Exercise-1

✍ **Marked questions are recommended for Revision.**

PART - I : SUBJECTIVE QUESTIONS

Section (A) : Galvanic cell, its Representation & salt bridge

Commit to memory :

Notation for Galvanic cell :

$$\overbrace{M(s) \underset{\text{Phase boundary}}{\underset{\downarrow}{|}} M^{2+}(aq, C_1)}^{\text{Anode half cell}} \underset{\text{Salt bridge}}{\underset{\downarrow}{||}} \overbrace{N^{2+}(aq, C_2) \underset{\text{Phase boundary}}{\underset{\downarrow}{|}} N(s)}^{\text{Cathode half cell}}$$

→ LOAN ≡ left oxidation- Anode-negative

A-1.✍ In the galvanic cell Cu | Cu^{2+} || Ag^+ | Ag, the electrons flow from Cu-electrode to Ag-electrode. Answer the following questions regarding this cell :

(a) Which is the anode ?
(b) Which is the cathode ?
(c) What happens at anode-reduction or oxidation ?
(d) What happens at cathode-oxidation or reduction ?
(e) Which electrode loses mass ?
(f) Which electrode gains mass ?
(g) Write the electrode reactions.
(h) Write the cell reaction
(i) Which metal has greater tendency to loss electron-Cu or Ag ?
(j) Which is the more reactive metal-Cu or Ag ?
(k) What is the function of salt bridge represented by the symbol || ?

A-2. Write cell reaction of the following cells :

(a) Cu | $Cu^{2+}(aq)$ | | $Ag^+(aq)$ | Ag
(b) Pt | Fe^{2+}, Fe^{3+} | | MnO_4^-, Mn^{2+}, H^+ | Pt
(c) Pt, Cl_2 | $Cl^-(aq)$ | | $Ag^+(aq)$ | Ag
(d) Cd | $Cd^{2+}(aq)$ | | $H^+(aq)$ | H_2 | Pt

A-3. Write cell notation of each cell with following cell reactions :

(a) $Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$
(b) $2Fe^{3+}(aq) + Sn^{2+}(aq) \rightarrow 2Fe^{2+}(aq) + Sn^{4+}(aq)$
(c) $Pb(s) + Br_2(l) \rightarrow Pb^{2+}(aq) + 2Br^-(aq)$

Section (B) : Electrochemical series & its Applications

Commit to memory :

$$\text{SRP} \propto \text{Oxidising power} \propto \frac{1}{\text{reducing power}} \propto \text{Non-metallic character} \propto \frac{1}{\text{Metallic character}}$$

B-1. The reduction potential values are given below
Al^{3+}/Al = –1.67 volt, Mg^{2+}/Mg = –2.34 volt, Cu^{2+}/Cu = +0.34 volt
I_2/I^- = +0.53 volt. Which one is the best reducing agent ?

B-2.✍ The standard reduction potential value of the three metallic cations X, Y and Z are 0.52, –3.03 and –1.18 V respectively. Write the decreasing order of reducing power of the corresponding metals :

B-3.✍ **(i)** Which of the following oxides is reduced by hydrogen ?
MgO, CuO and Na_2O

(ii) Which of the following oxides will decompose most easily on heating ?
ZnO, CuO, MgO and Ag_2O

(iii) The value of E^o_{OX} for electrode reactions,
$Fe \longrightarrow Fe^{2+} + 2e^-$, $Cu \longrightarrow Cu^{2+} + 2e^-$ and $Zn \longrightarrow Zn^{2+} + 2e^-$
are 0.444, –0.337 and 0.763 volt respectively. State which of these metals can replace the other two from the solution of their salts ?

B-4. For the cell reaction $2Ce^{4+} + Co \rightarrow 2Ce^{3+} + Co^{2+}$

E^o_{Cell} is 1.89 V. If $E^{\circ}_{Co^{2+}|Co}$ is – 0.28 V, what is the value of $E^{\circ}_{Ce^{4+}|Ce^{3+}}$?

B-5. Determine the standard reduction potential for the half reaction :

$Cl_2 + 2e^- \rightarrow 2Cl^-$

Given $Pt^{2+} + 2Cl^- \rightarrow Pt + Cl_2$, $E^o_{Cell} = -0.15$ V

$Pt^{2+} + 2e^- \rightarrow Pt$ $E^\circ = 1.20$ V

B-6. What is E^o_{Cell} if :

$2Cr + 3H_2O + 3OCl^- \rightarrow 2Cr^{3+} + 3Cl^- + 6\,OH^-$

$Cr^{3+} + 3e^- \rightarrow Cr$, $E^\circ = -0.74$ V

$OCl^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^-$ $E^\circ = 0.94$ V

Section (C) : Concept of ΔG

Commit to memory :

E^o_{cell} is an intensive property, so on multiplying or dividing electrode reaction, E^o_{cell} remains same.
Calcualte E^o_{cell} for 3rd reaction with the help of 1st and 2nd reaction using $\Delta G^o = -nF\,E^o_{cell}$.

$E^o_{target} = \dfrac{n_1E_1 + n_2E_2}{n_{target}}$ where n_1 = electrons participating in 1st reaction.

n_2 = electrons participating in 2nd reaction.

n_{target} = electrons participating in target reaction.

C-1. If $E^{\circ}_{Fe^{2+}|Fe} = -0.44$ V, $E^{\circ}_{Fe^{3+}|Fe^{2+}} = 0.77$ V. Calculate $E^{\circ}_{Fe^{3+}|Fe}$

C-2. Consider the standard reduction potentials (in volts) as shown in Fig. Find E°.

$$\begin{tikzcd} SO_4^{2-} \arrow[r, "-0.936"] \arrow[rr, bend right, "E^\circ = ?"'] & SO_3^{2-} \arrow[r, "-0.576"] & \frac{1}{2}S_2O_3^{2-} \end{tikzcd}$$

C-3. The standard oxidation potentials for Mn^{3+} ion acid solution are $Mn^{2+} \xrightarrow{-1.5\ V} Mn^{3+} \xrightarrow{-1.0\ V} MnO_2$.
Is the reaction $2\,Mn^{3+} + 2\,H_2O \longrightarrow Mn^{2+} + MnO_2 + 4H^+$ spontaneous under conditions of unit activity ? What is the change in free energy ?

C-4. Using the ΔG^o for the reactions

$C + O_2 \rightarrow CO_2$ $\Delta G^o = -395$ kJ / mole,

$2Al(l) + 3/2O_2 \rightarrow Al_2O_3(s)$ $\Delta G^o = -1269$ kJ/mole

$Al_2O_3(s) \rightarrow Al_2O_3$ (melt) $\Delta G^o = 16$ kJ/mole

Calculate the EMF for the cell reaction $2Al_2O_3$ (melt) + 3C $\rightarrow$ 4Al(□) + $3CO_2(g)$. The number of electrons involved in the reaction is 12.

Section (D) : Nernst equation & its Applications (including concentration cells)

Commit to memory :

Nernst equation : $E_{cell} = E^o_{cell}\ \dfrac{RT}{nf} - \ln Q$

At 25ºC, $E_{cell} = E^o_{cell} - \dfrac{0.0591}{n} \log Q$

where, n = number of transferred electron, Q = reaction quotient.
For concentration cell $E^o_{cell} = 0$

D-1. Calculate the oxidation potential of a hydrogen electrode at pH = 1 (T = 298 K).

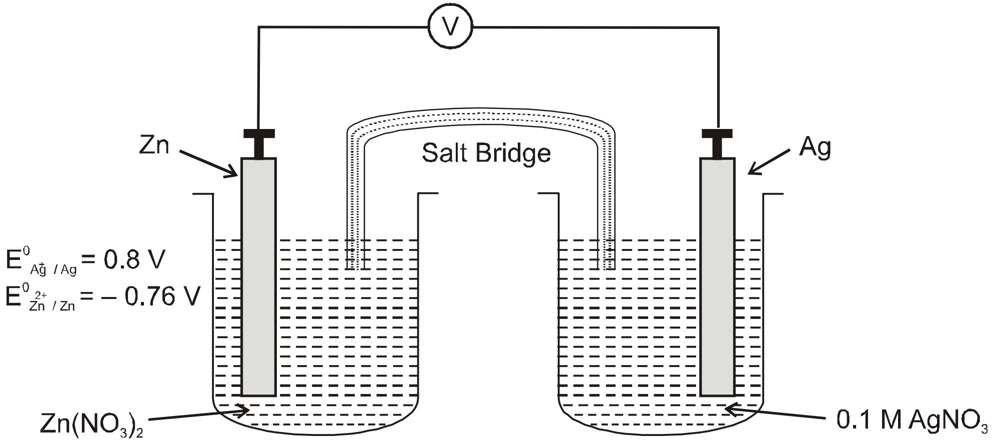
D-2. Calculate the equilibrium constant for the reaction :

$Fe^{2+} + Ce^{4+} \rightarrow Fe^{3+} + Ce^{3+}$, [Given $E^0_{Ce^{4+}/Ce^{3+}}$: = 1.61 V; $E^0_{Fe^{3+}/Fe^{2+}}$ = 0.77V]

D-3. The standard reduction potential of Cu^{2+} / Cu couple is 0.34 V at 25°C. Calculate the reduction potential at pH = 14 for this couple. (Given : K_{sp}, $Cu(OH)_2 = 1.0 \times 10^{-19}$).

D-4. The EMF of the cell M |M^{n+} (0.02 M) || H^+ (1M) | H_2 (g) (1 atm), Pt at 25°C is 0.81V. Calculate the valency of the metal if the standard oxidation potential of the metal is 0.76V.

D-5. Consider the following electrochemical cell :
(a) Write a balanced net ionic equation for the spontaneous reaction that take place in the cell.
(b) Calculte the standard cell potential Eº for the cell reaction.
(c) If the cell emf is 1.6 V, what is the concentration of Zn^{2+} ?
(d) How will the cell potential be affected if KI is added to Ag^+ half-cell ?



D-6. $NO_3^- \longrightarrow NO_2$ (acid medium), Eº = 0.790 V
$NO_3^- \longrightarrow NH_3OH^+$ (acid medium), Eº = 0.731 V.
At what pH, the above two will have same E value? Assume the concentration of all other species NH_3OH^+ except [H^+] to be unity.

D-7. The standard oxidation potential of Zn referred to SHE is 0.76V and that of Cu is –0.34V at 25ºC. When excess of Zn is added to $CuSO_4$, Zn displaces Cu^{2+} till equilibrium is reached. What is the approx value of $\log \frac{[Zn^{2+}]}{[Cu^{2+}]}$ at equilibrium?

Section (E) : Electrolysis

Commit to memory :
Higher SOP means higher tendency of oxidation.
Higher SRP means higher tendency of reduction.
SOP order : $SO_4^{2-} < NO_3^- < Cl^- < H_2O < Br^- < Ag < I^- < OH^- < Cu ..... < Li$
SRP order : Follow ECS

E-1.

	ELECTROLYTE	**ANODE Product**	**CATHODE Product**
1	NaCl (Molten) with Pt electrode		
2	NaCl (aq) with Pt electrode		
3	Na_2SO_4 (aq) with Pt electrode		
4	$NaNO_3$ (aq) with Pt electrode		
5	$AgNO_3$ (aq) with Pt electrode		
6	$CuSO_4$ (aq) with Inert electrode		
7	$CuSO_4$ (aq) with Copper electrode		

Section (F) : Faraday laws & its Applictions

Commit to memory :

Faraday's law of electrolysis :

Ist law $W = ZQ = \frac{EQ}{96500}$

$Q = it$

2nd law $\frac{W_1}{W_2} = \frac{Z_1}{Z_2} = \frac{E_1}{E_2}$ (Q = same)

Current efficiency (η) = $\frac{\text{actual amount of product}}{\text{theortical amount of product}} \times 100$

$W_{actual} = \left(\frac{E \times Q}{96500}\right)\frac{\eta}{100}$

F-1. Find the number of electrons involved in the electro–deposition of 63.5 g of copper from a solution of copper sulphate is :

F-2.✍ A current 0.5 ampere when passed through $AgNO_3$ solution for 193 sec. deposited 0.108 g of Ag. Find the equivalent weight of Ag :

F-3.✍ A certain metal salt solution is electrolysed in series with a silver coulometer. The weights of silver and the metal deposited are 0.5094 g and 0.2653g. Calculate the valency of the metal if its atomic weight is nearly that of silver.

F-4. 3A current was passed through an aqueous solution of an unknown salt of Pd for 1Hr. 2.977g of Pd^{+n} was deposited at cathode. Find n. (Given Atomic mass of Pd = 106.4)

F-5. How long a current of 2A has to be passed through a solution of $AgNO_3$ to coat a metal surface of $80 cm^2$ with $5 \mu m$ thick layer? Density of silver = $10.8 g/cm^3$.

F-6.✍ A certain electricity deposited 0.54g of Ag from $AgNO_3$ Solution. What volume of hydrogen will the same quantity of electricity liberate at STP (V_m = 22.4 L/mol).

F-7.✍ A current of 3.7A is passed for 6hrs. between Ni electrodes in 0.5L of 2M solution of $Ni(NO_3)_2$. What will be the molarity of solution at the end of electrolysis?

F-8. Cd amalgam is prepared by electrolysis of a solution of $CdCl_2$ using a mercury cathode. How long should a current of 5A be passed in order to prepare 12% Cd-Hg amalgam when 2 g Hg is used as cathode (atomic weight of Cd = 112.4)

F-9.✍ Electrolysis of a solution of HSO_4^- ions produces $S_2O_8^{2-}$. Assuming 75% current efficiency, what current should be employed to achieve a production rate of 1 mole of $S_2O_8^{2-}$ per hour ?

Section (G) : Commercial Cells & Corrosion

Commit to memory :

At STP, V_m (molar volume of the gas) = 22.4 L/mol

Volume of gas required at STP = moles of gas × 22.4

G-1.✍ A fuel cell uses $CH_4(g)$ and forms CO_3^{2-} at the anode. It is used to power a car with 80 Amp. for 0.96 hr. How many litres of $CH_4(g)$ (STP) would be required ? (V_m = 22.4 L/mol) (F = 96500). Assume 100% efficiency.

G-2. Find E° of cell formed for rusting of iron ?

$E^0_{Fe/Fe^{2+}} = +0.44 \text{ V}$

$E^0_{H_2O|O_2|H^+} = -1.23 \text{ V}$

Section (H) : Electrical Conductance

Commit to memory :

Conductivity (κ) = $C \times \frac{\ell}{A} = \frac{1}{R} \times \frac{\ell}{A}$

where, $\frac{\ell}{A}$ = cell constant, C = conductance, R = resistance.

