CHEMISTRY

Electrochemistry

No. of Questions	Maximum Marks	Time
30	120	1 Hour

Speed TEST 46

Chapter-wise

GENERAL INSTRUCTIONS

- This test contains 30 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solutions provided at the end of this book.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

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

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

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

2. The equivalent conductance of $\frac{M}{32}$ solution of a weak monobasic acid is 8.0 mho cm^2 and at infinite dilution is 400 mho cm^2. The dissociation constant of this acid is:

(a) 1.25×10^{-6} (b) 6.25×10^{-4}

(c) 1.25×10^{-4} (d) 1.25×10^{-5}

3. Aqueous solution of which of the following compounds is the best conductor of electric current ?

(a) Acetic acid, $C_2H_4O_2$

(b) Hydrochloric acid, HCl

(c) Ammonia, NH_3

(d) Fructose, $C_6H_{12}O_6$

4. The standard EMF of Daniell cell is 1.10 volt. The maximum electrical work obtained from the Daniell cell is

(a) 212.3 kJ

(b) 175.4 kJ

(c) 106.15 kJ

(d) 53.07 kJ

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ

5. Which of the following reaction occurs at the cathode during the charging of lead storage battery?

(a) $Pb^{2+} + 2e^- \longrightarrow Pb$

(b) $Pb^{2+} + SO_4^{2-} \longrightarrow PbSO_4$

(c) $Pb \longrightarrow Pb^{2+} + 2e^-$

(d) $PbSO_4 + 2H_2O \longrightarrow 2PbO_2 + 4H^+ + SO_4^{2-} + 2e^-$

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

(a) 130 S cm^2 mol^{-1}
(b) 65 S cm^2 mol^{-1}
(c) 260 S cm^2 mol^{-1}
(d) 187 S cm^2 mol^{-1}

7. Kohlrausch's law states that at :

(a) finite dilution, each ion makes definite contribution to equivalent conductance of an electrolyte, whatever be the nature of the other ion of the electrolyte.
(b) infinite dilution each ion makes definite contribution to equivalent conductance of an electrolyte depending on the nature of the other ion of the electrolyte.
(c) infinite dilution, each ion makes definite contribution to conductance of an electrolyte whatever be the nature of the other ion of the electrolyte.
(d) infinite dilution, each ion makes definite contriubtion to equivalent conductance of an electrolyte, whatever be the nature of the other ion of the electrolyte.

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

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

9. If the E°_{cell} for a given reaction has a negative value, then which of the following gives the correct relationships for the values of ΔG° and K_{eq} ?

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

10. Standard electrode potentials are : Fe^{+2}/Fe [E° = –0.44]; Fe^{+3}/Fe^{+2} E° = + 0.77 ; If Fe^{+2}, Fe^{+3} and Fe blocks are kept together, then

(a) Fe^{+3} increases
(b) Fe^{+3} decreases
(c) $\frac{Fe^{+2}}{Fe^{+3}}$ remains unchanged
(d) Fe^{+2} decreases

11. An electrolytic cell contains a solution of Ag_2SO_4 and has platinum electrodes. A current is passed until 1.6 gm of O_2 has been liberated at anode. The amount of silver deposited at cathode would be

(a) 107.88 gm (b) 1.6 gm
(c) 0.8 gm (d) 21.60 gm

12. If ϕ denotes reduction potential, then which is true?

(a) $E^\circ_{cell} = \phi_{right} - \phi_{left}$ (b) $E^\circ_{cell} = \phi_{left} + \phi_{right}$
(c) $E^\circ_{cell} = \phi_{left} - \phi_{right}$ (d) $E^\circ_{cell} = -(\phi_{left} + \phi_{right})$.

13. In a fuel cell methanol is used as fuel and oxygen gas is used as an oxidizer. The reaction is

$$CH_3OH(l) + 3/2O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$$

At 298 K standard Gibb's energies of formation for $CH_3OH(l)$, $H_2O(l)$ and and $CO_2(g)$ are –166.2 –237.2 and –394.4 kJ mol^{-1} respectively. If standard enthalpy of combustion of methonal is – 726 kJ mol^{-1}, efficiency of the fuel cell will be:

(a) 87% (b) 90%
(c) 97% (d) 80%

14. For the cell reaction,
Cu^{2+} (C_1, aq) + Zn(s) = Zn^{2+} (C_2, aq) + Cu(s) of an electrochemical cell, the change in free energy, ΔG, at a given temperature is a function of

