## EXERCISE # (O-I)

Electrode Potential, Galvanic Cell

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

2. Which of the following statement is wrong about galvanic cell ?

(A) Cathode is positive charged

(B) Anode is negatively charged

(C) Reduction takes place at the anode

(D) Electrons move from anode to cathode

3. Which of the following has been universally accepted as a reference electrode at all temperatures and has been assigned a value of zero volt?

(A) Standard platinum electrode   (B) Standard copper electrode

(C) Standard graphite electrode   (D) Standard hydrogen electrode

4. A standard hydrogen electrode has zero electrode potential because

(A) hydrogen is easier to oxidise   (B) electrode potential is assumed to be zero

(C) hydrogen atom has only one electron   (D) hydrogen is the lightest element.

5. Which is not true for a standard hydrogen electrode ?

(A) The hydrogen ion concentration must be 1 M

(B) Temperature must be 25°C

(C) Pressure of hydrogen must be 1 bar

(D) Temperature can vary

6. The equation representing the process by which standard reduction potential of zinc can be defined is :

(A) $Zn^{2+}(s) + 2e^- \longrightarrow Zn(s)$ (B) $Zn(g) \longrightarrow Zn^{2+}(g) + 2e^-$

(C) $Zn^{2+}(g) + 2e^- \longrightarrow Zn(s)$ (D) $Zn^{2+}(aq.) + 2e^- \longrightarrow Zn(s)$

ΔG =-nFE theoretical

7. E° for $F_2 + 2e^- = 2F^-$ is 2.8 V, E° for $\frac{1}{2}F_2 + e^- = F^-$ is ?

(A) 2.8 V   (B) 1.4 V   (C) –2.8 V   (D) –1.4 V

8. Doubling all the coefficients in the equation for the cell reaction -

(A) Doubles both E° and ΔG°   (B) Doubles E°, but does not change ΔG°

(C) Doubles ΔG°, but does not change E°   (D) Does not change E° or ΔG°
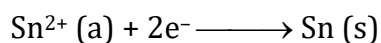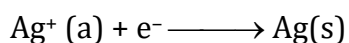
9. $E^\circ = 0.6$ V for the following reaction :

$Sn^{2+}(aq) + 2Fe^{3+}(aq) \longrightarrow Sn^{4+}(aq) + 2Fe^{2+}(aq)$
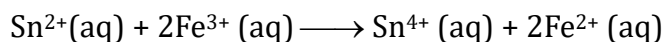
What is ΔG° for this reaction at $25^\circ C$ -

(A) –115.8 kJ   (B) –57.9 kJ   (C) 57.9 kJ   (D) 115.8 Kj

$$E_1 + E_2 = E_3$$

10. The standard electrode potentials for the reactions

$Ag^+(a) + e^- \longrightarrow Ag(s)$ $Sn^{2+}(a) + 2e^- \longrightarrow Sn(s)$

at 25 °C are 0.80 volt and –0.14 volt, respectively. The standard emf of the cell formed by these half-cells is

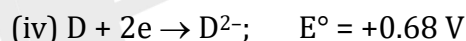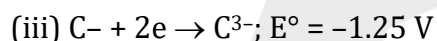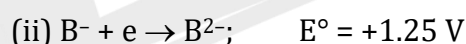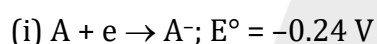(A) 0.66 volt   (B) 0.80 volt   (C) 1.08 volt   (D) 0.94 volt

11. $E^\circ(Ni^{2+}/Ni) = -0.25$ volt, $E^\circ(Au^{3+}/Au) = 1.50$ volt. The standard emf of the voltaic cell.

(A) 1.25 volt   (B) –1.75 volt   (C) 1.75 volt   (D) 4.0 volt

12. For the cell reaction $2Ce^{4+} + Co \longrightarrow 2Ce^{3+} + Co^{2+}$ $E^\circ_{cell} = 1.89$ V.

If $E^\circ_{Co2+/Co}$ is – 0.28 V, what is the value of $E^\circ_{Ce^{4+}|Ce^{3+}}$?

13. From the following E° values of half cells,

(i) $A + e \rightarrow A^-$; $E^\circ = -0.24$ V   (ii) $B^- + e \rightarrow B^{2-}$; $E^\circ = +1.25$ V

(iii) $C^- + 2e \rightarrow C^{3-}$; $E^\circ = -1.25$ V   (iv) $D + 2e \rightarrow D^{2-}$; $E^\circ = +0.68$ V
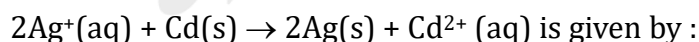
What combination of two half cells would result in a cell with the largest potential ?

(A) (ii) and (iii)   (B) (ii) and (iv)   (C) (i) and (iii)   (D) (i) and (iv)

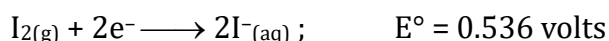**14.** The standard reduction potentials for two half-cell reactions are given below,

$Cd^{2+}(aq) + 2e^- \rightarrow Cd(s)$, $E^\circ = -0.40V$

$Ag^+(aq) + e^- \rightarrow Ag(s)$, $E^\circ = 0.80V$

The standard free energy change for the reaction

$2Ag^+(aq) + Cd(s) \rightarrow 2Ag(s) + Cd^{2+}(aq)$ is given by :

(A) 115.8 KJ   (B) –115.8 KJ   (C) –231.6 KJ   (D) 231.6KJ

15. Given electrode potentials :

$Fe^{3+}_{(aq)} + e^- \longrightarrow Fe^{2+}_{(aq)}$; $E^\circ = 0.771$ volts

$I_{2(g)} + 2e^- \longrightarrow 2I^-_{(aq)}$; $E^\circ = 0.536$ volts

E°_{cell} for the cell reaction,

$2Fe^{3+}_{(aq)} + 2I^-_{(aq)} \longrightarrow 2Fe^{2+}_{(aq)} + I_{2(g)}$ is –
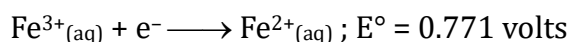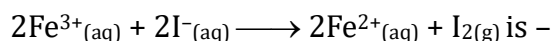
(A) $(2 \times 0.771 - 0.536) = 1.006$ volts   (B) $(0.771 - 0.5 \times 0.536) = 0.503$ volts

(C) $0.771 - 0.536 = 0.235$ volts   (D) $0.536 - 0.771 = -0.235$ volts

Electrode Potential And Equilibrium Constant

16. If $E^°_{Au^+/Au}$ is 1.69 V & $E^°_{Au^{3+}/Au}$ is 1.40 V, then $E^°_{Au^{3+}/Au^+}$ will be

(A) 0.19 V   (B) 2.945 V   (C) 1.255 V   (D) None

17. What is the standard electrode potential for the electrode MnO_4^- / MnO_2 in solution

$E^°_{MnO_4^-/Mn^{2+}} = 1.51$ volt, $E^°_{MnO_2/Mn^{2+}} = 1.23$ volt

(A) 0.7 V   (B) 3.33 V   (C) 1.70 V   (D) 2.5 V

18. Calculate the equilibrium constant for the reaction $Fe + CuSO_4 \rightleftharpoons FeSO_4 + Cu$ at 25°C.
Given E^0 (Fe/Fe^{2+}) = 0.44V, E^0 (Cu/Cu^{2+}) = -0.337V.