A = surface area of electrodes, ℓ = distance between electrodes.

Molar conductance (Λ_m) = $\frac{\kappa \times 1000}{M}$ S cm^2 mol^{-1}

Equivalent conductance (Λ_{eq}) = $\frac{\kappa \times 1000}{N}$ S cm^2 eq^{-1}

where, M = molarity, N = normality and N = M × valence factor

H-1. The resistance of a M/10 KCl solution in 245 ohms. Calculate the specific conductance and the molar conductance of the solution if the electrodes in the cell are 4 cm apart and each having an area of 7.0 sq. cm.

H-2.✍ The resistance of a solution 'A' is 50 ohms and that of solution 'B' is 100 ohms, both solutions being taken in the same conductivity cell. If equal volumes of solution A. and B are mixed, what will be the resistance of the mixture using the same cell. (Assume that there is no increase in the degree of dissociation of A and B on mixing.

H-3.✍ In a conductivity cell the two platinum electrodes, each of area 10 sq, cm, are fixed 1.5 cm apart. The cell contained 0.05 M solution of a salt. If the two electrodes are just half dipped into the solution which has a resistance of 50 ohms, find molar conductance of the salt solution.

H-4.✍ The equivalent conductance of 0.10 N solution of $MgCl_2$ is 97.1 mho cm^2 eq.$^{-1}$ at 25°C. A cell with electrodes that are 1.50 cm^2 in surface area and 0.50 cm apart is filled with 0.1N $MgCl_2$ solution. How much current will flow when the potential difference between the electrodes is 5 volts ?

H-5. The specific conductance of a N/10 KCl solution at 18°C is 1.12×10^{-2} mho cm^{-1}. The resistance of the solution contained in the cell is found to be 65 ohms. Calculate the cell constant.

Section (I) : Kohlrausch law and its applications

Commit to memory :

Kohlrausch law : At infinite dilution, $\Lambda^o_{m,\ electrolyte} = \nu_+\Lambda^o_{m^+} + \nu_-\Lambda^o_{m^-}$

where, ν_+ = number of cations in one formula unit of electrolyte.

ν_- = number of anions in one formula unit of electrolyte.

At infinite dilution equivalent conductance : $\Lambda^o_{eq,\ electrolyte} = \Lambda^o_{eq+} + \Lambda^o_{eq-}$

Degree of dissociation (D.O.D.) = $\alpha = \frac{\Lambda_m}{\Lambda^o_m} = \frac{\Lambda_{eq}}{\Lambda^0_{eq}}$

For weak electrolyte, dissociation constant (K_a) = $\frac{C\alpha^2}{1-\alpha}$, where, C = concentration of electrolyte.

Solubility (s) = $\frac{\kappa \times 1000}{\Lambda^o_m}$ and $K_{sp} = S^2$ for AB type salt.

I-1.✍ The molar conductance of an infinitely dilute solution of NH_4Cl is 150 and the ionic conductances of OH^- and Cl^- ions are 198 and 76 respectively. What will be the molar conductance of the solution of NH_4OH at infinite dilution. If the molar conductance of a 0.01 M solution NH_4OH is 9.6, what will be its degree of dissociation?

I-2. Given the molar conductance of sodium butyrate, sodium chloride and hydrogen chloride as 83, 127 and 426 mho cm^2 mol^{-1} at 25°C respectively. Calculate the molar conductance of butyric acid at infinite dilution.

I-3.✍ Calculate K_a of acetic acid if its 0.05 N solution has equivalent conductance of 7.36 mho cm^2 at 25°C. $(\lambda^{\infty}_{CH_3COOH} = 390.7)$.

I-4.✍ The specific conductance of a saturated solution of AgCl at 25°C after subtracting the specific conductance of conductivity of water is 2.28 × 10^{-6} mho cm^{-1}. Find the solubility product of AgCl at 25°C. $(\lambda^{\infty}_{AgCl} = 138.3 \text{ mho } cm^2)$

Section (J) : Conductometric Titration

Commit to memory :
H^+ and OH^- ions are highly conducting.

J-1.✍ Draw approximate titration curve for following :
(1) HCl(aq) is titrated with NaOH
(2) CH_3COOH(aq) is titrated with NaOH
(3) Equimolar mixture of HCl and HCN titrated withNaOH
(4) NH_4Cl(aq) is titrated withNaOH

PART - II : ONLY ONE OPTION CORRECT TYPE

*** Marked Questions are having more than one correct option.**

Section (A) : Galvanic cell, its Representation & salt bridge

A-1. In a galvanic cell
(A) Chemical reaction produces electrical energy
(B) electrical energy produces chemical reaction
(C) reduction occurs at anode
(D) oxidation occurs at cathode

A-2.✍ Which of the following is/are function(s) of salt-bridge ?
(A) It completes the electrical circuit with electrons flowing from one electrode to the other through external wires and a flow of ions between the two compartments through salt - bridge
(B) it minimises the liquid - liquid junction potential
(C) both correct
(D) none of these

A-3. Salt bridge contains :
(A) calomel (B) sugar (C) H_2O (D) agar-agar paste

A-4.✍ The emf of the cell, Ni | Ni^{2+} (1.0 M) || Ag^+ (1.0M) | Ag [E° for Ni^{2+} / Ni = – 0.25 volt, E° for Ag^+/Ag = 0.80 volt] is given by -
(A) –0.25 + 0.80 = 0.55 volt (B) –0.25 – (+0.80) = –1.05 volt
(C) 0 + 0.80 – (–0.25) = + 1.05 volt (D) –0.80 – (–0.25) = – 0.55 volt

Section (B) : Electrochemical series & its Applications

B-1.✍ E^o for $F_2 + 2e \longrightarrow 2F^-$ is 2.8 V, E^o for $\frac{1}{2}F_2 + e \longrightarrow F^-$ is
(A) 2.8 V (B) 1.4 V (C) –2.8 V (D) –1.4 V

B-2. Consider the cell potentials = $E^{o}_{Mg^{2+}|Mg}$ – 2.37 V and $E^{o}_{Fe^{3+}|Fe}$ = – 0.04 V. The best reducing agent would be
(A) Mg^{2+} (B) Fe^{3+} (C) Mg (D) Fe

B-3.✍ If a spoon of copper metal is placed in a solution of ferrous sulphate -
(A) Cu will precipitate out (B) iron will precipitate
(C) Cu and Fe will precipitate (D) no reaction will take place

B-4.✍ The position of some metals in the electrochemical series in decreasing electropositive character is given as Mg > Al > Zn > Cu > Ag. What will happen if a copper spoon is used to stir a solution of aluminium nitrate ?
(A) The spoon will get coated with aluminium (B) An alloy of aluminium and copper is formed
(C) The solution becomes blue (D) There is no reaction

B-5. For Zn^{2+} / Zn, E° = –0.76 V, for Ag^+/Ag E° = 0.799 V. The correct statement is -
(A) the reaction Zn getting reduced Ag getting oxidized is spontaneous
(B) Zn undergoes reduction and Ag is oxidized
(C) Zn undergoes oxidation Ag^+ gets reduced
(D) No suitable answer

B-6.✍ Electrode potential data are given below.
$Fe^{3+}(aq) + e^- \longrightarrow Fe^{2+}(aq)$; $E^o = +0.77$
$Al^{3+}(aq) + 3e^- \longrightarrow Al(s)$; $E^o = -1.66$ V
$Br_2(aq) + 2e^- \longrightarrow 2Br^-(aq)$; $E^o = +1.08$ V
Based one the data given above, reducing power of Fe^{2+}, Al and Br^- will increase in the order :
(A) $Br^- < Fe^{2+} < Al$ (B) $Fe^{2+} < Al < Br^-$ (C) $Al < Br^- < Fe^{2+}$ (D) $Al < Fe^{2+} < Br^-$

B-7.✍ KCl can be used in salt bridge as electrolyte in which of the following cells?
(A) Zn | $ZnCl_2$ || $AgNO_3$ | Ag (B) Pb | $Pb(NO_3)_2$ || $Cu(NO_3)_2$ | Cu
(C) Cu | $CuSO_4$ || $AuCl_3$ | Au (D) Fe | $FeSO_4$ || $Pb(NO_3)_2$ | Pb

B-8.✍ Consider the following E^o values :

$$E^0_{Fe^{3+}/Fe^{2+}} = +0.77\text{ V} \quad ; \quad E^0_{Sn^{2+}/Sn} = -0.14\text{ V}$$

Under standard conditions the potential for the reaction is
$Sn(s) + 2Fe^{3+}(aq) \rightarrow 2Fe^{2+}(aq) + Sn^{2+}(aq)$
(A) 1.68V (B) 1.40 V (C) 0.91 V (D) 0.63 V

Section (C) : Concept of ΔG

C-1. Given standard electrode potentials :
$Fe^{3+} + 3e^- \longrightarrow Fe$; E° = –0.036 volt
$Fe^{2+} + 2e^- \longrightarrow Fe$; E° = –0.440 volt
The standard electrode potential E° for $Fe^{3+} + e^- \longrightarrow Fe^{2+}$
(A) –0.476 volt (B) –0.404 volt (C) 0.440 volt (D) 0.772 volt

C-2. $Cu^+ + e^- \longrightarrow Cu$, E° = x_1 volt; $Cu^{2+} + 2e^- \longrightarrow Cu$, E° = x_2 volt, then for $Cu^{2+} + e^- \longrightarrow Cu^+$, E° (volt) will be -
(A) $x_1 - 2x_2$ (B) $x_1 + 2x_2$ (C) $x_1 - x_2$ (D) $2x_2 - x_1$

C-3.✍ Which of the following statements about the spontaneous reaction occurring in a galvanic cell is always true?
(A) $E^o_{cell} > 0$, $\Delta G^o < 0$, and Q < K (B) $E^o_{cell} > 0$, $\Delta G^o < 0$, and Q > K
(C) $E^o_{cell} > 0$, $\Delta G^o > 0$, and Q > K (D) $E_{cell} > 0$, $\Delta G < 0$, and Q < K

Section (D) : Nernst equation & its Applications (including concentration cells)

D-1.✍ The standard emf for the cell reaction $Zn + Cu^{2+} \longrightarrow Zn^{2+} + Cu$ is 1.10 volt at 25°C. The emf for the cell reaction when 0.1 M Cu^{2+} and 0.1 M Zn^{2+} solutions are used at 25°C is
(A) 1.10 volt (B) 0.110 volt (C) –1.10 volt (D) –0.110 volt

D-2. Consider the cell $\begin{array}{c}H_2(Pt)\\ 1\text{ atm}\end{array}\left|\begin{array}{l}H_3O^+(aq)\\ pH = 5.03\end{array}\right\|\left.\begin{array}{l}Ag^+\\ x\quad M\end{array}\right|$ Ag. The measured EMF of the cell is 1.0 V. What is the value of x ? $E^0_{Ag^+,Ag} = +0.8$ V. [T = 25°C]
(A) 2×10^{-2} M (B) 2×10^{-3} M (C) 1.5×10^{-3} M (D) 1.5×10^{-2} M

D-3. Zn | Zn^{2+} (C_1) || Zn^{2+} (C_2)|Zn. for this cell ΔG is negative if -
(A) $C_1 = C_2$ (B) $C_1 > C_2$ (C) $C_2 > C_1$ (D) None

D-4.✍ $\mathrm{Pt}\,\Big|\begin{matrix}H_2\\(p_1)\end{matrix}\Big|\begin{matrix}H^+\\(1\ \mathrm{M})\end{matrix}\Big\|\begin{matrix}H^+\\(1\ \mathrm{M})\end{matrix}\Big|\begin{matrix}H_2\\(p_2)\end{matrix}\Big|\mathrm{Pt}$ (where p_1 and p_2 are pressures) cell reaction will be spontaneous if :

(A) $p_1 = p_2$ (B) $p_1 > p_2$ (C) $p_2 > p_1$ (D) p_1 = 1 atm

D-5. Pt | (H_2) | pH = 1 || pH = 2 | (H_2)Pt
1 atm 1 atm
The cell reaction for the given cell is :

(A) spontaneous (B) non - spontaneous (C) equilibrium (D) none of these

D-6.✍ The EMF of a concentration cell consisting of two zinc electrodes, one dipping into $\frac{M}{4}$ sol. of zinc sulphate & the other into $\frac{M}{16}$ sol. of the same salt at 25^0 C is

(A) 0.0125 V (B) 0.0250 V (C) 0.0178 V (D) 0.0356 V

Section (E) : Electrolysis

E-1.✍ In an electrolytic cell of Ag/$AgNO_3$/Ag, when current is passed, the concentration of $AgNO_3$

(A) Increases (B) Decreases (C) Remains same (D) None of these

E-2. If 0.224 L of H_2 gas is formed at the cathode, the volume of O_2 gas formed at the anode under identical conditions, is

(A) 0.224 L (B) 0.448 L (C) 0.112 L (D) 1.12 L

E-3.✍ The two aqueous solutions, A ($AgNO_3$) and B (LiCl) were electrolysed using Pt. electrodes. The pH of the resulting solutions will

(A) increase in A and decrease in B (B) decrease in both
(C) increase in both (D) decrease in A and increase in B.

E-4. In the electrolysis of aqueous $CuBr_2$ using Pt electrodes :

(A) Br_2 gas is not evolved at the anode
(B) Cu (s) is deposited at the cathode
(C) Br_2 gas is evolved at anode and H_2 gas at cathode
(D) H_2 gas is evolved at anode.

E-5.✍ During electrolysis of $CuSO_4$ using Pt-electrodes, the pH of solution

(A) increases (B) decreases (C) remains unchanged (D) cannot be predicted

Section (F) : Faraday laws & its Applictions

F-1.✍ How many faradays are required to reduce one mol of MnO_4^- to Mn^{2+} -

(A) 1 (B) 2 (C) 3 (D) 5

F-2. Three faradays of electricity was passed through an aqueous solution of iron (II) bromide. The mass of iron metal (at. mass 56) deposited at the cathode is -

(A) 56 g (B) 84 g (C) 112 g (D) 168 g

F-3.✍ A current of 2 A was passed for 1 h through a solution of $CuSO_4$ 0.237g of Cu^{2+} ions were discharged at cathode. The current efficiency is

(A) 42.2% (B) 26.1% (C) 10% (D) 40.01%

F-4. A current of 9.65 ampere is passed through the aqueous solution NaCl using suitable electrodes for 1000 s. The amount of NaOH formed during electrolysis is

(A) 2.0 g (B) 4.0 g (C) 6.0 g (D) 8.0 g

F-5.✍ Salts of A (atomic mass 15), B (atomic mass 27) and C (atomic mass 48) were electrolysed using same amount of charge. It was found that when 4.5 g of A was deposited, the mass of B and C deposited were 2.7g and 9.6 g. The valencies of A, B and C respectively.

