0_{cell} = \frac{2.303RT}{nF}\log K_c$

   Explanation: ΔG^0 = - 2.303 RT log Kc ; ΔG^0 = -nFE^0cell

   Equating, $E^0_{cell} = \frac{2.303RT}{nF}\log Kc$

6. Corrosion is an electrochemical phenomenon in which metal gets decomposed in the presence of air and water and forms compounds like oxides, sulphates, carbonates, sulphides etc.
7. Metals having higher oxidation potential (or Lower reduction poetial) will liberate H_2 from H_2SO_4. Thus, A will liberate H_2 from H_2SO_4.
8. The specific resistance of a substance is its resistance when it is one-meter-long and its area of cross Section is one m^2. Its SI unit is Ωm(ohm meter).
9. Given,

Conductivity, $K = 0.146 \times 10^{-3} Scm^{-1}$

Resistance, R = $1500\,\Omega$

Therefore, Cell constant = $K \times R$

$= 0.146 \times 10^{-3} \times 1500 = 0.219 cm^{-1}$

10. i. According to the question,

$Ca^{2+} + 2e^{-1} \rightarrow \underset{40\,g}{Ca}$

Electricity required to produce 40 g of calcium = 2 F

Therefore, electricity required to produce 20 g of calcium = $\frac{2 \times 20}{40} F$

= 1 F

ii. According to the question,

$Al^{3+} + 3e^{-1} \rightarrow \underset{27g}{Al}$

Electricity required to produce 27 g of Al = 3 F

Therefore, electricity required to produce 40 g of Al = $\frac{3 \times 40}{27} F$

= 4.44 F

11. We have

2Cr (s) + 3Fe^{2+}(aq)$\rightarrow$ 2Cr^{3+}(aq) + 3Fe(s)

$Cr(s)|Cr^{3+}(aq)(0.1M)||Fe^{2+}(aq)(0.01M)|Fe(s)$

Anode half reaction:

$[Cr \rightarrow Cr^{3+} + 3e^{-}] \times 2$

Cathode half reaction:

$[Fe^{2+} + 2e^{-} \rightarrow Fe] \times 3$

Net cell reaction:

$2Cr + 3Fe^{2+} \rightarrow 2Cr^{3+} + 3Fe$

Also standard emf of the cell is

$E^{\Theta}_{cell} \;=\; E^{\Theta}_{(Fe^{2+}/Fe)} \;-\; E^{\Theta}_{(Cr^{3+}/Cr)}$

= -0.44-(-0.74) = 0.30 V

According to Nernst equation

[Here **n=6** moles of electrons]

$$E_{cell} = E^{\Theta}_{cell} - \frac{0.059}{n} \log \frac{[Cr^{3+}]^2}{[Fe^{2+}]^3}$$

$$E_{cell} = E^{\Theta}_{cell} \;-\; \frac{0.059}{6} \log \left[\frac{(0.1)^2}{(0.01)^3} \right]$$

$= 0.30 - \frac{0.059}{6} \log \left[\frac{10^{-2}}{10^{-6}} \right]$
$= 0.30 - \frac{0.059}{6} \log 10^4$
$= 0.3 - \frac{0.059}{6} \times 4$
= 0.30 - 0.039 = 0.261 V
$\therefore E_{cell} = 0.261\ V$

12. The lead storage battery is the most important secondary cell. The cell reaction when the battery is in use are given below:
At anode: $Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2e^-$
At cathode: $PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightarrow 2PbSO_4(s) + 2H_2O(l)$
The overall cell reaction is:
$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$
13. Mathematical expression for Kohlrausch's law is
Λ_m^∞ or μ^∞ = Molar conductance at infinite dilution
$= m\lambda_+^\infty + n\lambda_-^\infty$
Where m and n are number of ions formed.
14. A salt bridge is a U-shaped tube containing concentrated solution of an inert electrolyte like KCl, KNO_3 etc. or solidified solution of such an electrolyte in agar-agar and gelatine.
It is used for:
    i. To complete the electrical circuit by allowing ions to flow from one solution to the other without mixing the two solutions.
    ii. To maintain the electrical neutrality of the solution in the two half cells.
15. i. $E^\Theta{}_{Cr^{3+}/Cr} = 0.74V$
$E^\Theta{}_{Cd^{2+}/Cd} = 0.40V$
The galvanic cell of the given reaction is depicted as:
$Cr_{(s)}|Cr^{3+}{}_{(aq)}||Cd^{2+}{}_{(aq)}|Cd_{(s)}$
Now, the standard cell potential is $E^\Theta_{cell} = E^\Theta_R - E^\Theta_L$
= 0.40 - (-0.74)
= +0.34 V
$\Delta_r G^\Theta = -nFE^\Theta_{cell}$
In the given equation,
n = 6

F = 96487 C mol^{-1}

E^{Θ}_{cell} = +0.34 V

Then, $\Delta_r G^{\Theta} = -6 \times 96487 C mol^{-1} \times 0.34V$

= -196833.48 CV mol^{-1}

= -196833.48 J mol^{-1}

= -196.86 kJ mol^{-1}

Again, $\Delta_r G^{\Theta} = -RT\, ln\, K$

$\Delta_r G^{\Theta} = -2.303\, RT\, ln\, K$

log K = $-\frac{\Delta_r G^{\Theta}}{2.303 RT}$

$= \frac{196.83 \times 10^3}{2.303 \times 8.314 \times 298}$

= 34.496

Therefore, K = antilog (34.496)

$= 3.13 \times 10^{34}$

ii. $E^{\Theta}{}_{Fe^{3+}/Fe^{2+}} = 0.77\, V$

$E^{\Theta}{}_{Ag^{+}/Ag} = 0.80\, V$

The galvanic cell of the given reaction is depicted as:

$Fe^{2+}{}_{(aq)}|Fe^{3+}{}_{(aq)}||Ag^{+}{}_{(aq)}|Ag_{(s)}$

Now, the standard cell potential is $E^{\Theta}_{cell} = E^{\Theta}_{R} - E^{\Theta}_{L}$

= 0.80 - 0.77 = 0.03 V

Here, n = 1.

Then,$\Delta_r G^{\Theta} = -nFE^{\Theta}_{cell}$

=$-1 \times 96487 C mol^{-1} \times 0.03V$

= -2894.61 J mol^{-1}

= -2.89 kJ mol^{-1}

Again,$\Delta_r G^{\Theta} = 2.303\, RT\, In\, K$

log $K = -\frac{\Delta_r G}{2.303\, RT}$

$= \frac{-2894.61}{2.303 \times 8.314 \times 298}$

= 0.5073

Therefore, K = antilog (0.5073)

= 3.2 (approximately)