19. At 25°C the standard emf of cell having reactions involving two electrons change is found to be
0.295V. The equilibrium constant of the reaction is –

(A) 29.5×10^{-2} (B) 10   (C) 10^{10} (D) 29.5×10^{10}

20. The equilibrium constant for the reaction
$Sr(s) + Mg^{+2}$ (aq) $\rightleftharpoons Sr^{+2}$ (aq) $+ Mg(s)$ is 4×10^{12} at 25°C
The E° for a cell made up of the Sr/Sr^{+2} and Mg^{+2}/Mg half cells
(log 2 = 0.3)

(A) 0.3717 V   (B) 0.7434 V   (C) 0.1858 V   (D) 0.135 V

21. For a reaction - $A(s) + 2B^+_{(aq)} \rightarrow A^{2+}_{(aq)} + 2B_{(s)}$ K_C has been found to be 10^{12}. The E°cell is:

(A) 0.354 V   (B) 0.708 V   (C) 0.0098 V   (D) 1.36 V

22. Determine the value of E° cell for the following reaction -
$Cu^{+2}_{(aq)} + Sn^{+2}_{(aq)} \longrightarrow Cu_{(s)} + Sn^{+4}_{(aq)}$ Equilibrium constant is 10^6

(A) 0.177   (B) 0.0177   (C) 0.215   (D) 1.77

Application Of Electrode Potential, Reduction And Oxidation Power

23. A standard reduction electrode potential of four metals are
A = – 0.250 V, B = – 0.140 V   C = – 0.126 V,   D = – 0.402 V
The metal that displaces A from its aqueous solution is :–

(A) B   (B) C   (C) D   (D) None of the above

24. The standard reduction potentials at 25°C for the following half reactions are :

Zn^{2+} (aq.) $+ 2e^- \rightleftharpoons Zn(s); -0.762$

Cr^{3+} (aq.) $+ 3e^- \rightleftharpoons Cr(s); -0.740$

$2H^+ + 2e^- \rightleftharpoons H_2(g); 0.00$

$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}; 0.77$

Which is the strongest reducing agent ?
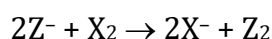
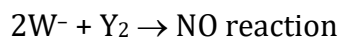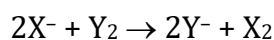(A) Zn   (B) Cr   (C) $H_2(g)$ (D) Fe^{2+} (aq)

25. 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$_2$ / 2I$^-$ = + 0.53 volt
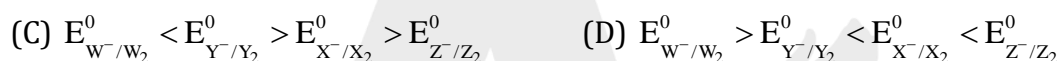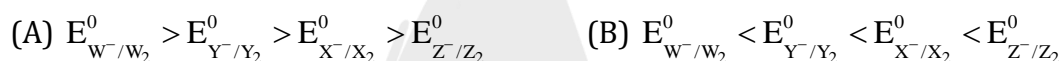
Which one is the best reducing agent ?

(A) Al   (B) Mg   (C) Cu   (D) I$_2$

26. The following facts are available :–

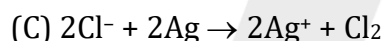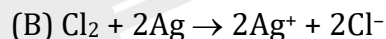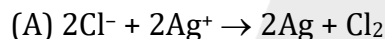$2X^- + Y_2 \rightarrow 2Y^- + X_2$

$2W^- + Y_2 \rightarrow$ NO reaction

$2Z^- + X_2 \rightarrow 2X^- + Z_2$

Which of the following statements is correct :–

(A) $E^0_{W^-/W_2} > E^0_{Y^-/Y_2} > E^0_{X^-/X_2} > E^0_{Z^-/Z_2}$ (B) $E^0_{W^-/W_2} < E^0_{Y^-/Y_2} < E^0_{X^-/X_2} < E^0_{Z^-/Z_2}$

(C) $E^0_{W^-/W_2} < E^0_{Y^-/Y_2} > E^0_{X^-/X_2} > E^0_{Z^-/Z_2}$ (D) $E^0_{W^-/W_2} > E^0_{Y^-/Y_2} < E^0_{X^-/X_2} < E^0_{Z^-/Z_2}$

Cell Representation, Types of Half Cell,

NERNST EQUATION & ITS APPLICATIONS

27. For the cell Pt (Cl$_2$) | Cl$^-$ (aq) || Ag$^+$ (aq) | Ag, cell reaction is given by

(A) $2Cl^- + 2Ag^+ \rightarrow 2Ag + Cl_2$ (B) $Cl_2 + 2Ag \rightarrow 2Ag^+ + 2Cl^-$

(C) $2Cl^- + 2Ag \rightarrow 2Ag^+ + Cl_2$ (D) $Cl_2 + 2Ag^+ \rightarrow 2Ag + 2Cl^-$
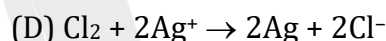
28. For a reaction, $M^{n+1} + n\,e^- \longrightarrow M^{+1}$, the Nernst equation has a form of :

(A) $E = E° + \dfrac{RT}{nF} \lambda n\, \dfrac{[M^+]}{[M^{n+1}]}$ (B) $E = E° - \dfrac{RT}{nF} \lambda n\, \dfrac{[M^+]}{[M^{n+1}]}$

(C) $E = E° - \dfrac{RT}{nF} \log \dfrac{[M^+]}{[M^{n+1}]}$ (D) $E = E° + \dfrac{RT}{nF} \log \dfrac{[M^+]}{[M^{n+1}]}$

29. The reduction potential of hydrogen electrode (P_{H_2} = 1 atms; [H$^+$] = 0.1 M) at 25°C will be –

(A) 0.00 V   (B) –0.059 V   (C) 0.118 V   (D) 0.059 V

30. Which of the following represents the reduction potential of silver wire dipped into 0.1 M

AgNO$_3$ solution at 25° C ?

(A) E°$_{red}$ (B) (E°$_{red}$ + 0.059)   (C) (E°$_{oxi}$ – 0.059)   (D) (E°$_{red}$ – 0.059)

31. By how much times will potential of half cell Cu^{+2}/Cu change if, the solution is diluted to 100

times at 298 K :–

(A) Increases by 59 mV   (B) Decrease by 59 mV

(C) Increases by 29.5 mV   (D) Decreases by 29.5 mV

32. How much will the reduction potential of a hydrogen electrode change when its solution initially at pH = 0 is neutralised to pH = 7 ?