(A) 1, 3 and 2 (B) 3, 1 and 3 (C) 2, 6 and 3 (D) 3, 1 and 2

Section (G) : Commercial Cells & Corrosion

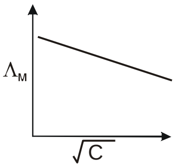
G-1. During discharge of a lead storage cell the density of sulphuric acid in the cell :
(A) increasing (B) decreasing
(C) remians unchanged (D) initially increases but decrease subsequently

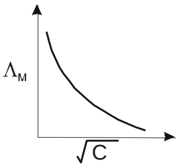
G-2. In H_2–O_2 fuel cell the reaction occuring at cathode is :
(A) $2H_2O + O_2 + 4e^- \longrightarrow 4\,OH^-$ (B) $2H_2 + O_2 \longrightarrow 2H_2O\ (l)$
(C) $H^+ + OH^- \longrightarrow H_2O$ (D) $H^+ + e^- \longrightarrow \frac{1}{2}H_2$.

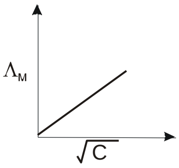
G-3. Which is not correct method for prevention of iron from Rusting -
(A) Galvanisation (B) Connecting to sacrificial electrode of Mg
(C) Making medium alkaline (D) Making medium acidic

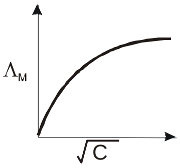
Section (H) : Electrical Conductance

H-1. Which of the following curve represents the variation of Λ_M with $\sqrt{C}$ for $AgNO_3$?

(A) 

(B) 

(C) 

(D) 

H-2. Which has maxmium conductivity :
(A) $[Cr(NH_3)_3\,Cl_3]$ (B) $[Cr(NH_3)_4\,Cl_2]Cl$ (C) $[Cr(NH_3)_5Cl]Cl_2$ (D) $[Cr(NH_3)_6]Cl_3$

H-3. Resistance of decimolar solution is 50 ohm. If electrodes of surface area 0.0004 m^2 each are placed at a distance of 0.02 m then conductivity of solution is :
(A) 1 s cm^{-} (B) 0.01 s cm^{-} (C) 0.001 s cm^{-} (D) 10 s cm^{-}

H-4. V_1 Litre of solution A (Resistance = 50 ohm) is mixed with V_2 Litre of solution B (Resistance = 100 ohm). Resistance of final solution is 80 ohm then $\frac{V_2}{V_1}$ will be (using same cell)
(A) 1 (B) 2 (C) 3 (D) 4

Section (I) : Kohlrausch law and its applications

I-1. The ionization constant of a weak electrolyte (HA) is 25×10^{-6} while the equivalent conductance of its 0.01 M solution is 19.6 S cm^2 eq^{-1}. The equivalent conductance of the electrolyte at infinite dilution (in S cm^2 eq^{-1}) will be
(A) 250 (B) 196 (C) 392 (D) 384

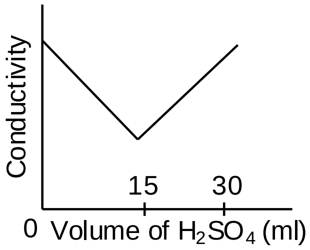
I-2. The conductivity of a saturated solution of $BaSO_4$ is 3.06×10^{-6} ohm^{-1} cm^{-1} and its equivalent conductance is 1.53 ohm^{-1} cm^2 $equiv^{-1}$. The K_{sp} for $BaSO_4$ will be
(A) 4×10^{-12} (B) 2.5×10^{-13} (C) 25×10^{-9} (D) 10^{-6}

I-3. Molar conductance of 0.1 M acetic acid is 7 ohm^{-1} cm^2 mol^{-1}. If the molar cond. of acetic acid at infinite dilution is 380.8 ohm^{-1} cm^2 mol^{-1}, the value of dissociation constant will be :
(A) 226×10^{-5} mol dm^{-3} (B) 1.66×10^{-3} mol dm^{-1}
(C) 1.66×10^{-2} mol dm^{-3} (D) 3.442×10^{-5} mol dm^{-3}

I-4. The conductivity of a solution of AgCl at 298 K is found to be 1.382×10^{-6} Ω^{-1} cm^{-1}. The ionic conductance of Ag^+ and Cl^- at infinite dilution are 61.9 Ω^{-1} cm^2 mol^{-1} and 76.3 Ω^{-1} cm^2 mol^{-1}, respecitvley. The solubility of AgCl is
(A) 1.4×10^{-5} mol L^{-1} (B) 1×10^{-2} mol L^{-1} (C) 1×10^{-5} mol L^{-1} (D) 1.9×10^{-5} mol L^{-1}

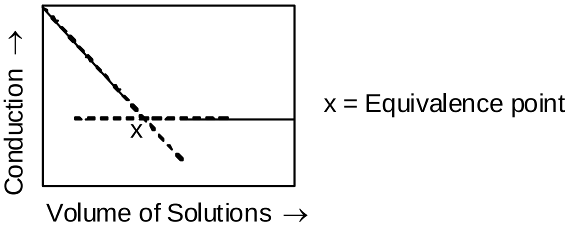
I-5. Molar conductances of $BaCl_2$, H_2SO_4 and HCl at infinite dilutions are x_1, x_2 and x_3, respectively. Equivalent conductance of $BaSO_4$ at infinite dilution will be :
(A) $\frac{[x_1 + x_2 - x_3]}{2}$ (B) $\frac{[x_1 - x_2 - x_3]}{2}$ (C) $2\,(x_1 + x_2 - 2x_3)$ (D) $\frac{[x_1 + x_2 - 2x_3]}{2}$

Section (J) : Conductometric Titration



J-1.✍ 20 ml KOH solution was titrated with 0.2 mol/l H_2SO_4 solution in conductivity cell. Concentration of KOH solution was –
(A) 0.3 M
(B) 0.15
(C) 0.12
(D) None of these

J-2. Following curve for conductometric titration is obtained when –



(A) NaOH solution is added in to HCl solution (B) NaOH solution is added in to CH_3COOH solution
(C) NH_4OH solution is added in to HCl solution (D) NH_4OH solution is added in to CH_3COOH solution

PART - III : MATCH THE COLUMN

1. Match the column

	Column I		**Column II**
(A)	$Zn \mid Zn^{+2} \mid\mid Mg^{2+} \mid Mg$ c_1 c_2 $(c_1 = c_2)$	**(p)**	$E_{cell} = 0$
(B)	$Zn \mid Zn^{+2} \mid\mid Ag^+ \mid Ag$ at. equilibrium	**(q)**	$E^0_{cell} = 0$
(C)	$Ag \mid Ag^+ \mid\mid Ag^+ \mid Ag$ c_1 c_2 $(c_1 = c_2)$	**(r)**	E^0_{cell} = +ve
(D)	$Fe \mid Fe^{+2} \mid\mid Ag \mid Ag^+$ c_1 c_2 $(c_1 = c_2)$	**(s)**	E^0_{cell} = –ve

2.✍ Match Matrix $(E^0_{Ag^+/Ag} = 0.8)$.

	Column I		**Column II**
(A)	Pt | H_2 (0.1 bar) | H^+ (0.1 M) || H^+ (1 M) | H_2 (0.01 bar) | Pt	**(p)**	Concentration cell
(B)	Ag | Ag^+ (10^{-9} M) || Ag^+ (10^{-2} M) | Ag	**(q)**	$E_{cell} > 0$
(C)	Cu | Cu^{2+} (0.1 M) || Cu^{2+} (0.01 M) | Cu	**(r)**	$E^o_{cell} = 0$ but cell is working.
(D)	Pt | Cl_2 (1bar) | HCl (0.1 M) || NaCl (0.1M) | Cl_2 | Pt (1 bar)	**(s)**	non working condition

Exercise-2

✍ **Marked questions are recommended for Revision.**

PART - I : ONLY ONE OPTION CORRECT TYPE

1. Given : $E^o(Cu^{2+} \mid Cu) = 0.337$ V and $E^o(Sn^{2+} \mid Sn) = -0.136$ V. Which of the following statements is correct?
(A) Cu^{2+} ions can be reduced by $H_2(g)$ (B) Cu can be oxidized by H^+
(C) Sn^{2+} ions can be reduced by $H_2(g)$ (D) Cu can reduce Sn^{2+}

2.✍ Red hot carbon will remove oxygen from the oxide AO and BO but not from MO, while B will remove oxygen from AO. The activity of metals A, B and M in decreasing order is
(A) A > B > M (B) B > A > M (C) M > B > A (D) M > A > B

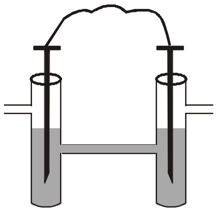
3. What is the emf at 25° C for the cell, $\text{Ag}, \left| \begin{matrix} \text{AgBr (s)}, & \text{Br}^- \\ & a = 0.34 \end{matrix} \right\| \begin{matrix} \text{Fe}^{3+} & , & \text{Fe}^{2+} \\ a = 0.1 & & a = 0.02 \end{matrix} \Big| \text{Pt}$

The standard reduction potentials for the half-reactions $AgBr + e^- \rightarrow Ag + Br^-$ and $Fe^{3+} + e^- \rightarrow Fe^{2+}$ are + 0.0713 V and + 0.770 V respectively.
(A) 0.474 volt (B) 0.529 volt (C) 0.356 volt (D) 0.713 volt

4.✍ A hydrogen electrode placed in a buffer solution of CH_3COONa and CH_3COOH in the ratios of x : y and y : x has electrode potential values E_1 volts and E_2 volts, respectively at 25ºC. The pK_a values of acetic acid is (E_1 and E_2 are oxidation potentials)
(A) $\frac{E_1 + E_2}{0.118}$ (B) $\frac{E_2 - E_1}{0.118}$ (C) $-\frac{E_1 + E_2}{0.118}$ (D) $\frac{E_1 - E_2}{0.118}$

5.✍ The electrode oxidation potential of electrode $M(s) \longrightarrow M^{n+}(aq)\ (2M) + ne^-$ at 298 K is E_1. When temperature (in ºC) is doubled and concentration is made half, then the electrode potential becomes E_2. Which of the following represents the correct relationship between E_1 and E_2 ?
(A) $E_1 > E_2$ (B) $E_1 < E_2$ (C) $E_1 = E_2$ (D) Cann't be predicted

6. Two weak acid solutions HA_1 and HA_2 each with the same concentration and having pK_a values 3 and 5 are placed in contact with hydrogen electrode (1 atm, 25ºC) and are interconnected through a salt bridge. The emf of the cell is :
(A) 0.21 V (B) 0.059 V
(C) 0.018 V (D) 0.021 V



7.✍ Electrolysis of a solution of $MnSO_4$ in aqueous sulphuric acid is a method for the preparation of MnO_2. Passing a current of 27A for 24 hours gives 1kg of MnO_2. The current efficiency in this process is :
(A) 100% (B) 95.185% (C) 80% (D) 82.951%

8.✍ During the preparation of $H_2S_2O_8$ (per disulphuric acid) O_2 gas also releases at anode as byproduct, When 9.72 L of H_2 releases at cathode and 2.35 L O_2 at anode at STP, the weight of $H_2S_2O_8$ produced in gram is
(A) 87.12 (B) 43.56 (C) 83.42 (D) 51.74

9.✍ When the sample of copper with zinc impurity is to be purified by electolysis, the appropriate electrode are :
(A) pure zinc as cathode and pure copper as anode
(B) impure sample as cathode and pure copper as anode
(C) impure zinc as cathode and impure sample as anode
(D) pure copper as cathode and impure sample as anode

10. A galvanic cell is composed of two hydrogen electrodes, one of which is a standard one. In which of the following solutions should the other electrode be immersed to get maximum emf ? $K_a(CH_3COOH) = 2 \times 10^{-5}$, $K_a(H_3PO_4) = 10^{-3}$.
(A) 0.1 M HCl (B) 0.1 M CH_3COOH (C) 0.1 M H_3PO_4 (D) 0.1 M H_2SO_4

11. When iron is rusted, it is :
(A) reduced (B) oxidised (C) evaporated (D) decomposed

12.✍ Which statement is correct.
(A) In SHE, the pressure of dihydrogen gas should be low and pH of solution should be zero.
(B) In the reaction $H_2O_2 + O_3 \longrightarrow 2H_2O + 2O_2$, H_2O_2 is oxidised to H_2O.
(C) The absolute value of electrode potential cannot be determined.
(D) According to IUPAC conventions, the standard electrode potential pertains to oxidation reactions only.

13.✍ Using the standard potential values given below, decide which of the statements I, II, III, IV are correct. Choose the right answer from (a), (b), (c) and (d)

$Fe^{2+} + 2e^- = Fe$, $E^o = -0.44$ V
$Cu^{2+} + 2e^- = Cu$, $E^o = +0.34$ V
$Ag^+ + e^- = Ag$, $E^o = +0.80$ V

I. Copper can displace iron from $FeSO_4$ solution
II. Iron can displace copper from $CuSO_4$ solution
III. Silver can displace Cu from $CuSO_4$ solution
IV. Iron can displace silver from $AgNO_3$ solution

(A) I and II (B) II and III (C) II and IV (D) I and IV

14.✍ When the electric current is passed through a cell having an electrolyte, the positive ions move towards cathode and negative ions towards the anode. If the cathode is pulled out of the solution
(A) the positive and negative ions will move towards anode
(B) the positive ions will start moving towards the anode while negative ions will stop moving
(C) the negative ions will continue to move towards anode while positive ions will stop moving
(D) the positive and negative ions will start moving randomly

15. Four moles of electrons were transferred from anode to cathode in an experiment on electrolysis of water. The total volume of the two gases (dry and at STP) produced will be approximately (in litres)
(A) 22.4 (B) 44.8 (C) 67.2 (D) 89.4

PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

1.✍ How many of the following comparisons are correct with respect to their Λ_m^∞ ?
(A) $K^+ > Na^+$ (B) $K^+ > H_3O^+$ (C) $Ca^{2+} > Na^+$ (D) $Mg^{2+} > NH_4^+$
(E) $H_3O^+ > Mg^{2+}$ (F) $K^+ > Mg^{2+}$

2. Λ^∞_m (weak mono basic HA acid) = 390.7 S cm^2 mol^{-1}
Λ_m of HA at 0.01 M is 3.907 S cm^2 mol^{-1}
Find pH of 0.01 M HA ?