(a) ln (C_1) (b) ln (C_2/C_1)
(c) ln (C_2) (d) ln ($C_1 + C_2$)

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

15. When electric current is passed through acidified water, 112 ml of hydrogen gas at STP collected at the cathode in 965 seconds. The current passed in amperes is

(a) 1.0 (b) 0.5 (c) 0.1 (d) 2.0

16. The electrode potential $E_{(Zn^{2+}/Zn)}$ of a zinc electrode at 25°C with an aqueous solution of 0.1 M $ZnSO_4$ is $[E^\circ_{(Zn^{2+}/Zn)} = -0.76$ V. Assume $\frac{2.303RT}{F} = 0.06$ at 298 K].

(a) $+0.73$ (b) -0.79

(c) -0.82 (d) -0.70

17. A gas X at 1 atm is bubbled through a solution containing a mixture of 1 M Y^- and M Z^- at 25°C. If the reduction potential of Z > Y > X, then,

(a) Y will oxidize X and not Z

(b) Y will oxidize Z and not X

(c) Y will oxidize both X and Z

(d) Y will reduce both X and Z

18. For the electrochemical cell, $M \mid M^+ \parallel X^- \mid X$,

$E^\circ M^+/M = 0.44$ V and $E^\circ (X/X^-) = 0.33$ V.

From this data one can deduce that

(a) $M + X \rightarrow M^+ + X^-$ is the spontaneous reaction

(b) $M^+ + X^- \rightarrow M + X$ is the spontaneous reaction

(c) $E_{cell} = 0.77$ V

(d) $E_{cell} = -0.77$ V

19. 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:

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

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

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

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

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

20. A hypothetical electrochemical cell is shown below

$A|A^+(xM)\|B^+(yM)|B$

The emf measured is +0.20 V. The cell reaction is

(a) $A^+ + e^- \rightarrow A;\ B^+ + e^- \rightarrow B$

(b) The cell reaction cannot be predicted

(c) $A + B^+ \rightarrow A^+ + B$

(d) $A^+ + B \rightarrow A + B^+$

21. Conductance of 0.1 M KCl (conductivity = X $Ohm^{-1}cm^{-1}$) filled in a conductivity cell is Y Ohm^{-1}. If the conductance of 0.1 M NaOH filled in the same cell is Z Ohm^{-1}, the molar conductance of NaOH will be

(a) $10^3 \frac{XZ}{Y}$ (b) $10^4 \frac{XZ}{Y}$ (c) $10 \frac{XZ}{Y}$ (d) $0.1 \frac{XZ}{Y}$

22. On the basis of the following E° values, the strongest oxidizing agent is :

$Fe(CN)_6]^{4-} \rightarrow [Fe(CN)_6]^{3-} + e^-$; $E^\circ = -0.35$ V

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

(a) $[Fe(CN)_6]^{4-}$ (b) Fe^{2+}

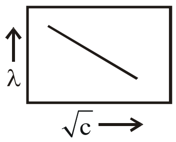
(c) Fe^{3+} (d) $[Fe(CN)_6]^{3-}$

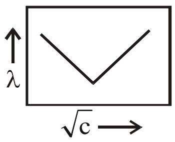
23. The mathematical expression for law of independent migration of ions and Ostwald's dilution law are given by

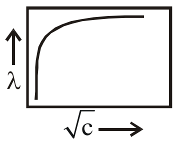
(a) $\Lambda = \Lambda_m^o - BC^{1/2}$ (b) $\Lambda^o = F(U_+ + U_-)$

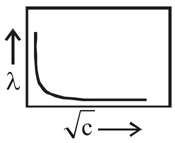
(c) $\Lambda_m^o = \nu_+\lambda_+ + \nu_-\lambda_-$ (d) $\frac{\Lambda^o}{\Lambda_m} = \frac{1}{\Lambda_m^o} + \frac{\Lambda_m c}{K_a(\Lambda_m^o)^2}$

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

(a)


(b)


(c)


(d)


RESPONSE GRID					
	15. ⓐⓑⓒⓓ	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ	19. ⓐⓑⓒⓓ
	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ	24. ⓐⓑⓒⓓ

25. A device that converts energy of combustion of fuels like hydrogen and methane, directly into electrical energy is known as :