(A) increase by 0.059V   (B) decrease by 0.059V

(C) increase by 0.413V   (D) decrease by 0.413V

33. If the pressure of H_2 gas is increased from 1 atm to 100 atm keeping H+ concentration constant at 1 M, the change in reduction potential of hydrogen half-cell at 25°C will be

(A) 0.059 V   (B) 0.59 V   (C) 0.0295 V   (D) 0.118 V

Nernst Equation .Full Reaction

34. Which of the following will increase the voltage of the cell with following cell reaction

$Sn_{(s)} + 2Ag^+_{(aq)} \rightarrow Sn^{+2}_{(aq)} + 2Ag_{(s)}$

(A) Decrease in the concentration of Ag^+ ions

(B) Increase in the concentration of Sn^{+2} ions

(C) Increase in the concentration of Ag^+ ions

(D) (A) & (B) both

35. The emf of the cell

Ti / Ti$^+$ (0.01M) | | Cu^{2+}(0.1M) / Cu is 0.83 V

The emf of this cell will be increased by :

(A) Increase the concentration of Cu^{++} ions   (B) Decreasing the concentration of Ti$^+$

(C) Increasing the concentration of both   (D) (A) & (B) both

36. Consider the cell, Cu|Cu^{+2}||Ag$^+$|Ag. If the concentration of Cu^{2+} and Ag$^+$ ions becomes ten times then emf of the cell :–

(A) Becomes 10 times   (B) Remains same

(C) Increase by 0.0295 V   (D) Decrease by 0.0295 V

37. The emf of the cell in which the following reaction,

Zn(s) + Ni^{2+}$_{(aq)}$ (a = 0.1) $\rightarrow$ Zn^{2+}$_{(aq)}$ (a = 1.0) + Ni(s)

occurs, is found to be 0.5105 V at 298 K. The standard e.m.f. of the cell is :-

(A) –0.5105 V   (B) 0.5400 V   (C) 0.4810 V   (D) 0.5696 V

38. The standard emf for the cell reaction,

$Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$ 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+} solution are used at 25°C is :

(A) 1.10 volt   (B) 0.110 volt   (C) –1.10 volt   (D) –0.110 volt

39. Consider the reaction,

$Cl_{2(g)} + 2Br^-_{(aq)} \longrightarrow 2Cl^-_{(aq)} + Br_{2(g)}$

The emf of the cell when [Cl$^-$]=[Br$^-$]=0.01M and Cl$_2$ gas at 1 atm pressure while Br$_2$(g) at 0.01 atm will be (E° for the above reaction is = 0.29 volt) :

(A) 0.54 volt   (B) 0.35 volt   (C) 0.24 volt   (D) –0.29 volt

Concentration Cell

40. What is the potential of the cell containing two hydrogen electrodes as represented below

$Pt \mid H_2(g) \mid H^+_{(aq)}(10^{-8}\ M) \mid\mid H^+_{(aq)}(0.001\ M) \mid H_2(g) \mid Pt$

(A) – 0.295 V   (B) – 0.0591 V   (C) 0.295 V   (D) 0.0591 V

41. Which represent a concertation cell ?

(A) $Pt \mid H_2 \mid HCl \mid\mid HCl \mid PtH_2$ (B) $Pt \mid H_2 \mid HCl \mid\mid Cl_2 \mid Pt$

(C) $Zn \mid Zn^{2+} \mid\mid Cu^{2+} \mid Cu$ (D) $Fe \mid Fe^{+2} \mid\mid Cu^{2+} \mid Cu$

42. $Zn \mid Zn^{2+}\ (C_1) \mid\mid Zn^{2+}\ (C_2) \mid Zn$. for this cell ΔG is negative if -

(A) $C_1 = C_2$ (B) $C_1 > C_2$ (C) $C_2 > C_1$ (D) None

Metal Sparingly Soluble Salt

Metal, Metal Insoluble Salt- Ion Electrode

**43.** The chemical reaction

$2AgCl(s) + H_2(g) \longrightarrow 2HCl\ (aq) + 2Ag\ (s)$

taking place in a galvanic cell is represented by the notation

(A) $Pt(s) \mid H_2(g),\ 1\ bar \mid 1\ M\ KCl\ (aq) \mid AgCl(s) \mid Ag\ (s)$

(B) $Pt(s) \mid H_2(g),\ 1\ bar \mid 1\ M\ HCl\ (aq) \mid 1\ M\ Ag^+\ (aq) \mid Ag\ (s)$

(C) $Pt(s) \mid H_2(g),\ 1\ bar \mid 1\ M\ HCl\ (aq) \mid AgCl\ (s) \mid Ag\ (s)$

(D) $Pt(s) \mid H_2(g),\ 1\ bar \mid 1\ M\ HCl\ (aq) \mid Ag\ (s) \mid AgCl\ (s)$

44. A silver wire dipped in 0.1 M HCl solution saturated with AgCl develops oxidation potential of – 0.209 V. If $E^0_{Ag/Ag^+} = -\ 0.799$ V, the K_{sp} of AgCl in pure water will be

(A) 3×10^{-11} (B) 10^{-11} (C) 4×10 (D) 3×10^{-11}

45. The solubility product of silver iodide is 8.3×10^{-17} and the standard reduction potential of Ag, Ag^+ electrode is + 0.8 volts at 25° C. The standard reduction potential of $Ag, AgI/I^-$ electrode from these data is

(A) – 0.30 V   (B) + 0.15 V   (C) + 0.10 V   (D) – 0.15 V

Metal Sparingly Soluble Salt

THERMODYNAMIC FUNCTIONS OF CELL

46. $\Delta G = \Delta H - T\Delta S$ and $\Delta G = \Delta H + T\left[\dfrac{d(\Delta G)}{dT}\right]_p$ then $\left(\dfrac{dE_{cell}}{dT}\right)$ is :

(A) $\dfrac{\Delta S}{nF}$ (B) $\dfrac{nE}{\Delta S}$ (C) $-\ nFF_{cell}$ (D) $+\ nEF_{cell}$

47. The maximum efficiency of cell is given by-

(A) $\dfrac{\Delta H}{\Delta G}$ (B) $\dfrac{nFE_{cell}}{\Delta G}$ (C) $-\ \dfrac{nFE_{cell}}{\Delta H}$ (D) Zero

48. The efficiency of a hypothetical cell is about 84% which involves the following reaction :

$A (s) + B^{2+} (aq) \longrightarrow A^{2+} (aq) + B (s) : \Delta H = -285$ kJ
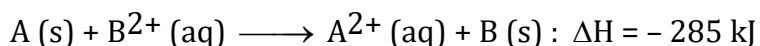
Then, the standard electrode potential of the cell will be (Assume as $\Delta S = 0$)

(A) 1.20   (B) 2.40 V   (C) 1.10 V   (D) 1.24 V

49. The temperature coefficient, of the emf i.e. $\dfrac{dE}{dT} = -0.00065$ volt. deg^{-1} for the cell Cd | CdCl$_2$

(1M) || AgCl (s) | Ag at 25°C. Calculate the entropy changes ΔS_{298K} for the cell reaction, Cd +

$2AgCl \rightarrow Cd^{++} + 2Cl^{-} + 2Ag$

(A) – 105.5 JK^{-1} (B) – 150.2 JK^{-1} (C) – 75.7 JK^{-1} (D) – 125.5 JK^{-1}

Salt Bridge

50. KCl can be used in salt bridge if electrolyte of a galvanic cell contains:

(A) Ag$^+$- ions   (B) Pb^{2+}- ions   (C) Hg$_2^{2+}$ -ions   (D) Au^{3+}- ions

51. 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

Electrolytic Cell Calculations

52. When an electric current is passed through a cell containing an electrolyte, positive ions move towards the cathode and negative ions towards the anode. What will happen if the cathode is pulled out of the solution?