3.✍ The conductivity of a solution which is 0.1 M in $Ba(NO_3)_2$ and 0.2 M in $AgNO_3$ is 5.3 Sm^{-1}. If $\lambda^o_{(Ag^+)} = 6 \times 10^{-3}$ Sm^2 mol^{-1} & $\lambda^o_{(Ba^{2+})} = 13 \times 10^{-3}$ Sm^2 mol^{-1}, determine $\lambda^o_{(NO_3^-)}$ in same unit. Report your answer after multiplying by 1000.

4.✍
$H_4XeO_6 + 2H^+ + 2e^- \longrightarrow XeO_3 + 3H_2O$ $E^o = 3$ V
$F_2 + 2e^- \longrightarrow 2F^-$ $E^o = 2.87$ V
$O_3 + 2H^+ + 2e^- \longrightarrow O_2 + H_2O$ $E^o = 2.07$ V
$Ce^{4+} + e^- \longrightarrow Ce^{3+}$ $E^o = 1.67$ V
$2HClO + 2H^+ + 2e^- \longrightarrow Cl_2 + 2H_2O$ $E^o = 1.63$ V
$ClO_4^- + 2H^+ + 2e^- \longrightarrow ClO_3^- + H_2O$ $E^o = 1.23$ V
$ClO^- + H_2O + 2e^- \longrightarrow Cl^- + 2OH^-$ $E^o = 0.89$ V
$BrO^- + H_2O + 2e^- \longrightarrow Br^- + 2OH^-$ $E^o = 0.76$ V
$ClO_4^- + H_2O + 2e^- \longrightarrow ClO_3^- + 2OH^-$ $E^o = 0.36$ V
$[Fe(CN)_6]^{3-} + e^- \longrightarrow [Fe(CN)_6]^{4-}$ $E^o = 0.36$ V

Based on the above data, how many of the following statements are correct ?
(A) F_2 is better oxidizing agent than $H_4X_6O_6$.
(B) Ozone can oxidize Cl_2
(C) ClO_4^- is better oxidizing agent in basic medium than in acidic medium
(D) Ferrocyanide ion can be easily oxidized by ClO^-, Ce^{4+}, Li^+, BrO^-
(E) ClO^- can oxidize Br^- and ClO_3^- in basic medium.
(F) Ce^{4+} can oxidize Cl_2 in acidic medium under standard conditions.

5. For a saturated solution of AgCl at 25°C, $\kappa = 3.4 \times 10^{-6}$ ohm^{-1} cm^{-1} and that of H_2O(□) used is 2.02×10^{-6} ohm^{-1} cm^{-1}. Λ°_m for AgCl is 138 ohm^{-1} cm^2 mol^{-1} then the solubility of AgCl in mili moles per m^3 will be :

6.✍ Estimate the cell potential of a Daniel cell having 1.0M Zn^{2+} and originally having 1.0M Cu^{2+} after sufficient NH_3 has been added to the cathode compartment to make NH_3 concentration 2.0M at equilibrium. Given K_f for $[Cu(NH_3)_4]^{2+} = 1 \times 10^{12}$, E° for the reaction, $Zn + Cu^{2+} \longrightarrow Zn^{2+} + Cu$ 1.1V. (Take $\frac{2.303\ \ RT}{F} = 0.06$, log 6.25 = 0.8) Respond as 10 × your answer.

7. Molar conductivity of 0.04 $MgCl_2$ solution at 298 k is 200 Scm^2mole^{-1}. A conductivity cell which is filled with $MgCl_2$ have area of cross-section of electrode $4cm^2$ & distance between electrode is 8 cm. If potential difference between electrode is 10V then find current flow in miliampere.

8.✍ At 298 K, the conductivity of pure water is 5.5×10^{-6} S m^{-1}. Calculate the ionic product of water using the following data :

λ_m° values (in S m^2 mol^{-1}) : $Ba(OH)_2 = 5.3 \times 10^{-2}$, $HCl = 4.25 \times 10^{-2}$, $BaCl_2 = 2.8 \times 10^{-2}$.

Does your answer match with experimental value. Write 20 for yes & 40 for No.

9. A hydrogen gas electrode is made by dipping platinum wire in a solution of NaOH of pH = 10 and by passing hydrogen gas around the platinum wire at one atm pressure. The oxidation potential of electrode is 10x milivolt. Find x ? (Take $\frac{2.303\ \ RT}{F} = 0.059$)

PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1.✍ Given $E^{\circ}_{Ag^+/Ag} = 0.80V$, $E^{\circ}_{Mg^{2+}/Mg} = -2.37V$, $E^{\circ}_{Cu^{2+}/Cu} = 0.34V$, $E^{\circ}_{Hg^{2+}/Hg} = 0.79$ V.

Which of the following statements is/are correct

(A) $AgNO_3$ can be stored in copper vessel
(B) $Mg(NO_3)_2$ can be stored in copper vessel
(C) $CuCl_2$ can be stored in silver vessel
(D) $HgCl_2$ can be stored in copper vessel

2.✍ Any redox reaction would occur spontaneously, if :

(A) the free energy change (ΔG) is negative
(B) the ΔG^o is positive
(C) the cell e.m.f. (E^o) is negative
(D) the cell e.m.f. is positive

3. On electrolysis, in which of the following, O_2 would be liberated at the anode ?

(A) dilute H_2SO_4 with Pt electrodes
(B) aqueous $AgNO_3$ solution with Pt electrodes
(C) dilute H_2SO_4 with Cu electrodes
(D) aqueous NaOH with a Fe cathode & a Pt anode

4.✍ A current of 2.68 A is passed for one hour through an aqueous solution of $CuSO_4$ using copper electrodes. Select the correct statement(s) from the following :

(A) increase in mass of cathode = 3.174 g
(B) decrease in mass of anode = 3.174 g
(C) no change in masses of electrodes
(D) the ratio between the change of masses of cathode and anode is 1 : 2 .

5. Three moles of electrons are passed through three solutions in succession containing $AgNO_3$, $CuSO_4$, and $AuCl_3$, respectively. The molar ratio of amounts of cations reduced at cathode will be

(A) 1 : 2 : 3
(B) $\frac{1}{1} : \frac{1}{2} : \frac{1}{3}$
(C) 3 : 2 : 1
(D) 6 : 3 : 2

6.✍ Mark out the correct statement(s) regarding electrolytic molar conductivity.

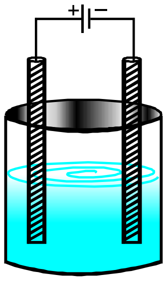
(A) It increase as temperature increases.
(B) It experiences resistance due to vibration of ion at the mean position.
(C) Increase in concentration decreases the electrolytic molar conductivity of both the strong as well as the weak electrolyte.
(D) Greater the polarity of solvent, greater is the electrolytic molar conduction.

7. If same quantity of electricity is passed through three electrolytic cells containing $FeSO_4$, $Fe_2(SO_4)_3$ and $Fe(NO_3)_3$, then

(A) the amount of iron deposited in $FeSO_4$ and $Fe_2(SO_4)_3$ are equal
(B) the amount of iron deposited in $FeSO_4$ is 1.5 times of the amount of iron deposited in $Fe(NO_3)_3$.
(C) the amount of iron deposited in $Fe_2(SO_4)_3$ and $Fe(NO_3)_3$ are equal
(D) the same amount of gas is evolved in all three cases at the anode.

8.✍ When a lead storage battery is discharged then :
(A) SO_2 is evolved
(B) lead sulphate is produced at both electrodes
(C) sulphuric acid is consumed
(D) water is formed

9.✍ Consider an electrolytic cell E being powered by a galvenic cell G, as shown in the figure. Then :



(A) Anode of E is connected to cathode of G

(B) Anode of E is connected to anode of G

(C) Cathode of E is connected to anode of G

(D) Cathode of E is connected to cathode of G

10.✍ On increasing dilution following will increase :
(A) Equivalent conductivity
(B) Conductivity
(C) Molar conductivity
(D) All of these

11. The resistances of following solutions of KCl were measured using conductivity cells of different cell constants, at same temperature. (Consider that at concentration less than 0.1 M, the specific conductivity of solution is directly proportional to the concentration of solution.)

	Concentration of Solution	**Cell Constant**
1.	0.1 M	1 cm^{-1}
2.	0.01 M	10 cm^{-1}
3.	0.005 M	5 cm^{-1}
4.	0.0025 M	25 cm^{-1}

Which of the following comparisons between their conductances (G) is/are correct ?
(A) G_1 is maximum
(B) G_4 is minimum
(C) $G_3 >> G_2$
(D) G_4 is maximum

12. Identify correct statements :
(A) Kohlrausch law is applicable only on weak electrolyte.
(B) On increasing dilution conductance, molar conductivity, equivalent conductivity increases but conductivity decreases.
(C) $\Lambda_m = \dfrac{K}{C}$ following formula has units $\Lambda_m \rightarrow \Omega^{-}\ dm^2/mol$ $\quad K \rightarrow \Omega^{-}\ dm^{-1}$, $C \rightarrow mol/$□
(D) Equation $\Lambda_m = \Lambda_m^{\infty} - b\sqrt{C}$ is applicable on weak as well as strong electrolyte.

13.✍ Select the correct option(s):

(A) $\dfrac{\overset{o}{\lambda}_{eq}\ (Al^{3+})}{3} = \overset{o}{\lambda}_m\ (Al^{3+})\ \&\ \dfrac{\overset{o}{\lambda}_{eq}\ (SO_4^{2-})}{2} = \overset{o}{\lambda}_m\ (SO_4^{2-})$

(B) $\overset{o}{\lambda}_{eq}\ (Al^{3+}) = \dfrac{\overset{o}{\lambda}_m\ (Al^{3+})}{3}\ \&\ \overset{o}{\lambda}_{eq}\ (SO_4^{2-}) = \dfrac{\overset{o}{\lambda}_m\ (SO_4^{2-})}{2}$

(C) $\overset{o}{\lambda}_{eq}\ (Al_2(SO_4)_3) = \dfrac{\overset{o}{\lambda}_m\ (Al^{3+})}{3} + \dfrac{\overset{o}{\lambda}_m\ (SO_4^{2-})}{2}$

(D) $\overset{o}{\lambda}_m\ (Al_2(SO_4)_3) = 6 \times \overset{o}{\lambda}_{eq}\ (Al_2(SO_4)_3)$

14.✍ Which of the following order is correct related to their mobility in solution:
(A) $Cs^+_{aq} > Rb^+_{aq} > K^+_{aq} > Na^+_{aq} > Li^+_{aq}$
(B) $Be^{+2}_{aq} > Li^+_{aq} > Cs^+_{aq}$
(C) $H^+_{aq} > Li^+_{aq} > Be^{+2}_{aq} > Na^+_{aq} > Mg^{+2}_{aq}$
(D) $H^+_{(aq)} > Na^+_{(aq)} > Li^+_{(aq)} > Be^{+2}_{(aq)}$

15.✍ For strong electrolyte Λ_M increases slow with dilution and can be represented by the equation
$\wedge_M = \wedge_M^0 - AC^{½}$
Select correct statement.
(A) Plot of $\wedge_M$ against $C^{½}$ is obtain a straight line with intercept $\wedge_M^0$ & and slope '–A'
(B) Value of A depends upon temperature solvent and nature of electrolyte.
(C) NaCl and KCl have different value of constant 'A'.
(D) NaCl and $MgSO_4$ have different value of constant 'A'.

PART - IV : COMPREHENSION

Read the following passage carefully and answer the questions.

Comprehension # 1

If an element can exist in several oxidation states, it is convenient to display the reduction potentials corresponding to the various half reactions in diagrammatic form, known as Latimer diagram. The Latimer diagram for chlorine in acid solution is

$ClO_4^- \xrightarrow{+1.20\text{ V}} ClO_3^- \xrightarrow{+1.18\text{ V}} HClO_2 \xrightarrow{+1.60\text{ V}} HClO \xrightarrow{1.67\text{ V}} Cl_2 \xrightarrow{1.36\text{ V}} Cl^-$

in basic solution.

$ClO_4^- \xrightarrow{0.37\text{ V}} ClO_3^- \xrightarrow{0.30\text{ V}} ClO_2^- \xrightarrow{0.68\text{ V}} ClO^- \xrightarrow{0.42\text{ V}} Cl_2 \xrightarrow{1.36\text{ V}} Cl^-$

The standard potentials for two nonadjacent species can also be calculated by using the concept that $\Delta G°$ as an additive property but potential is not an additive property and $\Delta G° = -\,nFx^0$. If a given oxidation state is a stronger oxidising agent than in the next higher oxidation state, disproportionation can occur. The reverse of disproportionation is called comproportionation. The relative stabilities of the oxidation state can also be understood by drawing a graph of $\Delta G°/F$ against oxidation state, known as Frost diagram, choosing the stability of zero oxidation state arbitrarily as zero. The most stable oxidation state of a species lies lowest in the diagram. Disproportionation is spontaneous if the species lies above a straight line joining its two product species.

1. Which of the following couple have same value of potential at pH = 0 and pH = 14?

(A) $\dfrac{ClO_4^-}{ClO_3^-}$ (B) $\dfrac{ClO_2^-}{Cl_2}$ (C) $\dfrac{ClO^-}{Cl_2}$ (D) $\dfrac{Cl_2}{Cl^-}$

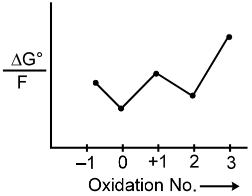
2. What is the potential of couple $\dfrac{ClO^-}{Cl^-}$ at pH = 14 ?

(A) 1.78 V (B) – 0.94 V (C) 0.89 V (D) – 0.89 V

3. Which of the following statement is correct ?

(A) Cl_2 undergoes disproportionation into Cl^- and ClO^- both at pH = 0 and pH = 14.
(B) Cl_2 undergoes disproportionation into Cl^- and ClO^- at pH = 14 but not at pH = 0.
(C) Cl_2 undergoes disproportionation into Cl^- and ClO^- at pH = 0 but not at pH = 14.
(D) None of these

4. For a hypothetical element, the Frost diagram is shown in figure?



Which of the following oxidation state is least stable?