(a) Electrolytic cell (b) Dynamo
(c) Ni-Cd cell (d) Fuel Cell

26. In acidic medium MnO_2 is an oxidant as

$$MnO_2\ (s) + 4H^+ + 2e^- \longrightarrow Mn^{2+} + 2H_2O$$

If the pH of solution is decreased by one unit, the electrode potential of the half cell Pt : $MnO_2,\ Mn^{2+}$ will change by

(a) 0.236 V (b) –0.236 V
(c) –0.118 V (d) 0.118 V

27. Consider the following cell reaction:

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

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

(a) 1.47 V (b) 1.77 V
(c) 1.87 V (d) 1.57 V

28. In a hydrogen-oxygen fuel cell, combustion of hydrogen occurs to

(a) produce high purity water
(b) create potential difference between two electrodes
(c) generate heat
(d) remove adsorbed oxygen from electron surfaces

29. Consider the following relations for emf of a electrochemical cell:

(i) emf of cell = (Oxidation potential of anode) – (Reduction potential of cathode)
(ii) emf of cell = (Oxidation potential of anode) + (Reduction potential of cathode)
(iii) emf of cell = (Reduction potential of anode) + (Reduction potential of cathode)
(iv) emf of cell = (Oxidation potential of anode) – (Oxidation potential of cathode)

Which of the above relations are correct?

(a) (ii) and (iv)
(b) (iii) and (i)
(c) (i) and (ii)
(d) (iii) and (iv)

30. A hydrogen gas electrode is made by dipping platinum wire in a solution of HCl of pH = 10 and by passing hydrogen gas around the platinum wire at one atm pressure. The oxidation potential of electrode would be ?

(a) 0.59 V (b) 0.118 V
(c) 1.18 V (d) 0.059 V

RESPONSE GRID	
	25. ⓐⓑⓒⓓ 26. ⓐⓑⓒⓓ 27. ⓐⓑⓒⓓ 28. ⓐⓑⓒⓓ 29. ⓐⓑⓒⓓ 30. ⓐⓑⓒⓓ

CHEMISTRY CHAPTERWISE SPEED TEST-46			
Total Questions	30	Total Marks	120
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	37	Qualifying Score	53
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

HINTS & SOLUTIONS (CHEMISTRY – Chapter-wise Tests)

Speed Test-46

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

2. **(d)** Degree of dissociation,

$$\alpha = \frac{\Lambda}{\Lambda_\infty} = \frac{8.0}{400} = 2\times10^{-2}$$

$$K_a = \frac{C\alpha^2}{(1-\alpha)} \approx C\alpha^2 = \frac{1}{32}\times\left(2\times10^{-2}\right)^2$$

$$= 1.25\times10^{-5}$$

3. **(b)** HCl completely dissociates to give H^r and Cl^- ions, hence act as very good electrolyte. While others are non-electrolytes.

4. **(a)** $\Delta G = -nFE^\circ_{cell} = -2\times96500\times1.1\ J = 212.3\ kJ.$

5. **(d)**

6. **(a)** $\Lambda_m^\infty = 57+73 = 130\ Scm^2mol^{-1}$

7. **(d)** Kohlrausch's Law states that at infinite dilution, each ion migrates independently of its co-ion and contributes to the total equivalent conductance of an electrolyte a definite share which depends only on its own nature.
From this definition we can see that option (d) is the correct answer.

8. **(c)** Writing the equation for pentane-oxygen fuel cell at respective electrodes and overall reaction, we get
At Anode:

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

At Cathode:

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

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

Calculation of ΔG° for the above reaction
$\Delta G^\circ = [5\times(-394.4) + 6\times(-237.2)] - [-8.2]$
$= -1972.0 - 1423.2 + 8.2 = -3387.0\ kJ$
$= -3387000$ Joules.
From the equation we find n = 32

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

$-3387000 =$

or $E^\circ_{cell} = \dfrac{3387000}{32\times96500}$

$= \dfrac{3387000}{3088000}$ or $\dfrac{3387}{3088}V = 1.0968\,V$
Thus option (c) is correct answer.

9. **(d)** Standard Gibbs free energy is given as $\Delta G^\circ = -nE^\circ F$
If $E^\circ_{cell} < 0$ i.e., – ve
$\Delta G^\circ > 0$
Further $\Delta G^\circ = -RT\ln K_{eq}$
$\therefore\ \Delta G^\circ > 0$ and $K_{eq} < 1$

10. **(b)** Fe^{+2}/Fe ; $E^\circ = -0.44$
Fe^{+3}/Fe^{+2} ; $E^\circ = 0.77$
The metals having higher negative electrode potential values can displace metals having lower values of negative electrode potential from their salt solutions.