(A) The positive ions will start moving towards the anode and negative ions will stop moving.

(B) The negative ions will continue to move towards the anode and the positive ions will stop moving

(C) Both positive and negative ions will move towards the anode.

(D) None of these movements will take place.

53. When one coulomb of electricity is passed through an electrolytic solution the mass deposited on the electrode is equal to :

(A) equivalent weight   (B) molecular weight

(C) electrochemical equivalent   (D) one gram

54. When the same electric current is passed through the solution of different electrolytes in series the amounts of elements deposited on the electrodes are in the ratio of their:

(A) atomic number   (B) atomic masses   (C) specific gravities   (D) equivalent masses

55. The electric charge for electro deposition of 1 equivalent of a substance is :

(A) one ampere for one second   (B) 1 coulomb

(C) one ampere for one hour   (D) charge on one mole of electrons

56. Electro chemical equivalent of a substance is 0.0006; its equivalent weight is :

(A) 57.9   (B) 28.95   (C) 115.8   (D) cannot be calculated

57. A current of 9.65 amp. flowing for 10 minutes deposits 3.0 g of a metal. The equivalent wt. of the metal is :

(A) 10   (B) 30   (C) 50   (D) 96.5

58. The amount of electricity that can deposit 108 g. of silver from silver nitrate solution is:

(A) 1 ampere   (B) 1 coulomb   (C) 1 Faraday   (D) 2 ampere

59. W g of copper deposited in a copper voltameter when an electric current of 2 ampere is passed for 2 hours. If one ampere of electric current is passed for 4 hours in the same voltameter, copper deposited will be :

(A) W   (B) W/2   (C) W/4   (D) 2W

60. A current of 9.65 amp. passing for 16 min. 40 sec. through a molten tin salt deposits 5.95 gm of Tin. The oxidation state of the tin in the salt is : (at. wt of Sn = 119)

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

61. One mole of electron passes through each of the solution of $AgNO_3$, $CuSO_4$ and $AlCl_3$ when Ag, Cu and Al are deposited at cathode. The molar ratio of Ag, Cu and Al deposited are

(A) 1 : 1 : 1   (B) 6 : 3 : 2   (C) 6 : 3 : 1   (D) 1 : 3 : 6

62. The ratio of weights of hydrogen and magnesium deposited by the same amount of electricity from aqueous H_2SO_4 and fused $MgSO_4$ are :

(A) 1 : 8   (B) 1 : 12   (C) 1 : 16   (D) None of these

63. The same amount of electricity was passed through two separate electrolytic cells containing solutions of nickel nitrate $[Ni(NO_3)_2]$ and chromium nitrate $[Cr(NO_3)_3]$ respectively. If 0.3 g of nickel was deposited in the first cell, the amount of chromium deposited is :

(at. wt. of Ni = 59, at. wt. of Cr = 52)

(A) 0.1 g   (B) 0.17 g   (C) 0.3 g   (D) 0.6 g

64. When an electric current is passed through acid diluted water, 112 ml. of hydrogen gas at 1 atm and 273 K collects at the cathode in 965 second. The current passed, in ampere is :

(A) 1.0   (B) 0.5   (C) 0.1   (D) 2.0

65. How many coulombs of electric charge are required for the oxidation of 1 mole of H_2O to O_2 ?

(A) 9.65×10^4 C   (B) 4.825×10^5 C   (C) 1.93×10^5 C   (D) 1.93×10^4 C

66. An electric current is passed through silver voltameter connected to a water voltameter in series. The cathode of the silver voltameter weighed 0.108g more at the end of the electrolysis. The volume of oxygen evolved at STP is :

(A) 56cm³   (B) 550 cm³   (C) 5.675 cm³   (D) 11.2 cm³

67. The charge required for the oxidation of one mole Mn_3O_4 into MnO_4^{2-} in presence of alkaline medium is

(A) 5×96500 C   (B) 96500 C   (C) 10×96500 C   (D) 2×96500 C

68. The time required to coat a surface of 80 cm² with 5×10^{-3} cm thick layer of silver (density 1.08 g cm⁻³) with the passage of 9.65A current through a silver nitrate solution is :

(A) 10 sec.   (B) 40 sec.   (C) 30 sec.   (D) 20 sec.

Order Of Deposition

69. The products formed when an aqueous solution of NaBr is electrolyzed in a cell having inert electrodes are :

(A) Na and Br_2 (B) Na and O_2 (C) H_2, Br_2 and NaOH   (D) H_2 and O_2

70. Electrolysis of a $CuSO_4$ produces :–

(A) An increase in pH   (B) A decrease in pH

(C) H_2 will produce at anode   (D) H_2 will produce at cathode

71. A solution of sodium sulphate in water is electrolysed using inert electrodes. The products at the cathode and anode are respectively.

(A) H_2, O_2 (B) O_2, H_2 (C) O_2, Na   (D) none

72. When an aqueous solution of lithium chloride is electrolysed using graphite electrodes

(A) Cl_2 is liberated at the anode.

(B) Li is deposited at the cathode

(C) as the current flows, pH of the solution remains constant

(D) as the current flows, pH of the solution decreases.

Cells and batteries

Commercial Cells & Corrosion

73. 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 $CH_4(g)$ (at 1 atm and 273 K) would be required ?(F = 96500). Assume 100% efficiency.

(A) 5   (B) 6   (C) 7   (D) 8

74. When lead storage battery is charged :

(A) lead dioxide dissolves

(B) sulphuric acid is regenerated

(C) the lead electrode becomes coated with lead sulphate

(D) the amount of sulphuric acid in solution decreases

75. 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

Conductance ,Conductivity, Molar Conductance

76. Electrolytic conduction differs from metallic conduction from the fact that in the former

(A) The resistance increases with increasing temperature

(B) The resistance decreases with increasing temperature

(C) The resistance remains constant with increasing temperature

(D) The resistance is independent of the length of the conductor

77. Which of the following solution of KCl has the lowest value of specific conductance :

(A) 1 M   (B) 0.1 M   (C) 0.01 M   (D) 0.001 M

78. Which of the following solutions of KCl has the lowest value of molar conductance ?

(A) 1 M   (B) 0.1 M   (C) .01 M   (D) .001 M

79. The resistance of 0.5 M solution of an electrolyte in a cell was found to be 50 Ω. If the electrodes in the cell are 2.2 cm apart and have an area of 4.4 cm^2 then the molar conductivity (in S m^2 mol^{-1}) of the solution is

(A) 0.2   (B) 0.02   (C) 0.002   (D) None of these

80. If 0.01 M solution of an electrolyte has a resistance of 40 ohms in a cell having a cell constant of 0.4 cm^{-1} then its molar conductance in ohm^{-1} cm^2 mol^{-1} is :