(A) – 1 (B) 0 (C) + 2 (D) + 3

5. Which of the following statement is correct ? According to Q.4

(A) A^{+1} undergoes disproportionation into A and A^{2+}.
(B) A^{2+} undergoes disporportionation in A and A^{3+}.
(C) A undergoes comporportionation in A^{+1} and A^{-1}.
(D) All of the above.

Comprehension # 2

The molar conductance of NaCl varies with the concentration as shown in the following table and all values follows the equation

$\lambda_m^C = \lambda_m^\infty - b\sqrt{C}$ Where λ_m^C = molar specific conductance

λ_m^∞ = molar specific conductance at infinite dilution

C = molar concentration

Molar Concentration of NaCl	Molar Conductance in ohm^{-1} cm^2 mole^{-1}
4×10^{-4}	107
9×10^{-4}	97
16×10^{-4}	87

When a certain conductivity cell (C) was filled with 25×10^{-4} (M) NaCl solution. The resistance of the cell was found to be 1000 ohm. At Infinite dilution, conductance of Cl^- and SO_4^{-2} are 80 ohm^{-1} cm^2 mole^{-1} and 160 ohm^{-1} cm^2 mole^{-1} respectively.

6. What is the molar conductance of NaCl at infinite dilution ?
(A) 147 ohm^{-1} cm^2 mole^{-1} (B) 107 ohm^{-1} cm^{2}s mole^{-1}
(C) 127 ohm^{-1} cm^2 mole^{-1} (D) 157 ohm^{-1} cm^2 mole^{-1}

7. What is the cell constant of the conductivity cell (C)
(A) 0.385 cm^{-1} (B) 3.85 cm^{-1} (C) 38.5 cm^{-1} (D) 0.1925 cm^{-1}

8. If the cell (C) is filled with 5×10^{-3} (N) Na_2SO_4 the observed resistance was 400 ohm. What is the molar conductance of Na_2SO_4.
(A) 19.25 ohm^{-1} cm^2 mole^{-1} (B) 96.25 ohm^{-1} cm^2 mole^{-1}
(C) 385 ohm^{-1} cm^2 mole^{-1} (D) 192.5 ohm^{-1} cm^{2}s mole^{-1}

9. If a 100 mL solution of 0.1M HBr is titrated using a very concentrated solution of NaOH, then the conductivity (specific conductance) of this solution at the equivalence point will be (assume volume change is negligible due to addition of NaOH) . Report your answer after multipling it with 10 in Sm^{-1}.
[Given $\lambda^o_{(Na^+)} = 8 \times 10^{-3}$ Sm^2 mol^{-1} , $\lambda^o_{(Br^-)} = 4 \times 10^{-3}$ S m^2 mol^{-1}]
(A) 6 (B) 12 (C) 15 (D) 24

Comprehension # 3

Answer 10, Q.11 and Q.12 by appropriately matching the information given in the three columns of the following table.

The curves in Column 1 shows the variation of conductivity during different titrations. The analyte and titrants has been listed in Column 2 & Column 3 respectively.

Column-1		**Column-2**		**Column-3**	
(I)	Conductivity decreases initially then increases slowly then increases rapidly	(i)	$(C_2H_5)_2NH$	(P)	HCl
(II)	Conductivity decreases initially then increases	(ii)	CH_3COOH	(Q)	NaOH
(III)	Conductivity decreases initially then remains approximately same	(iii)	HBr	(R)	CH_3COOH
(IV	Conductivity increases initially then remains approximately same	(iv)	NaOH	(S)	NH_4OH

10. Which of the following is an incorrect combination of curves in Column 1.
(A) (II) (iii) (Q) (B) (I) (i) (P) (C) (I) (iii) (S) (D) (I) (ii) (Q)

11. The correct combination for a titration in which conductance at equivalent point is lower than initial
(A) (I) (ii) (Q) (B) (I) (iii) (S) (C) (III) (iv) (R) (D) (IV) (ii) (S)

12. Select the correct combination
(A) (I) (iii) (Q) (B) (IV) (ii) (S) (C) (I) (iii) (S) (D) (I) (iv) (R)

Exercise-3

*** Marked Questions are having one or more than one correct options.**

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. Standard electrode potential data are useful for understanding the suitability of an oxidant in a redox titration. Some half cell reactions and their standard potentials are given below : **[JEE 2002, 3/84]**

$MnO_4^-(aq.) + 8H^+(aq.) + 5e^- \rightarrow Mn^{2+}(aq.) + 4H_2O(\ell)$ $E^o = 1.51$ V

$Cr_2O_7^{2-}(aq.) + 14H^+(aq.) + 6e^- \rightarrow 2Cr^{3+}(aq.) + 7H_2O(\ell)$ $E^o = 1.38$ V

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

$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq.)$ $E^o = 1.40$ V

Identify the only INCORRECT statement regarding the quantitative estimation of aqueous $Fe(NO_3)_2$:

(A) MnO_4^- can be used in aqueous HCl.
(B) $Cr_2O_7^{2-}$ can be used in aqueous HCl.
(C) MnO_4^- can be used in aqueous H_2SO_4.
(D) $Cr_2O_7^{2-}$ can be used in aqueous H_2SO_4.

2. Two students use the same stock solution of $ZnSO_4$ and different solutions of $CuSO_4$ to make Daniel cell. The emf of one cell is 0.03 V higher than the other. The concentration of $CuSO_4$ solution in the cell with higher emf value is 0.5 M. Find out the concentration of $CuSO_4$ solution in the other cell.

$\left(\text{Given} \ : \ \frac{2.303 \quad RT}{F} = 0.06\right)$ **[JEE 2003, 2/60]**

3. The emf of the cell, Zn | Zn^{2+}(0.01 M) || Fe^{2+}(0.001 M) | Fe ; at 298 K is 0.2905 V. Then the value of equilibrium constant for the cell reaction is : **[JEE 2004, 3/84]**

(A) $e^{\frac{0.32}{0.0295}}$ (B) $10^{\frac{0.32}{0.0295}}$ (C) $10^{\frac{0.26}{0.0295}}$ (D) $10^{\frac{0.32}{0.059}}$

4. Find the equilibrium constant at 298 K for the reaction : **[JEE 2004, 4/60]**

$$Cu^{2+}(aq) + In^{2+}(aq) \rightleftharpoons Cu^+(aq) + In^{3+}(aq)$$

Given that $E^o_{Cu^{2+}/Cu^+} = 0.15$ V, $E^o_{In^{3+}/In^+} = -0.42$ V, $E^o_{In^{2+}/In^+} = -0.40$ V.

5. The half cell reactions for rusting of iron are :

$$2H^+ + \frac{1}{2}O_2 + 2e^- \longrightarrow H_2O;\ E^o = +1.23 \text{ V } \& \ Fe^{2+} + 2e^- \longrightarrow Fe\ ;\ E^o = -0.44 \text{ V}$$

ΔG^o (in kJ/mol) for the overall reaction is : **[JEE 2005, 3/84]**

(A) – 76 (B) – 322 (C) – 122 (D) – 176

Comprehension # 1

Tollen's reagent is used for the detection of aldehyde. When a solution of $AgNO_3$ is added to glucose with NH_4OH, then gluconic acid is formed.

$Ag^+ + e^- \longrightarrow Ag$; $E^o_{red} = 0.8$ V

$C_6H_{12}O_6 + H_2O \longrightarrow C_6H_{12}O_7$ (Gluconic acid) $+ 2H^+ + 2e^-$; $E^o_{oxd} = -0.05$ V

$Ag(NH_3)_2^+ + e^- \longrightarrow Ag(s) + 2NH_3$; $E^o = -0.337$ V

[Use $2.303 \times \frac{RT}{F} = 0.0592$ and $\frac{F}{RT} = 38.92$ at 298 K]

Now answer the following three questions :

6. $2Ag^+ + C_6H_{12}O_6 + H_2O \longrightarrow 2Ag(s) + C_6H_{12}O_7 + 2H^+$

Find ln K of this reaction : **[JEE 2006, 5/184]**

(A) 66.13 (B) 58.38 (C) 28.30 (D) 46.29

7. When ammonia is added to the solution, pH is raised to 11. Which half-cell reaction is affected by pH and by how much : **[JEE 2006, 5/184]**

(A) E_{oxd} will increase by a factor of 0.65 for E^o_{oxd}
(B) E_{oxd} will decrease by a factor of 0.65 for E^o_{oxd}
(C) E_{red} will increase by a factor of 0.65 for E^o_{red}
(D) E_{red} will decrease by a factor of 0.65 for E^o_{red}

8. Ammonia is always is added in this reaction. Which of the following must be INCORRECT :
(A) NH_3 combines with Ag^+ to form a complex. **[JEE 2006, 5/184]**
(B) $Ag(NH_3)_2^+$ is a weaker oxidising reagent than Ag^+.
(C) In absence of NH_3, silver salt of gluconic acid is formed.
(D) NH_3 has affected the standard reduction potential of glucose/gluconic acid electrode.

9. We have taken a saturated solution of AgBr. K_{sp} of AgBr is 12×10^{-14}. If 10^{-7} mole of $AgNO_3$ are added to 1 litre of this solution, find conductivity (specific conductance) of this solution in terms of 10^{-7} Sm^{-1}.
Given : $\Lambda^o_{(Ag^+)} = 6 \times 10^{-3}$ Sm^2mol^{-1}, $\Lambda^o_{(Br^-)} = 8 \times 10^{-3}$ Sm^2mol^{-1}, $\Lambda^o_{(NO_3^-)} = 7 \times 10^{-3}$ Sm^2mol^{-1}.
[JEE 2006, 6/184]

Comprehension # 2

Chemical reactions involve interaction of atoms and molecules. A large number of atoms/molecules (approximately 6.023×10^{23}) are present in a few grams of any chemical compound varying with its atomic/molecular masses. To handle such large number conveniently, the mole concept was introduced. This concept has implications in diverse areas such as analytical chemistry, biochemistry, electrochemistry and radiochemistry. The following example illustrates a typical case, involving chemical/electrochemical reaction, which requires a clear understanding of the mole concept.
A 4.0 molar aqueous solution of NaCl is prepared and 500 mL of this solution is electrolysed. This leads to the evolution of chlorine gas at one of the electrodes.
(Given : Atomic masses : Na = 23, Hg = 200 ; 1 Faraday = 96500 coulombs)
Now answer the following three questions :

10. The total number of moles of chlorine gas evolved is : **[JEE 2007, 4/162]**
(A) 0.5 (B) 1.0 (C) 2.0 (D) 3.0

11. If the cathode is Hg electrode, the maximum weight (in g) of amalgam formed from this solution is :
[JEE 2007, 4/162]
(A) 200 (B) 225 (C) 400 (D) 446

12. The total charge (in coulombs) required for complete electrolysis is : **[JEE 2007, 4/162]**
(A) 24125 (B) 48250 (C) 96500 (D) 193000

Comprehension # 3

Redox reactions play a pivoted role in chemistry and biology. The values of standard redox potential (E°) of two half-cell reactions decide which way the reaction is expected to proceed. A simple example is a Daniel cell in which zinc goes into solution and copper gets deposited. Given below is a set of half-cell reactions (acidic medium) along with their E° values with respect to normal hydrogen electrode. Using this data, obtain the correct explanations to questions 15 - 16.

$I_2 + 2e^- \longrightarrow 2I^-$ $E^o = 0.54$ V
$Cl_2 + 2e^- \longrightarrow 2Cl^-$ $E^o = 1.36$ V
$Mn^{3+} + e^- \longrightarrow Mn^{2+}$ $E^o = 1.50$ V
$Fe^{3+} + e^- \longrightarrow Fe^{2+}$ $E^o = 0.77$ V
$O_2 + 4H^+ + 4e^- \longrightarrow 2H_2O$ $E^o = 1.23$ V

13. Among the following, identify the correct statement : **[JEE 2007, 4/162]**
(A) Chloride ion is oxidised by O_2 (B) Fe^{2+} is oxidised by iodine
(C) Iodine ion is oxidised by chlorine (D) Mn^{2+} is oxidised by chlorine

14. While Fe^{3+} is stable, Mn^{3+} is not stable in acid solution, because : **[JEE 2007, 4/162]**
(A) O_2 oxidises Mn^{2+} to Mn^{3+}
(B) O_2 oxidises both Mn^{2+} to Mn^{3+} and Fe^{2+} to Fe^{3+}
(C) Fe^{3+} oxidises H_2O to O_2
(D) Mn^{3+} oxidises H_2O to O_2

15. Electrolysis of dilute aqueous NaCl solution was carried out by passing 10 milliampere current. The time required to liberate 0.01 mole of H_2 gas at the cathode is : (1 Faraday = 96500 C)
[JEE 2008, 3/163]
(A) 9.65×10^4 sec (B) 19.3×10^4 sec
(C) 28.95×10^4 sec (D) 38.6×10^4 sec

16.* For the reduction of NO_3^- ion in an aqueous solution, E° is +0.96 V. Values of E° for some metal ions are given below :

$V^{2+}(aq) + 2e^- \longrightarrow V$ $E^o = -1.19$ V
$Fe^{3+}(aq) + 3e^- \longrightarrow Fe$ $E^o = -0.04$ V
$Au^{3+}(aq) + 3e^- \longrightarrow Au$ $E^o = +1.40$ V
$Hg^{2+}(aq) + 2e^- \longrightarrow Hg$ $E^o = +0.86$ V

The pair(s) of metals that is(are) oxidized by NO_3^- in aqueous solution is(are) : **[JEE 2009, 4/160]**

(A) V and Hg (B) Hg and Fe (C) Fe and Au (D) Fe and V

Comprehension # 4

The concentration of potassium ions inside a biological cell is at least twenty times higher than the outside. The resulting potential difference across the cell is important in several processes such as transmission of nerve impulses and maintaining the ion balance. A simple model for such a concentration cell involving a metal M is : $M(s) \mid M^+(aq\ ;\ 0.05\ molar) \parallel M^+(aq\ ;\ 1\ molar) \mid M(s)$

For the above electrolytic cell, the magnitude of the cell potential is $|E_{cell}| = 70$ mV.