11. **(d)** $\dfrac{W_A}{E_A} = \dfrac{W_B}{E_B}$; $\dfrac{1.6}{8} = \dfrac{\text{Wt. of Ag}}{108}$
$\therefore$ Wt. of Ag = 21.6 g

12. **(a)** $E_{cell} = E_{right\ (cathode)} - E_{left\ (anode)}$.

13. **(c)** $CH_3OH\,(l) + \frac{3}{2}O_2\,(g) \rightarrow CO_2\,(g) + 2H_2O\,(l)$

$$\Delta G_r = [\Delta G_f(CO_2, g) + 2\Delta G_f(H_2O, \ell)] - \left[\Delta G_f(CH_3OH, \ell) + \frac{3}{2}\Delta G_f(O_2, g)\right]$$

$= -394.4 + 2(-237.2) - (-166.2) - 0$
$= -394.4 - 474.4 + 166.2 = -702.6$ k J

$$\%\ \text{efficiency} = \frac{702.6}{726}\times100 = 97\%$$

14. **(b)** $\Delta G = -nE^\circ F$

For concentration cell, $E = \dfrac{RT}{nF}\ln\dfrac{C_2}{C_1}$

In it R, T, n and F are constant
So E is based upon $\ln C_2/C_1$

Now $\Delta G = -nEF = -nF\times\dfrac{RT}{nF}\ln C_2/C_1$
$= -RT\ln C_2/C_1$
At constant temperature ΔG is based upon $\ln(C_2/C_1)$.

15. **(a)** 112 ml of H_2 at STP $= \dfrac{2\times112g}{22400}$ (Since 22400 ml at STP

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

$\therefore \frac{2 \times 112}{22400} = \frac{1 \times 965 \times i}{96500}$;

$i = 1$ amp

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

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

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

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

17. (a) The given order of reduction potentials (or tendencies) is Z > Y > X. A spontaneous reaction will have the following characteristics

Z reduced and Y oxidised
Z reduced and X oxidised
Y reduced and X oxidised
Hence, Y will oxidise X and not Z.

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

19. (a) MnO_4^- will oxidise Cl^- ion according to the equation

$$2MnO_4^- + 16H^+ + 10Cl^- \longrightarrow 2Mn^{2+} + 8H_2O + 5Cl_2 \uparrow$$

The cell corresponding to this reaction is as follows:

$Pt,\ Cl_2(1\ atm)\ |Cl^-\ ||\ MnO_4^-, Mn^{2+}, H^+\ |\ Pt$

$E^o_{cell} = 1.51 - 1.40 = 0.11\ V$

E^o_{cell} being +ve, ΔG° will be -ve and hence the above reaction is feasible. MnO_4^- will not only oxidise Fe^{2+} ion but also Cl^- ion simultaneously.

20. **(c)** The cell reaction is as follows :

$$A \rightarrow \overset{+}{A} + e^-$$
$$\overset{+}{B} + e \rightarrow B$$
$$\text{Adding}\quad A + \overset{+}{B} \rightarrow \overset{+}{A} + B$$

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

$\therefore$ Cell constant $= \frac{X}{Y}$

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

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

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

23. (c) At infinite dilution each ion makes a definite contribution towards molar conductance which is given by

$$\Lambda^o_m = v_+\lambda_+ + v_-\lambda_-$$

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

25. (d) A device that converts energy of combustion of fuels, directly into electrical energy is known as fuel cell.

26. (d) $E = E^{\circ} - \frac{0.0592}{2} \log \frac{[Mn^{2+}]}{[H^+]^4}$

$$= E^{\circ} - \frac{0.0592 \times 4}{2} \log \frac{[Mn^{2+}]^{1/4}}{[H^+]}$$

$$= E^{\circ} - 0.0592 \times 2\ (\log[Mn^{2+}]^{1/4} + pH)$$

$$\Delta E = E_2 - E_1 = 0.0592 \times 2\,(pH_1 - pH_2)$$
$$= 0.118 \times 1$$
$$= 0.118V$$

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

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

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

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

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

29. **(a)**

30. **(a)** $\underset{1\ atm}{H_2} \longrightarrow \underset{10^{-10}}{2H^+} + 2e^-$

$$E_{H_2/H^+} = 0 - \frac{0.059}{2} \log \frac{\left(10^{-10}\right)^2}{1}$$

$$E_{H_2/H^+} = +0.59\ V$$