(A) 10   (B) 10^2 (C) 10^3 (D) 10^4

81. The resistance of 0.01 N solution of an electrolyte was found to be 200 ohm at 298 K using a conductivity cell of cell constant 1.5 cm^{-1}. The equivalent conductance of solution is :–

(A) 750 mho cm^2 eq^{-1} (B) 75 mho cm^2 eq^{-1}

(C) 750 mho^{-1} cm^2 eq^{-1} (D) 75 mho^{-1}cm^2 eq^{-1}

82. Equal volumes of 0.015 M CH$_3$COOH & 0.015 M NaOH are mixed together. What would be molar conductivity of mixture if conductivity of CH$_3$COONa is 6.3 ×10^{-4} S cm^{-1}

(A) 8.4 S cm^2 mol^{-1} (B) 84 S cm^2 mol^{-1} (C) 4.2 S cm^2 mol^{-1} (D) 42 S cm^2 mol^{-1}

Kohlrausch Law, Kohlrausch And Alpha

83. The molar conductance at infinite dilution of AgNO$_3$, AgCl and NaCl are 115, 120 and 110 respectively. The molar conductance of NaNO$_3$ is :–

(A) 110   (B) 105   (C) 130   (D) 150

84. Equivalent conductance of Ba^{+2} and Cl$^-$ ions are 127 & 76 ohm^{-1} cm2 eq^{-1} respectively. Equivalent conductance of BaCl$_2$ at infinite dilution is -

(A) 139.5   (B) 101.5   (C) 203   (D) 279

85. The equivalent conductivity of 0.1 N CH$_3$COOH at 25 °C is 80 and at infinite dilution 400. The degree of dissociation of CH$_3$COOH is :

(A) 1   (B) 0.2   (C) 0.1   (D) 0.5

86. Equivalent conductance of 0.1 M HA(weak acid) solution is 10 Scm^{2}equivalent^{-1} and that at infinite dilution is 200 S cm^2 eq^{-1} Hence pH of HA solution is

   (A) 1.3   (B) 1.7   (C) 2.3   (D) 3.7

87. The dissociation constant of n-butyric acid is 1.6×10^{-5} M and the molar conductivity at infinite dilution is 380×10^{-4} S m^2 mol^{-1}. The specific conductance of the 0.01 M acid solution is

   (A) 1.52×10^{-5} S m^{-1} (B) 1.52×10^{-2} S m^{-1}

   (C) 1.52×10^{-3} S m^{-1} (D) None

K_{sp} And Kohlrausch

88. The conductivity of a saturated solution of $BaSO_4$ is 3.06×10^{-6} ohm^{-1} cm^{-1} and its molar conductance is 1.53 ohm^{-1} cm^2 mol^{-1}. The K_{sp} of $BaSO_4$ will be :

   (A) 4×10^{-12} (B) 2.5×10^{-9} (C) 2.5×10^{-13} (D) 4×10^{-6}

89. The conductivity of a saturated solution of Ag_3PO_4 is 9×10^{-6} S m^{-1} and its equivalent conductivity is 1.50×10^{-4} S m^2 equivalent^{-1}. The K_{sp} of Ag_3PO_4 is

   (A) 4.32×10^{-18} (B) 1.8×10^{-9} (C) 8.64×10^{-13} (D) None of these

EXERCISE # S-I

Electrode Potential, Galvanic Cell

Galvanic Cell, Its Representation & Salt Bridge

1. In the galvanic cell $Cu \mid Cu^{2+} \parallel Ag^+ \mid Ag$, 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 ?

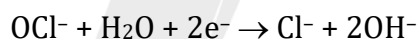   (k) What is the function of salt bridge represented by the symbol $\parallel$?

$$E_1 + E_2 = E_3$$

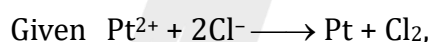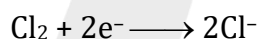### STANDARD CELL POTINTIAL AND ELECTROCHEMICAL SERIES

2. What is E°_{Cell} if :

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

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

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

3. Determine the standard reduction potential for the half reaction :

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

    Given $Pt^{2+} + 2Cl^- \longrightarrow Pt + Cl_2,$ $E^{\circ}_{Cell} = -\,0.15\ V$

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

ΔG And Electrode Potential

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

5. If for the half cell reactions $Cu^{2+} + e^- \longrightarrow Cu^+$ $E^{\circ} = 0.15\ V$
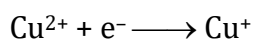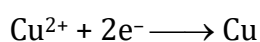
                                        $Cu^{2+} + 2e^- \longrightarrow Cu$ $E^{\circ} = 0.34\ V$

    Calculate E° of the half-cell reaction
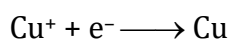
    $$Cu^+ + e^- \longrightarrow Cu$$

6. Consider the standard reduction potentials (in volts) as shown in figure. Find E°.

    $$SO_4^{2-} \xrightarrow{-0.936} SO_3^{2-} \xrightarrow{-0.576} \frac{1}{2}S_2O_3^{2-}$$
    $$\underset{E^{\circ} = ?}{\underline{\hspace{6cm}}}\Big\uparrow$$
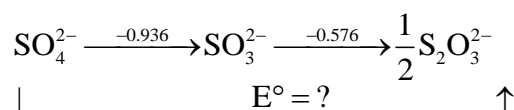
7. If for the half cell reactions

$$Cu^{2+} + e^- \longrightarrow Cu^+ \qquad E° = 0.15 \text{ V}$$

$$Cu^+ + e^- \longrightarrow Cu \qquad E° = 0.53 \text{ V}$$

predict whether Cu^+ undergoes disproportionation or not.

8. The standard oxidation potentials for Mn^{2+} ion acid solution are

$$Mn^{2+} \xrightarrow{\ -1.5\,V\ } Mn^{3+} \xrightarrow{\ -1.0\,V\ } MnO_2 .$$

Is the reaction

$$2\,Mn^{3+} + 2\,H_2O \longrightarrow Mn^{2+} + MnO_2 + 4H^+$$
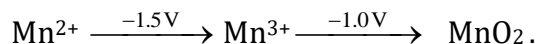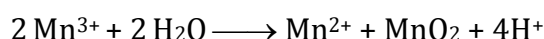
spontaneous under conditions of unit activity ? What is the change in free energy ?

Electrode Potential And Equilibrium Constant

9. Calculate the equilibrium constant for the reaction

$Fe^{2+} + Ce^{4+} \rightleftharpoons Fe^{3+} + Ce^{3+}$,

[given : $E^0{}_{Ce4+ / Ce3+}$ = 1.44V; $E^0{}_{Fe3+/Fe2+}$ = 0.68V]

10. For a cell $Mg(s) \mid Mg^{2+}(aq) \parallel Ag^+ (aq) \mid Ag$,

(i) Calculate the equilibrium constant at 25°C.

(ii) Also find the maximum work per mole Mg that can be obtained by operating the cell.

$E^0 (Mg^{2+}/Mg)$ = –2.37V, $E^0 (Ag^+/Ag)$ = 0.8 V.

11. 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

approximate value of $\log \dfrac{[Zn^{2+}]}{[Cu^{2+}]}$ at equilibrium?