Now answer the following two questions :

17. For the above cell : **[JEE 2010, 3/163]**

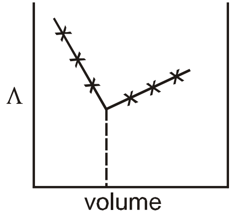
(A) $E_{cell} < 0$; $\Delta G > 0$ (B) $E_{cell} > 0$; $\Delta G < 0$

(C) $E_{cell} < 0$; $\Delta G^o > 0$ (D) $E_{cell} > 0$; $\Delta G^o < 0$

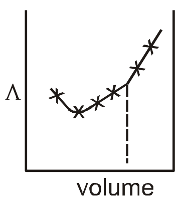
18. If the 0.05 molar solution of M^+ is replaced by a 0.0025 molar M^+ solution, then the magnitude of the cell potential would be : **[JEE 2010, 3/163]**

(A) 35 mV (B) 70 mV (C) 140 mV (D) 700 mV

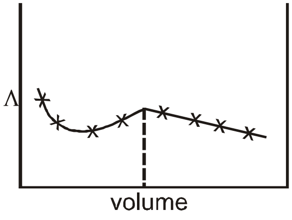
19. $AgNO_3$(aq.) was added to an aqueous KCl solution gradually and the conductivity of the solution was measured. The plot of conductance (Λ) versus the volume of $AgNO_3$ is : **[JEE 2011, 3/180]**



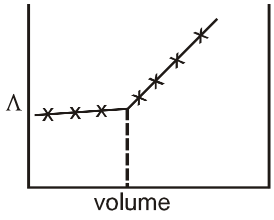
(P)



(Q)



(R)



(S)

(A) (P) (B) Q (C) (R) (D) (S)

20. Consider the following cell reaction : **[JEE 2011, 3/180]**

$$2Fe\,(s) + O_2\,(g) + 4H^+\,(aq) \longrightarrow 2Fe^{2+}\,(aq) + 2H_2O\,(l) \qquad E^o = 1.67\ V$$

At $[Fe^{2+}] = 10^{-3}$ M, $P(O_2) = 0.1$ atm and pH = 3, the cell potential at 25°C is :

(Take $\frac{2.303\ R\ (298)}{F} = 0.06$)

(A) 1.47 V (B) 1.77 V (C) 1.87 V (D) 1.57 V

Comprehension # 5

The electrochemical cell shown below is a concentration cell.

$M|M^{2+}$ (saturated solution of a sparingly soluble salt,MX_2)|| M^{2+} (0.001 mol dm^{-3}) |M

The emf of the cell depends on the difference in concetration of M^{2+} ions at the two electrodes. The emf of the cell at 298 is 0.059 V

21. The solubility product (K_{sp} ; in $mol^3\ dm^{-9}$) of MX_2 at 298 K based on the information available in the given concentration cell is : (Take 2.303× R × 298/F = 0.059 V) **[IIT-JEE 2012, 3/66]**

(A) 1×10^{-15} (B) 4×10^{-15} (C) 1×10^{-12} (D) 4×10^{-12}

22. The value of ΔG (in kJ mol^{-1}) for the given cell is : (Take 1F = 96500 C mol^{-1}) **[IIT-JEE 2012, 3/136]**

(A) – 5.7 (B) 5.7 (C) 11.4 (D) –11.4

23. An aqueous solution of **X** is added slowly to an aqueous solution of **Y** as shown in list I. The variation in conductivity of these reactions is given in List II. Match List I with List II and select the correct answer using the code given below the lists : **[JEE(Advanced) 2013, 3/120]**

	List I		**List II**
P.	$\underset{X}{(C_2H_5)_3N} + \underset{Y}{CH_3COOH}$	1.	Conductivity decreases and then increases
Q.	$\underset{X}{KI\ (0.1M)} + \underset{Y}{AgNO_3(0.01M)}$	2.	Conductivity decreases and then does not change much
R.	$\underset{X}{CH_3COOH} + \underset{Y}{KOH}$	3.	Conductivity increases and then does not change much
S.	$\underset{X}{NaOH} + \underset{Y}{HI}$	4.	Conductivity does not change much and then increases

Codes :

	P	Q	R	S		P	Q	R	S
(A)	3	4	2	1	(B)	4	3	2	1
(C)	2	3	4	1	(D)	1	4	3	2

24. The standard reduction potential data at 25ºC is given below. **[JEE(Advanced) 2013, 3/120]**

$E^o(Fe^{3+}.Fe^{2+}) = +0.77$ V; $E^o(Fe^{2+}.Fe) = -0.44$ V;

$E^o(Cu^{2+}.Cu) = +0.34$ V; $E^o(Cu^{+}.Cu) = +0.52$ V;

$E^o(O_2(g) + 4H^+ + 4e^- \rightarrow 2H_2O) = +1.23$ V ; $E^o(O_2(g) + 2H_2O + 4e^- \rightarrow 4OH) = +0.40$ V

$E^o(Cr^{3+}.Cr) = -0.74$ V; $E^o(Cr^{2+}.Cr) = -0.91$ V

Match Eº of the rebox pair in List I with the values given in List II and select the correct answer using the code given below the lists :

	List I		**List II**
P.	$E^o(Fe^{3+}, Fe)$	1.	– 0.36 V
Q.	$E^o(4H_2O \rightleftharpoons 4H^+ + 4OH^-)$	2.	–0.4 V
R.	$E^o(Cu^{2+} + Cu \rightarrow 2Cu^+)$	3.	–0.04 V
S.	$E^o(Cr^{3+}, Cr^{+2})$	4.	–0.83 V

Codes :

	P	Q	R	S		P	Q	R	S
(A)	4	1	2	3	(B)	2	3	4	1
(C)	1	2	3	4	(D)	3	4	1	2

25. In a galvanic cell, the salt bridge **[JEE(Advanced) 2014, 3/120]**

(A) does not participate chemically in the cell reaction.
(B) stops the diffusion of ions from one electrode to another.
(C) is necessary for the occurrence of the cell reaction.
(D ensures mixing of the two electrolytic solutions.

26. All the energy released from the reaction X → Y, $\Delta_rG^o = -193$ kJ mol^{-1} is used for oxidizing M^+ as $M^+ \rightarrow M^{3+} + 2e^-$, $E^o = -0.25$ V. Under standard conditions, the number of moles of M^+ oxidized when one mole of X is converted to Y is : [F = 96500 C mol^{-1}] **[JEE(Advanced) 2015, 4/168]**

27. The molar conductivity of a solution of a weak acid HX (0.01 M) is 10 times smaller than the molar conductivity of a solution of a weak acid HY (0.10 M). If $\lambda^o_{X^-} \approx \lambda^o_{Y^-}$, the difference in their pK_a values, pK_a (HX) – pK_a (HY), is (consider degree of ionization of both acids to be <<1)

[JEE(Advanced) 2015, 4/168]

28. For the following electrochemical cell at 298 K,

Pt(s) | H_2 (g, 1 bar) | H^+ (aq, 1 M) || M^{4+}(aq) | M^{2+}(aq) | Pt(s), E_{cell}= 0.092 V when $\frac{[M^{2+(aq)}]}{[M^{4+(aq)}]} = 10^x$.

Given : $E^0_{M^{4+}|M^{2+}} = 0.151$ V; $2.303\ \frac{RT}{F} = 0.059$ V. The value of x is : **[JEE(Advanced) 2016, 3/124]**

(A) –2 (B) –1 (C) 1 (D) 2

29. The conductance of a 0.0015 M aqueous solution of a weak monobasic acid was determined by using a conductivity cell consisting of platinized Pt electrodes. The distance between the electrodes is 120 cm with an area of cross section of 1 cm^2. The conductance of this solution was found to be 5×10^{-7} S. The pH of the solution is 4. The value of limiting molar conductivity (Λ^o_m) of this weak monobasic acid in aqueous solution is Z $\times10^2$ S cm^{-1} mol^{-1}. The value of Z is **[JEE(Advanced) 2017, 3/122]**

30. For the following cell, Zn(s) | $ZnSO_4$(aq) || $CuSO_4$ (aq) | Cu(s) when the concentration of Zn^{2+} is 10 times the concentration of Cu^{2+}, the expression for ΔG (in J mol^{-1}) is : **[JEE(Advanced) 2017, 3/122]**
[F is Faraday constant; R is gas constant; T is temperature; E^o(cell) = 1.1 V]
(A) 2.303 RT + 1.1 F (B) 1.1 F (C) 2.303 RT – 2.2 F (D) –2.2 F

31. For the electrochemical cell, Mg(s) | Mg^{2+} (aq,1 M) || Cu^{2+} (aq,1M) | Cu(s)
the standard emf of the cell is 2.70 V at 300 K. When the concentration of Mg^{2+} is changed to *x* M, the cell potential changes to 2.67 V at 300 K. The value of *x* is ____. (Given, $\frac{F}{R}$ = 11500 K V^{-1}, where F is the Faraday constant and R is the gas constant, ln(10) = 2.30). **[JEE(Advanced) 2018, 3/120]**

32. Consider an electrochemical cell : A(s) | A^{n+}(aq, 2 M) || B^{2n+}(aq, 1 M) | B(s). The value of $\Delta H°$ for the cell reaction is twice that of $\Delta G°$ at 300 K. If the emf of the cell is zero, the $\Delta S°$(in J $K^{-1}mol^{-1}$) of the cell reaction per mole of B formed at 300 K is____.
(Given : ln (2) = 0.7, R(universal gas constant) = 8.3 J K^{-1} mol^{-1}. H, S and G are enthalpy, entropy and Gibbs energy, respectively.) **[JEE(Advanced) 2018, 3/120]**

PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

JEE(MAIN) OFFLINE PROBLEMS

1. For the following cell with hydrogen electrodes at two different pressure $p_1$and p_2,

$$\underset{}{Pt}\ |\ \underset{p_1}{H_2(g)}\ |\ \underset{1M}{H^+(aq)}\ |\ \underset{p_2}{H_2(g)}\ |\ Pt$$

emf is given by : **[AIEEE 2002, 3/225]**
(1) $\frac{RT}{F}\log_e\frac{p_1}{p_2}$ (2) $\frac{RT}{2F}\log_e\frac{p_1}{p_2}$ (3) $\frac{RT}{F}\log_e\frac{p_2}{p_1}$ (4) $\frac{RT}{2F}\log_e\frac{p_2}{p_1}$

2. Which of the following reactions is possible at anode : **[AIEEE 2002, 3/225]**
(1) 2 $Cr^{3+} + 7H_2O \rightarrow Cr_2O_7^{2-} + 14H^+$ (2) $F_2 \rightarrow 2F^-$
(3) $\frac{1}{2}O_2 + 2H^+ \rightarrow H_2O$ (4) displacement reaction

3. For a cell given below : **[AIEEE 2002, 3/225]**

$$\underset{-}{Ag\ |\ Ag^+}\ ||\ \underset{+}{Cu^{2+}\ |\ Cu}$$

$Ag^+ + e^- \longrightarrow Ag$ $E^o = x$
$Cu^{2+} + 2e^- \longrightarrow Cu,$ $E^o = y$
The value of E^o_{cell} is :
(1) x + 2y (2) 2x + y (3) y –x (4) y – 2x

4. Conductance (with unit Siemens S) is directly proportional to area of the electrode plates and the concentration of the solution in the cell and is inversely proportional to the separation between the electrode plates. Then the unit of the constant of proportionality is : **[AIEEE 2002, 3/225]**
(1) S$m\ mol^{-1}$. (2) S$m^2\ mol^{-1}$. (3) $S^{-2}m^2$ mol. (4) $S^2m^2\ mol^{-1}$.

5. For a cell reaction involving a two electron change, the standard emf of the cell is found to be 0.295 V at 25°C. The equilibrium constant of the reaction at 25°C will be : **[AIEEE 2003, 3/225]**
(1) 1×10^{-10} (2) 29.5×10^{-2} (3) 10 (4) 1×10^{10}

6. Standard 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 is in the order : **[AIEEE 2003, 3/225]**
(1) B > C > A (2) A > B > C (3) C > B > A (4) A > C > B

7. Consider the following E° values :

$E^0_{Fe^{3+}/Fe^{2+}} = +0.77$ V ; $E^0_{Sn^{2+}/Sn} = -0.14$ V

Under standard conditions, the cell potential for the reaction given below is : **[AIEEE 2004, 3/225]**

$Sn_{(s)} + 2Fe^{3+}_{(aq)} \rightarrow 2Fe^{2+}_{(aq)} + Sn^{2+}_{(aq)}$

(1) 1.68 V (2) 1.40 V (3) 0.91 V (4) 0.63 V

8. The limiting molar conductivities Λ^o for NaCl, KBr and KCl are 126, 152 and 150 S cm^2 mol^{-1} respectively. The value of Λ^o for NaBr is : **[AIEEE 2004, 3/225]**

(1) 128 S cm^2 mol^{-1} (2) 176 S cm^2 mol^{-1} (3) 278 S cm^2 mol^{-1} (4) 302 S cm^2 mol^{-1}

9. In a cell that utilizes the reaction $Zn_{(s)} + 2H^+_{(aq)} \rightarrow Zn^{2+}_{(aq)} + H_{2(g)}$, addition of H_2SO_4 to cathode compartment will : **[AIEEE 2004, 3/225]**

(1) lower the E and shift equilibrium to the left.
(2) lower the E and shift the equilibrium to the right.
(3) increase the E and shift the equilibrium to the right.
(4) increase the E and shift the equilibrium to the left.

10. The $E^0_{M^{3+}/M^{2+}}$ values for Cr, Mn, Fe and Co are –0.41, +1.57, +0.77 and +1.97 V respectively. For which one of these metals, the change in oxidation state from +2 to +3 is easiest : **[AIEEE 2004, 3/225]**

(1) Cr (2) Mn (3) Fe (4) Co

11. The highest electrical conductivity among the following aqueous solutions is of : **[AIEEE–2005, 3/225]**

(1) 0.1 M acetic acid (2) 0.1 M chloroacetic acid
(3) 0.1 M fluoroacetic acid (4) 0.1 M difluoroacetic acid

12. Aluminium oxide may be electrolysed at 1000°C to furnish aluminium metal (At.Mass of Al = 27 amu ; 1 Faraday = 96,500 Coulombs). The cathode reaction is $Al^{3+} + 3e^- \rightarrow Al^0$. To prepare 5.12 kg of aluminium metal by this method, one would require : **[AIEEE–2005, 3/225]**

(1) 5.49×10^7 C of electricity (2) 1.83×10^7 C of electricity
(3) 5.49×10^4 C of electricity (4) 5.49×10^{10} C of electricity

13. The molar conductivities Λ^0_{NaOAc} and Λ^0_{HCl} at infinite dilution in water at 25°C are 91.0 and 426.2 Scm^2/mol respectively. To calculate Λ^0_{HOAc}, the additional value required is : **[AIEEE–2006, 3/165]**

(1) $\Lambda^0_{H_2O}$ (2) Λ^0_{KCl} (3) Λ^0_{NaOH} (4) Λ^0_{NaCl}

14. Given data is at 25°C :

$Ag + I^- \rightarrow AgI + e^-$; $E° = 0.152$ V
$Ag \rightarrow Ag^+ + e^-$; $E° = -0.800$ V

What is the value of log K_{sp} for AgI : (Take $\frac{0.474}{0.059} = 8.065$) **[AIEEE–2006, 3/165]**

(1) – 8.12 (2) + 8.612 (3) – 37.83 (4) – 16.13

15. 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 Sm^{-1}. Resistance of the same cell when filled with 0.02 M of the same solution is 520 Ω. The molar conductivity of 0.02 M solution of the electrolyte will be: (Take $\frac{129}{520} = 0.248$) **[AIEEE–2006, 3/165]**

(1) 124×10^{-4} Sm^{2}mol^{-1} (2) 1240×10^{-4} Sm^{2}mol^{-1}
(3) 1.24 Sm^{2}mol^{-1} (4) 12.4×10^{-4} Sm^{2}mol^{-1}

16. The equivalent conductances of two strong electrolytes at infinite dilution in H_2O (where ions move freely through a solution) at 25°C are given below : **[AIEEE–2007, 3/120]**

$\Lambda^0_{CH_3COONa} = 91.0$ Scm^2/equiv and $\Lambda^0_{HCl} = 426.2$ Scm^2/equiv

What additional information/quantity one needs to calculate Λ^o of an aqueous solution of acetic acid :

(1) The limiting equivalent conductance of H$^+$ ($\lambda^{\circ}_{H^+}$) (2) Λ^o of chloroacetic acid ($ClCH_2COOH$)
(3) Λ^o of NaCl (4) Λ^o of CH_3COOK

17. The cell Zn | Zn^{2+}(1M) || Cu^{2+}(1M) | Cu : (E°_{cell} = 1.10V) was allowed to completely discharge at 298 K. The relative concentration of Zn^{2+} to Cu^{2+} $\left(\frac{\left[Zn^{2+}\right]}{\left[Cu^{2+}\right]}\right)$ is : (Take $\frac{1.1}{0.059}$ = 18.65) **[AIEEE–2007, 3/120]**

(1) $10^{37.3}$ (2) 9.65×10^4 (3) antilog (24.08) (4) 37.3

18. Given : $E^0_{Cr^{3+}/Cr} = -0.72$, $E^0_{Fe^{2+}/Fe} = -0.42$ V

The potential for the cell Cr | Cr^{3+}(0.1 M) || Fe^{2+}(0.01 M) | Fe at 298 K is :

(Take $\frac{2.303\ \ R\ \ (298)}{F}$ = 0.06) **[AIEEE–2008, 3/105]**

(1) 0.339 V (2) – 0.339 V (3) – 0.26 V (4) 0.26 V

19. Given : $E^0_{Fe^{3+}/Fe} = -0.036$ V, $E^0_{Fe^{2+}/Fe} = -0.439$ V

The value of standard electrode potential for the change, $Fe^{3+}_{(aq)} + e^- \longrightarrow Fe^{2+}_{(aq)}$ will be :

[AIEEE–2009, 8/144]

(1) 0.385V (2) 0.770V (3) –0.270V (4) –0.072V

20. The Gibbs energy for the decomposition of Al_2O_3 at 500ºC is as follows :

$\frac{2}{3}\ Al_2O_3 \rightarrow \frac{4}{3}\ Al + O_2$; $\Delta_rG = +\ 966\ kJmol^{-1}$. The potential difference needed for electrolytic reduction of Al_2O_3 at 500ºC is at least : **[AIEEE–2010, 4/144]**

(1) 4.5 V (2) 3.0 V (3) 2.5 V (4) 5.0 V

21. The reduction potential of hydrogen half-cell will be negative, if : **[AIEEE–2011(1), 4/120]**

(1) $p(H_2)$ = 1 atm and $[H^+]$ = 2.0 M (2) $p(H_2)$ = 1 atm and $[H^+]$ = 1.0 M

(3) $p(H_2)$ = 2 atm and $[H^+]$ = 1.0 M (4) $p(H_2)$ = 2 atm and $[H^+]$ = 2.0 M

22. 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 $X + Y^{2+} \rightarrow X^{2+} + Y$ will be spontaneous, when : **[AIEEE 2012, 4/120]**

(1) X = Ni, Y = Fe (2) X = Ni, Y = Zn (3) X= Fe, Y = Zn (4) X= Zn, Y = Ni

23. Given : $E^0_{Cr^{3+}/Cr} = -0.74$ V ; $E^0_{MnO_4^-/Mn^{2+}} = 1.51$ V

$E^0_{Cr_2O_7^{2-}/Cr^{3+}} = 1.33$ V ; $E^0_{Cl/Cl^-} = 1.36$ V

Based on the data given above, strongest oxidising agent will be : **[JEE(Main) 2013, 4/120]**

(1) Cl (2) Cr^{3+} (3) Mn^{2+} (4) MnO_4^-

24. Resistance of 0.2 M solution of an electrolyte is 50 Ω. The specific conductance of the solution is 1.4 S m^{-1}. The resistance of 0.5 M solution of the same electrolyte is 280 Ω. The molar conductivity of 0.5 M solution of the electrolyte in S m^2 mol^{-1} is : **[JEE(Main) 2014, 4/120]**

(1) 5×10^{-4} (2) 5×10^{-3} (3) 5×10^{3} (4) 5×10^{2}

25. 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 : (where the constant B is positive)

[JEE(Main) 2014, 4/120]

(1) $\Lambda_C = \Lambda_\infty + (B)C$ (2) $\Lambda_C = \Lambda_\infty - (B)C$ (3) $\Lambda_C = \Lambda_\infty - (B)\sqrt{C}$ (4) $\Lambda_C = \Lambda_\infty + (B)\sqrt{C}$

26. The metal that cannot be obtained by electrolysis of an aqueous solution of its salts is :

[JEE(Main) 2014, 4/120]

(1) Ag (2) Ca (3) Cu (4) Cr

27. Given below are the half-cell reactions : **[JEE(Main) 2014, 4/120]**

$Mn^{2+} + 2e^- \longrightarrow Mn$; $E^o = -1.18$ V

$2(Mn^{3+} + e^- \longrightarrow Mn^{2+})$; $E^o = +1.51$ V

The E^o for $3Mn^{2+} \longrightarrow Mn + 2Mn^{3+}$ will be :

(1) –2.69 V ; the reaction will not occur (2) –2.69 V ; the reaction will occur

(3) –0.33 V ; the reaction will not occur (4) –0.33 V ; the reaction will occur

28. 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) **[JEE(Main) 2015, 4/120]**

(1) 0 g (2) 63.5 g (3) 2 g (4) 127 g

29. Galvanization is applying a coating of : **[JEE(Main) 2016, 4/120]**

(1) Cr (2) Cu (3) Zn (4) Pb

30. Given : $E^{o}_{Cl_2/Cl^-} = 1.36$ V, $E^{o}_{Cr^{3+}/Cr} = -0.74$ V ; $E^{o}_{Cr_2O_7^{2-}/Cr^{3+}} = 1.33$ V, $E^{o}_{MnO_4^-/Mn^{2+}} = 1.51$ V

Among the following, the strongest reducing agent is : **[JEE(Main) 2017, 4/120]**

(1) Mn^{2+} (2) Cr^{3+} (3) Cl^- (4) Cr

31. 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? **[JEE(Main)-2018, 4/120]**
(Atomic weight of B = 10.8u)

(1) 3.2 hours (2) 1.6 hours (3) 6.4 hours (4) 0.8 hours

JEE(MAIN) ONLINE PROBLEMS

1. 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 :
[JEE(Main) 2014 Online (09-04-14), 4/120]

(1) A, C, B, D (2) B, D, C, A (3) C, B, D, A (4) D, A, B, C

2. A current of 10.0 A flows for 2.00 h through an electrolytic cell containing a molten salt of metal X. This results in the decomposition of 0.250 mol of metal X at the cathode. The oxidation state of X in the molten salt is : (F = 96,500 C) **[JEE(Main) 2014 Online (09-04-14), 4/120]**

(1) 1 + (2) 2 + (3) 3 + (4) 4 +

3. Given :
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$; $E^o = +0.77$ V
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$; $E^o = -1.66$ V
$Br_2(aq) + 2e^- \rightarrow 2Br^-$; $E^o = +1.09$ V

Considering the electrode potentials, which of the following represents the correct order of reducing power?
[JEE(Main) 2014 Online (11-04-14), 4/120]

(1) $Fe^{2+} < Al < Br^-$ (2) $Br^- < Fe^{2+} < Al$ (3) $Al < Br^- < Fe^{2+}$ (4) $Al < Fe^{2+} < Br^-$

4. How many electrons would be required to deposit 6.35 g of copper at the cathode during the electrolysis of an aqueous solution of copper sulphate ? (Atomic mass of copper = 63.5 u, N_A = Avogadro's constant). **[JEE(Main) 2014 Online (12-04-14), 4/120]**

(1) $\frac{N_A}{20}$ (2) $\frac{N_A}{10}$ (3) $\frac{N_A}{5}$ (4) $\frac{N_A}{2}$

5. A variable, opposite external potential (E_{ext}) is applied to the cell $Zn|Zn^{2+}$ (1 M) || Cu^{2+} (1M) | Cu, of potential 1.1 V. When $E_{ext} < 1.1$ V and $E_{ext} > 1.1$ V respectively electrons flow from :
[JEE(Main) 2015 Online (10-04-15), 4/120]

(1) Cathode to anode in both cases (2) cathode to anode and anode to cathode
(3) anode to cathode and cathode to anode (4) anode to cathode in both cases

6. At 298 K, the standard reduction potentials are 1.51 V for $MnO_4^-|Mn^{2+}$, 1.36 V for $Cl_2|Cl^-$, 1.07 V for $Br_2|Br$, and 0.54 V for $I_2|I^-$. At pH = 3, permanganate is expected to oxidize : $\left(\frac{RT}{F} = 0.059\,V\right)$
[JEE(Main) 2015 Online (11-04-15), 4/120]

(1) Cl^-, Br^- and I^- (2) Br^- and I^- (3) Cl^- and Br^- (4) I^- only

7. What will occur if a block of copper metal is dropped into a beaker containing a solution of 1M $ZnSO_4$?
[JEE(Main) 2016 Online (09-04-16), 4/120]
(1) The copper metal will dissolve and zinc metal will be deposited.
(2) The copper metal will dissolve with evolution of oxygen gas.
(3) The copper metal will dissolve with evolution of hydrogen gas.
(4) No reaction will occur.

8. Identify the correct statement: **[JEE(Main) 2016 Online (10-04-16), 4/120]**
(1) Corrosion of iron can be minimized by forming an impermeable barrier at its surface.
(2) Iron corrodes in oxygen-free water.
(3) Iron corrodes more rapidly in salt water because its electrochemical potential is higher.
(4) Corrosion of iron can be minimized by forming a contact with another metal with a higher reduction potential.

9. What is the standard reduction potential (E°) for Fe^{3+} □ Fe ?
Given that : **[JEE(Main) 2017 Online (08-04-17), 4/120]**
$Fe^{2+} + 2e^-$ □ Fe; $E^{o}_{Fe^{2+}/Fe} = -0.47$ V
$Fe^{3+} + e^-$ □ Fe^{2+} ; $E^{o}_{Fe^{2+}/Fe}\ \ E^{o}_{Fe^{2+}/Fe^{2+}} = +0.77$ V
(1) + 0.30 V (2) – 0.057 V (3) + 0.057 V (4) – 0.30 V

10. Consider the following standard electrode potentials (E° in volts) in aqueous solution :
[JEE(Main) 2017 Online (08-04-17), 4/120]

Element	**M^{3+} / M**	**M^{+} / M**
Al	–1.66	+ 0.55
Tl	+1.26	– 0.34

Based on these data, which of the following statements is **correct** ?
(1) Al^+ is more stable than Al^{3+} (2) Tl^{3+} is more stable than Al^{3+}
(3) Tl^+ is more stable than Al^{3+} (4) Tl^+ is more stable than Al^+

11. Which of the following ions does not liberate hydrogen gas on reaction with dilute acids ?
[JEE(Main) 2017 Online (09-04-17), 4/120]
(1) Mn^{2+} (2) Ti^{2+} (3) V^{2+} (4) Cr^{2+}

12. To find the standard potential of M^{3+}/M electrode, the following cell is constituted : Pt / M / M^{3+} (0.001 mol L^{-1}) / Ag^+ (0.01 mol L^{-1}) / Ag
The emf of the cell is found to be 0.421 volt at 298 K. The standard potential of half reaction $M^{3+} + 3e^- \longrightarrow M$ at 298 K will be : **[JEE(Main) 2017 Online (09-04-17), 4/120]**
(Given $E^{-}_{Ag^{+}/Ag}$ at 298 K = 0.80 volt)
(1) 0.32 Volt (2) 0.66 Volt (3) 0.38 Volt (4) 1.28 Volt

13. When an electric current is passed through acidified water, 112 mL of hydrogen gas at N.T.P was collected at the cathode in 965 seconds. The current passed, in ampere, is :
[JEE(Main) 2018 Online (15-04-2018), 4/120]
(1) 2.0 (2) 0.1 (3) 0.5 (4) 1.0

14. When 9.65 ampere current was passed for 1.0 hour into nitrobenzene in acidic medium, the amount of p-aminophenol produced is : **[JEE(Main) 2018 Online (16-04-2018), 4/120]**
(1) 109.0 g (2) 98.1 g (3) 9.81 g (4) 10.9 g

15. The anodic half–cell of lead–acid battery is recharged using electricity of 0.05 Faraday. The amount of $PbSO_4$ electrolyzed in g during the process is : (Molar mass of $PbSO_4$ = 303 g mol^{-1})
[JEE(Main) 2019 Online (09-01-2019), 4/120]
(1) 15.2 (2) 22.8 (3) 7.6 (4) 11.6