12. The standard reduction potential at 25°C for the reduction of water

$$2H_2O + 2e^- \rightleftharpoons H_2 + 2OH^- \text{ is -0.84 volt.}$$

Calculate the equilibrium constant for the reaction

$$H_2O \rightleftharpoons H^+ + OH^- \text{ at 25°C.}$$

(Take $\dfrac{2.303RT}{F} = 0.06$)

13. Calculate the equilibrium constant for the reaction:

$3Sn(s) + 2Cr_2O_7{}^{2-} + 28H^+ \longrightarrow 3Sn^{4+} + 4Cr^{3+} + 14H_2O$

E^0 for Sn/Sn^{2+} =0.136 V

E^0 for Sn^{2+}/Sn^{4+} = – 0.154 V

E^0 for $Cr_2O_7{}^{2-}/Cr^{3+}$ = 1.33 V

14. For the reaction,

$4Al(s) + 3O_2(g) + 6H_2O + 4\,OH^- \rightleftharpoons 4\,[Al(OH)_4{}^-]$; $E°_{cell}$ = 2.73 V.

If $\Delta G°_f (OH^-)$ = –157 kJ mol^{-1} and $\Delta G°_f (H_2O)$ = –237.2 kJ mol^{-1},

Determine $\Delta G°_f [Al (OH)_4{}^-]$.

Application Of Electrode Potential, Reduction And Oxidation Power

15. 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 ?

16. 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 :

17. The value of E^o for electrode reactions,

$Fe \longrightarrow Fe^{2+} + 2e^- \quad E^o = 0.44$ volt

$Cu \longrightarrow Cu^{2+} + 2e^- \quad E^o = -0.33$ volt

$Zn \longrightarrow Zn^{2+} + 2e^- \quad E^o = 0.76$ volt

State which of these metals can replace the other two from the solution of their salts ?

18. Is 1.0 M H^+ solution under H_2SO_4 at 1.0 atm capable of oxidising silver metal in the presence of 1.0 M Ag^+ ion?

$$E^o_{Ag^+|Ag} = 0.80 \text{ V}, \qquad\qquad E^o_{H^+|H_2(Pt)} = 0.0 \text{ V}$$

Cell Representation, Types Of Half Cell

19. Write cell reaction of the following cells :

(a) Ag | Ag$^+$ (aq) || Cu^{2+} (aq) | Cu   (b) Pt | Fe^{2+} , Fe^{3+} || MnO$^-_4$, Mn^{2+}, H$^+$ | Pt

(c) Pt,Cl$_2$ | Cl$^-$ (aq) || Ag$^+$ (aq) | Ag   (d) Pt, H$_2$ | H$^+$ (aq) || Cd^{2+} (aq) | Cd

20. Write cell representation for following cells.

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

(b) 2Ag$^+$ (aq) + H$_2$ (g) $\longrightarrow$ 2H$^+$ (aq) + 2Ag (s)

(c) Cr$_2$O$^{2-}_7$ (a) + 14H$^+$ (aq) + 6Fe^{2+} (aq) $\longrightarrow$ 6Fe^{3+} (aq) + 2Cr^{3+} (aq) + 7H$_2$O (λ)

NERNST EQUATION

Nernst equation, Half reaction

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

22. At what concentration of Cu^{2+} in a solution of CuSO$_4$ will the electrode potential be zero at 25°C? Given : E^0 (Cu | Cu^{2+}) = –0.34 V.

23. A zinc electrode is placed in a 0.1M solution at 25°C. Assuming that the salt is 20% dissociated at this dilution calculate the electrode reduction potential. E^0 (Zn^{2+}| Zn) = -0.76V.

24. 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 × 10^{-19}).

Nernst equation. Full reaction

25. Calculate the EMF of a Daniel cell when the concentration of $ZnSO_4$ and $CuSO_4$ are 0.001 M and 0.1M respectively. The standard potential of the cell is 1.1V.

26. Calculate E^0 and E for the cell $Sn \mid Sn^{2+}$ (1M) $\parallel Pb^{2+}(10^{-3}M) \mid Pb$,

E^0 ($Sn^{2+}\mid$ Sn) = -0.14V, E^0 ($Pb^{2+}\mid$ Pb) = -0.13V. Is cell representation is correct?

27. Consider the following electrochemical cell :
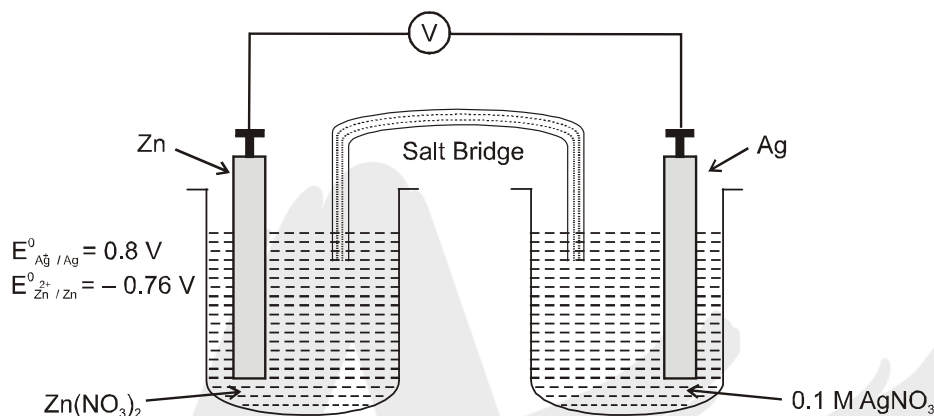
(a) Write a balanced net ionic equation for the spontaneous reaction that take place in the cell.

(b) Calculate the standard cell potential E° 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 ?

Concentration Cell

28. Calculate the EMF of the following cell

$Zn \mid Zn^{2+}$ (0.01M) $\parallel Zn^{2+}$ (0.1 M) $\mid$ Zn

at 298 K.

29. Calculate pH using the following cell :

Pt (H_2) $\mid H^+$ (x M) $\parallel H^+$ (1 M) $\mid Pt$ (H_2)   if E_{cell} = 0.2364 V.

1 atm   1 atm

30. Equinormal Solutions of two weak acids, HA (pK_a = 3) and HB (pK_a = 5) are each placed in contact with equal pressure of hydrogen electrode at 25°C to form two hydrogen half-cell. Find the emf of a cell constructed by interconnecting them.

31. In two vessels each containing 500ml water, 0.5 mmol of aniline (K_b= 10^{-9}) and 50 mmol of HCl are added separately. Two hydrogen electrodes are constructed using these solutions. Calculate the emf of cell made by connecting them appropriately.

Metal Sparingly Soluble Salt

Metal- Metal Insoluble Salt- Ion Electrode

32. Write cell reaction from given cell diagrams :

(A) $Cu \,|\, Cu^{2+} \,||\, Cl^- \,|\, Hg_2Cl_2 \,|\, Hg \,|\, Pt$

(B) $Ag\,(s) \,|\, AgIO_3\,(s)|Ag^+, HIO_3 \,||\, Zn^{2+} \,|\, Zn\,(s)$

(C) $Mn\,(s) \,|\, Mn\,(OH)_2\,(s)\, Mn^{2+}, OH^- \,||\, Cu^{2+}|Cu\,(s)$
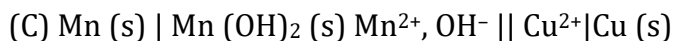
33. For the galvanic cell : $Ag \,|\, AgBr(s)| KBr\,(0.001M) \,||\, KCl\,(0.2M)|AgCl(s)\,|Ag$,

Calculate the EMF generated? (Take $\dfrac{2.303RT}{F} = 0.06$)

$[K_{sp(AgCl)} = 10^{-10} ; K_{sp(AgBr)} = 10^{-13}]$ $[\log 5 = 0.7]$

34. The emf of the cell $Ag \,|\, AgI(s) \,|\, KI(0.05M) \,||\, AgNO_3(0.05M) \,|Ag$ is 0.788V. Calculate the solubility product of AgI.

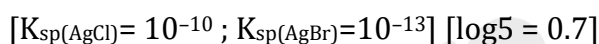**35.** Consider the cell $Ag \,|\, AgBr(s) \,|\, Br^- \,||\, Cl^- \,|\, AgCl(s) \,|\, Ag$ at 25º C . The solubility product constants of AgBr & AgCl are respectively 5×10^{-13} & 1×10^{-10} . For what ratio of the concentrations of Br^- & Cl^- ions would the emf of the cell be zero ?

36. Given, $E° = -0.27$ V for the $Cl^- \,|\, PbCl_2\,|Pb$ couple and -0.12 V for the $Pb^{2+} \,|\, Pb$ couple, determine K_{sp} for $PbCl_2$ at 25°C ? (Take $\dfrac{2.303RT}{F} = 0.06$)

37. The pK_{sp} of AgI is 16. if the E° value for $Ag+ \,|\, Ag$ is 0.8 V. Find the E° for the half cell reaction $AgI(s) + e^- \rightarrow Ag + I^-$? (Take $\dfrac{2.303RT}{F} = 0.06$)
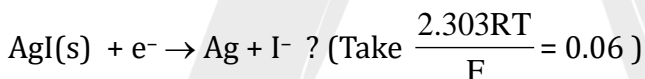
Electrolytic Cell Calculations

38. Calculate the no. of electrons lost or gained during electrolysis of

(a) 3.55 gm of Cl^- ions   (b) 64 gm Cu^{2+} ions   (c) 2.7 gm of Al^{3+} ions

($N_A = 6 \times 10^{23}$)
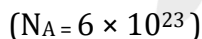
39. How many faradays of electricity are required to convert

(a) 0.25 mole Al^{3+} to Al.

(b) 27.6 gm of SO_3 to SO^{2-}_3

(c) Cu^{2+} in 1100 ml of 0.5 M Cu^{2+} to Cu.
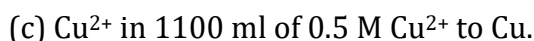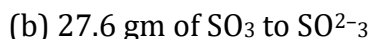
40. 0.5 mole of electron is passed through two electrolytic cells in series. One contains silver ions, and the other zinc ions. Assume that only cathode reaction in each cell is the reduction of the ion to the metal. How many gm of each metal will be deposited.

41. 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)

42. If 0.224 litre of H_2 gas is formed at the cathode, how much O_2 gas is formed at the anode under identical conditions?

43. Assume 96500 C as one unit of electricity. If cost of electricity of producing x gm Al is Rs x, what is the cost of electricity of producing x gm Mg?

44. Chromium metal can be plated out from an acidic solution containing CrO_3 according to following equation:

$$CrO_3(aq) + 6H^+ (aq) + 6e^- \rightarrow Cr(s) + 3H_2O$$

Calculate :

(i) How many grams of chromium will be plated out by 24125 coulombs and

(ii) How long will it take to plate out 1.5 gm of chromium by using 12.5 ampere current

45. A current of 3 amp was passed for 2 hours through a solution of $CuSO_4$. 3 g of Cu^{2+} ions were deposited as Cu at cathode. Calculate percentage current efficiency of the process.

46. The electrosynthesis of MnO_2 is carried out from a solution of $MnSO_4$ in H_2SO_4 (aq). If a current of 25.5 ampere is used with a current efficiency of 85%, how long would it take to produce 1 kg of MnO_2?

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

Order Of Deposition

48.

	ELECTROLYTE	Product at ANODE	Product at CATHODE
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		

49. A constant current of 30 A is passed through an aqueous solution of NaCl for a time of 1.0 hr. How many moles of NaOH are produced? What is volume of Cl_2 gas at 1atm, 273K produced (in litre) ?

50. After electrolysis of 600 ml NaCl solution with inert electrodes for a certain period of time, was found to be 1N in NaOH. During the same time, 31.75 g of Cu was deposited in the copper voltameter in series with the electrolytic cell. Calculate the percentage yield of NaOH obtained considering 100% yield in copper voltameter.

51. A solution of $Ni(NO_3)_2$ is electrolysed between platinum electrodes using a current of 5 ampere for 20 minutes. What mass of Ni is deposited at the cathode?

52. 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?

Molar Conductance

53. When a solution of specific conductance 1.342 ohm^{-1} m^{-1} was placed in a conductivity cell with parallel electrodes, the resistance was found to be 170.5 ohm. Area of electrodes is 1.86×10^{-4} m^2. Calculate separation of electrodes.

54. The resistance of a conductivity cell filled with 0.01M solution of NaCl is 200 ohm at 18°C. Calculate the molar conductivity of the solution. The cell constant of the conductivity cell is 0.88 cm^{-1}.

55. A solution containing 2.08 g of anhydrous barium chloride is 500 CC of water has a specific conductance 0.005 ohm^{-1}cm^{-1}. What are molar and equivalent conductivities of this solution.

56. For 0.01N KCl, the resistivity 800 ohm cm. Calculate the conductivity and equivalent conductance.

57. The molar conductivity of 0.1 M CH$_3$COOH solution is 4 Scm^{2}mole^{-1}. What is the conductivity and resistivity of the solution ?

58. The conductivity of pure water in a conductivity cell with electrodes of cross sectional area 4 cm^2 and 2 cm apart is 8×10^{-7} S cm^{-1}.
(i) What is resistance of conductivity cell ?
(ii) What current would flow through the cell under an applied potential difference of 1 volt?

Kohlrausch Law, Kohlrausch and Alpha

59. For the strong electrolytes NaOH, NaCl and BaCl$_2$ the molar ionic conductivities at infinite dilution are 240×10^{-4}, 125×10^{-4} and 280.0×10^{-4} mho cm^2 mol^{-1} respectively. Calculate the molar conductivity of Ba(OH)$_2$ at infinite dilution.

60. The value of $\Lambda^{\infty}{}_m$ for HCl, NaCl and CH$_3$CO$_2$Na are 425, 125 and 100 S cm^2 mol^{-1} respectively. Calculate the value of $\Lambda^{\infty}{}_m$ for acetic acid. If the molar conductivity of a given acetic acid solution is 48 S cm^2 mol^{-1} at 25° C, calculate its degree of dissociation.