16. If the standard electrode potential for a cell is 2 V at 300 K, the equilibrium constant (K) for the reaction
$$Zn(s) + Cu^{2+}(aq) \rightleftharpoons Zn^{2+}(aq) + Cu(s)$$
at 300 K is approximately (R = 8 JK^{-1}mol, F = 96000 C mol^{-1})
[JEE(Main) 2019 Online (09-01-2019), 4/120]
(1) e^{320} (2) e^{-80} (3) e^{160} (4) e^{-160}

17. Consider the following reduction processes :

$Zn^{2+} + 2e^- \rightarrow Zn(s)$; $E^0 = -0.76$ V

$Ca^{2+} + 2e^- \rightarrow Ca(s)$; $E^0 = -2.86$ V

$Mg^{2+} + 2e^- \rightarrow Mg(s)$; $E^0 = -2.36$ V

$Ni^{2+} + 2e^- \rightarrow Ni(s)$; $E^0 = -0.25$ V

The reducing power of the metals increases in the order: **[JEE(Main) 2019 Online (10-01-2019), 4/120]**

(1) Ca < Mg < Zn < Ni (2) Ni < Zn < Mg < Ca (3) Ca < Zn < Mg < Ni (4) Zn < Mg < Ni < Ca

18. In the cell, Pt(s) | H_2(g,1bar) | HCl(aq) | AgCl (s) | Ag(s)| Pt(s)

The cell potential is 0.92 V when a 10^{-6} molal HCl solution is used. The standard electrode potential of (AgCl / Ag, Cl^-) electrode is : $\left\{\text{Given}, \frac{2.303RT}{F} = 0.06\text{V at } 298\text{k}\right\}$

[JEE(Main) 2019 Online (10-01-2019), 4/120]

(1) 0.76 V (2) 0.20 V (3) 0.94 V (4) 0.40 V

19. The electrolytes usually used in the electroplating of gold and silver, respectively, are:

[JEE(Main) 2019 Online (10-01-2019), 4/120]

(1) $[Au(CN)_2]^-$ and $[AgCl_2]^-$ (2) $[Au(NH_3)_2]^+$ and $[Ag(CN)_2]^-$

(3) $[Au(CN)_2]^-$ and $[Ag(CN)_2]^-$ (4) $[Au(OH)_4]^-$ and $[Ag(OH)_2]^-$

20. For the cell Zn(s) $|Zn^{2+}$ (aq)$||M^{x+}$ (aq) |M(s), different half cells and their standard electrode potentials are given below :

M^{x+}(aq)/M(s)	Au^{3+}(aq)/ Au(s)	Ag^+(aq)/Ag(s)	Fe^{3+}(aq)/Fe^{2+}(aq)	Fe^{2+}(aq)/Fe(s)
$E^\circ_{M^{x+}/M}$(V)	1.40	0.80	0.77	–0.44

If $E^\circ_{Zn^{2+}/Zn} = -0.76$ V, which cathode will give a maximum value of E°_{cell} per electron transferred ?

[JEE(Main) 2019 Online (11-01-2019), 4/120]

(1) Au^{3+} / Au (2) Fe^{3+} / Fe^{2+} (3) Fe^{2+} / Fe (4) Ag^+ / Ag

21. Given the equilibrium constant : K_C of the reaction $Cu(s) + 2Ag^+(aq) \rightarrow Cu^{2+}(aq) + 2Ag(s)$ is 10×10^{15}, caluclate the E^0_{cell} of this reaction at 298 K : $\left[2.303\frac{RT}{F} \text{ at } 298\text{K} = 0.059 \text{ V}\right]$

[JEE(Main) 2019 Online (11-01-2019), 4/120]

(1) 0.4736 mV (2) 0.04736 V (3) 0.4736 V (4) 0.04736 mV

22. The standard electrode potential $E^\ominus$ and its temperature coefficient $\left(\frac{dE^\ominus}{dT}\right)$ for a cell are 2 V and -5×10^{-4} VK^{-1} at 300 K respectively. The cell reaction is

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

The standard reaction enthalpy ($\Delta_r H^\ominus$) at 300 K in kJ mol^{-1} is :

(Use R = 8JK^{-1} mol^{-1} and F = 96,000 $Cmol^{-1}$) **[JEE(Main) 2019 Online (12-01-2019), 4/120]**

(1) 206.4 (2) –384.0 (3) 192.0 (4) –412.8

23. Λ^o_m for NaCl, HCl and NaA are 126.4, 425.9 and 100.5 S cm^2mol^{-1}, respectively. If the conductivity of 0.001 M HA is 5×10^{-5} S cm^{-1}, degree of dissociation of HA is:

[JEE(Main) 2019 Online (12-01-2019), 4/120]

(1) 0.125 (2) 0.50 (3) 0.75 (4) 0.25

Answers

EXERCISE - 1

PART - I

A-1. (a) Cu (b) Ag (c) oxidation (d) reduction (e) Cu
(f) Ag (g) anode-Cu $\longrightarrow Cu^{2+} + 2e^-$; cathode-$Ag^+ + e^- \longrightarrow Ag$
(h) $Cu + 2Ag^+ \longrightarrow Cu^{2+} + 2Ag$ (i) Cu (j) Cu
(k) to complete circuit and maintain electrical neutrality in solution

A-2. (a) $2Ag^+ + Cu \longrightarrow 2Ag + Cu^{2+}$ (b) $8H^+ + MnO_4^- \longrightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$
(c) $2Ag^+ + 2Cl^- \longrightarrow 2Ag + Cl_2$ (d) $Cd + 2H^+ \longrightarrow Cd^{2+} + H_2$

A-3. (a) $Zn \mid Zn^{2+} \mid\mid H^+ \mid H_2 \mid Pt$ (b) $Pt \mid Sn^{2+}, Sn^{4+} \mid\mid Fe^{3+}, Fe^{2+} \mid Pt$ (c) $Pb \mid Pb^{2+} \mid\mid Br^- \mid\mid Br_2 \mid Pt$

B-1. Mg **B-2.** Y > Z > X

B-3. **(i)** CuO **:** Cu is below hydrogen in series, so it can reduce from CuO to Cu.
(ii) Ag_2O **:** Lower in series stability of oxide become lesser.
(iii) Lower S.R.P. metal can displace higher S.R.P. metals ions from solution.

B-4. 1.61 V **B-5.** 1.35 V **B-6.** 1.68 V **C-1.** –0.036 V

C-2. –0.756 V **C-3.** Spontaneous, – 48250 J **C-4.** –1.14 volt

D-1. 0.059 volt **D-2.** 10^{14} **D-3.** –0.2214 V **D-4.** n = 2

D-5. (a) The spontaneous cell reaction : $Zn + 2Ag^+ (aq) \rightleftharpoons Zn^{2+} (aq) + 2Ag (s)$
(b) 1.56 V (c) $[Zn^{2+}] = 4 \times 10^{-4}$ M
(d) As we add KI to cathode chamber, some Ag^+ will precipitate out as : $Ag^+ + I^- \longrightarrow AgI$
The above reaction reducing $[Ag^+]$ from cathode chamber. This will reduce E_{cell} according to Nernst's equation.

D-6. pH = 1.5. **D-7.** $\log [Zn^{2+}] / [Cu^{2+}] = 37.22$

E-1.

	ELECTROLYTE	ANODE Product	CATHODE Product
1	NaCl (Molten) with Pt electrode	$Cl_2(g)$	Na
2	NaCl (aq) with Pt electrode	$Cl_2(g)$	$H_2(g)$
3	Na_2SO_4 (aq) with Pt electrode	$O_2(g)$	$H_2(g)$
4	$NaNO_3$ (aq) with Pt electrode	$O_2(g)$	$H_2(g)$
5	$AgNO_3$ (aq) with Pt electrode	$O_2(g)$	Ag
6	$CuSO_4$ (aq) with Inert electrode	$O_2(g)$	Cu
7	$CuSO_4$ (aq) with Copper electrode	Cu dissolve	Cu

F-1. 12.04×10^{23} **F-2.** 108. **F-3.** 2 **F-4.** n = 4

F-5. t = 193 sec. **F-6.** $V_{(H_2)}$ = 56.0 mL. **F-7.** Ni^{2+} = 2M **F-8.** t = 93.65 sec.

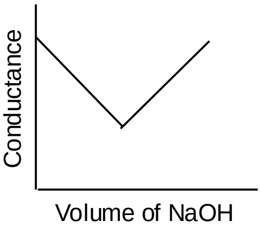
F-9. + 71.5 amp **G-1.** 8 **G-2.** 1.67 V

H-1. 2.332×10^{-3} mho cm^{-1}, 23.32 mho cm^2 mol^{-1}. **H-2.** R = 66.67 ohms **H-3.** 120 mho cm^2 mol^{-1}

H-4. 0.1456 amp **H-5.** 0.728 cm^{-1}. **I-1.** 272, 0.0353 **I-2.** 382 mho cm^2 mol^{-1}.

I-3. 1.76×10^{-5} mole/litre. **I-4.** 2.70×10^{-10} (mole/litre)^2.

J-1. (1)



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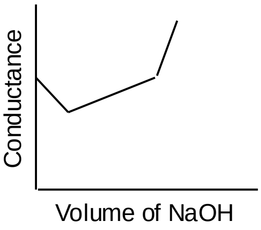

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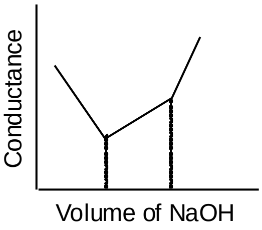

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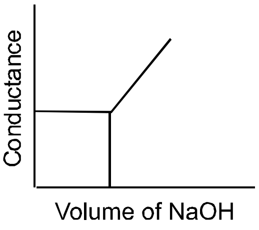

PART - II

A-1.	(A)	**A-2.**	(C)	**A-3.**	(D)	**A-4.**	(C)	**B-1.**	(A)
B-2.	(C)	**B-3.**	(D)	**B-4.**	(D)	**B-5.**	(C)	**B-6.**	(A)
B-7.	(C)	**B-8.**	(C)	**C-1.**	(D)	**C-2.**	(D)	**C-3.**	(D)
D-1.	(A)	**D-2.**	(A)	**D-3.**	(C)	**D-4.**	(B)	**D-5.**	(B)
D-6.	(C)	**E-1.**	(C)	**E-2.**	(C)	**E-3.**	(D)	**E-4.**	(B)
E-5.	(B)	**F-1.**	(D)	**F-2.**	(B)	**F-3.**	(C)	**F-4.**	(B)
F-5.	(C)	**G-1.**	(B)	**G-2.**	(A)	**G-3.**	(D)	**H-1.**	(A)
H-2.	(D)	**H-3.**	(B)	**H-4.**	(C)	**I-1.**	(C)	**I-2.**	(D)
I-3.	(D)	**I-4.**	(C)	**I-5.**	(D)	**J-1.**	(A)	**J-2.**	(C)

PART - III

1. (A - s) ; (B - p,r) ; (C - p,q) ; (D - r)

2. (A - p, q, r) ; (B - p, q, r) ; (C - p, s) ; (D - p, s)

EXERCISE - 2

PART - I

1.	(A)	**2.**	(C)	**3.**	(D)	**4.**	(A)	**5.**	(B)
6.	(B)	**7.**	(B)	**8.**	(B)	**9.**	(D)	**10.**	(B)
11.	(B)	**12.**	(C)	**13.**	(C)	**14.**	(D)	**15.**	(C)

PART - II

1.	4	**2.**	4	**3.**	$7\ Sm^2\ mol^{-1}$	**4.**	3 (B, E & F)	**5.**	10
6.	E° = 7 V.	**7.**	40	**8.**	20	**9.**	59		

PART - III

1.	(BC)	**2.**	(AD)	**3.**	(ABD)	**4.**	(AB)	**5.**	(BD)
6.	(ACD)	**7.**	(BCD)	**8.**	(BCD)	**9.**	(AC)	**10.**	(AC)
11.	(AB)	**12.**	(BC)	**13.**	(BCD)	**14.**	(A)	**15.**	(ABD)

PART - IV

1.	(D)	**2.**	(C)	**3.**	(B)	**4.**	(D)	**5.**	(A)
6.	(C)	**7.**	(D)	**8.**	(D)	**9.**	(B)	**10.**	(C)
11.	(C)	**12.**	(B)						

EXERCISE - 3

PART - I

1.	(A)	**2.**	0.05 M	**3.**	(B)	**4.**	$K_C = 10^{10}$	**5.**	(B)
6.	(B)	**7.**	(A)	**8.**	(D)	**9.**	$55\ S\ m^{-1}$	**10.**	(B)
11.	(D)	**12.**	(D)	**13.**	(C)	**14.**	(D)	**15.**	(B)
16.*	(ABD)	**17.**	(B)	**18.**	(C)	**19.**	(D)	**20.**	(D)

21.	(B)	**22.**	(D)	**23.**	(A)	**24.**	(D)	**25.**	(A)
26.	4	**27.**	3	**28.**	(D)	**29.**	6	**30.**	(C)
31.	10	**32.**	$-11.62\ JK^{-1}mol^{-1}$						

PART - II

JEE(MAIN) OFFLINE PROBLEMS

1.	(2)	**2.**	(1)	**3.**	(3)	**4.**	(2)	**5.**	(4)
6.	(1)	**7.**	(3)	**8.**	(1)	**9.**	(3)	**10.**	(1)
11.	(4)	**12.**	(1)	**13.**	(4)	**14.**	(4)	**15.**	(1)
16.	(3)	**17.**	(1)	**18.**	(4)	**19.**	(2)	**20.**	(3)
21.	(3)	**22.**	(4)	**23.**	(4)	**24.**	(1)	**25.**	(3)
26.	(2)	**27.**	(1)	**28.**	(2)	**29.**	(3)	**30.**	(4)
31.	(1)								

JEE(MAIN) ONLINE PROBLEMS

1.	(3)	**2.**	(3)	**3.**	(2)	**4.**	(3)	**5.**	(4)
6.	(2)	**7.**	(4)	**8.**	(1)	**9.**	(2)	**10.**	(4)
11.	(1)	**12.**	(1)	**13.**	(4)	**14.**	(3)	**15.**	(3)
16.	(3)	**17.**	(2)	**18.**	(2)	**19.**	(3)		
20.	NTA answer was (4), but correct answer is (1)					**21.**	(3)	**22.**	(4)
23.	(1)								