61. Equivalent conductance of 0.01 N Na$_2$SO$_4$ solution is 120 ohm^{-1} cm^2 eq^{-1}. The equivalent conductance at infinite dilution is 150 ohm^{-1}cm^{2}eq^{-1}. What is the degree of dissociation in 0.01 N Na$_2$SO$_4$ solution?

62. Hydrofluoric acid is weak acid. At 25°C, the molar conductivity of 0.002M HF is 200 ohm^{-1} cm^2 mole^{-1}. If its $\Lambda^{\infty}{}_m = 400$ ohm^{-1} cm^2 mole^{-1}, calculate its degree of dissociation and equilibrium constant at the given concentration.

Ksp and Kohlrausch

63. Saturated solution of AgCl at 25°C has specific conductance of 1.12×10^{-6} ohm^{-1} cm^{-1}. The λ_{∞} Ag$^+$ and λ_{∞}Cl$^-$ are 54 and 58 ohm^{-1} cm^2 eq^{-1}. respectively. Calculate the solubility product of AgCl at 25°C.

64. Specific conductance of a saturated solution of AgBr is 8.75×10^{-7} ohm^{-1}cm^{-1} at 25°C. Specific conductance of pure water at 25°C is 0.75×10^{-7} ohm^{-1} cm^{-2}. Λ^{∞}_m for KBr , AgNO$_3$ and KNO$_3$ are 140 , 130 , 110 (S cm^2 mol^{-1}) respectively. Calculate the solubility of AgBr in gm/litre.

65. At 25°C, λ_{∞}(H$^+$) = 3.5×10^{-2} S m^2 mol^{-1} and λ_{∞}(OH$^-$) = 2×10^{-2} S m^{2}mol^{-1}.
Given: Sp. conductance = 5.5×10^{-6} S m^{-1} for H$_2$O, determine pH and K$_w$.

EXERCISE # (O-II)

Single correct

1. The standard emf of the cell, $Cd(s) \mid CdCl_2(aq) (0.1\ M) \mid\mid AgCl(s) \mid Ag(s)$ in which the cell reaction is,

$Cd(s) + 2AgCl(s) \longrightarrow 2Ag(s) + Cd^{+2}(aq) + 2Cl^-(aq)$ is 0.6915 V at 0°C and 0.6753 V at 25°C. The ΔH° of the reaction at 25°C is :

(A) – 176 kJ   (B) – 234.7 kJ   (C) + 123.5 kJ   (D) – 167.6 kJ

2.
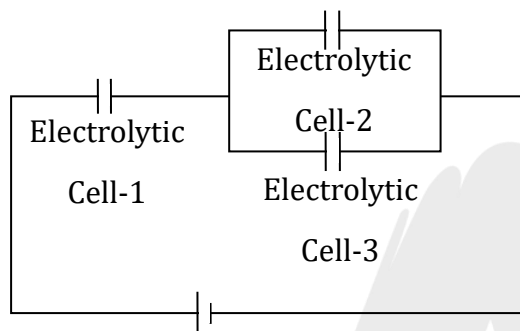
	Content	Resistance	Volume of gas produced (at same T & P)
Cell-1	$CuSO_4$ (aq)	10 Ω	at anode is V_1
Cell-2	NaCl (aq)	2 Ω	at anode is V_2
Cell-3	$ZnSO_4$ (aq)	6 Ω	at cathode is V_3

The ratio $V_1 : V_2 : V_3$ is

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

3. For saturated solution of CaF_2, choose the correct relationship-

(A) $\Lambda^\infty_{m_{CaF_2}} = \lambda^\infty_{eq_{Ca^{2+}}} + 2\lambda^\infty_{eq_{F^\ominus}}$

(B) $\Lambda^\infty_{m_{CaF_2}} = 2\left(\lambda^\infty_{eq_{Ca^{2+}}} + \lambda^\infty_{eq_{F^\ominus}}\right)$

(C) $\Lambda^\infty_{m_{CaF_2}} = 2\left(\lambda^\infty_{eq_{Ca^{2+}}} + \lambda^\infty_{eq_{F^\ominus}}\right)$

(D) $\Lambda^\infty_{m_{CaF_2}} = \frac{1}{2}\left(\lambda^\infty_{eq_{Ca^{2+}}} + \lambda^\infty_{eq_{F^\ominus}}\right)$

4. Which of the following is the most appropriate graph for conductometric titration when $AgNO_3$(aq.) solution is titrated against KCl (aq.) solution. (Assuming that these ions do not differ much in ionic conductance)
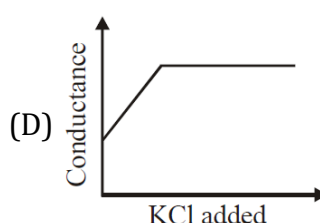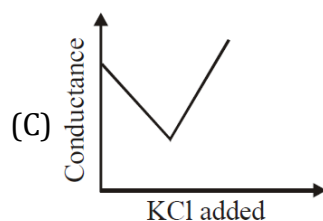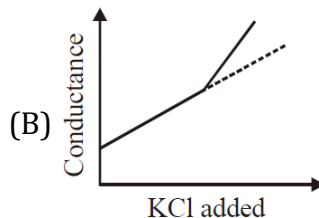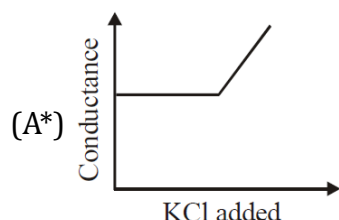
Multiple correct:

5. The value of E° for elements are as follows :

$Fe^{+2} + 2e^- \longrightarrow Fe$; $E^o = -0.44$ V

$Fe^{+3} + 1e^- \longrightarrow Fe^{+2}$; $E^o = +0.77$ V

$Sn^{+4} + 2e^- \longrightarrow Sn^{+2}$; $E^o = +0.13$ V

$I_2 + 2e^- \longrightarrow 2I^-$; $E^o = +0.54$ V

$Cr^{3+} + 3e^- \longrightarrow Cr$; $E^o = -0.74$V
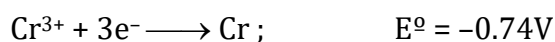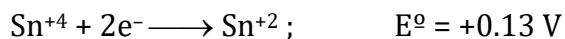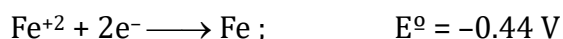
Based on the above data correct statements are -

(A) Strongest reducing agent is Cr^{3+} (B) Strongest oxidising agent is Fe^{3+}

(C) Sn^{+4} can oxidise I^- (D) Fe^{+3} can oxidise I^-

6. Pick out the correct statements among the following from inspection of standard reduction potentials (Assume standard state conditions).

Cl_2 (a) + 2e $\rightleftharpoons$ $2Cl^-$ (aq) $E^0_{Cl_2/Cl^-}$ = +1.36 volt

Br_2 (a) + 2e $\rightleftharpoons$ $2Br^-$(aq) $E^0_{Br_2/Br}$ = +1.09 volt

I_2(s) + 2e $\rightleftharpoons$ $2I^-$ (aq) $E^0_{I_2/I^-}$ = +0.54 volt

$S_2O_8^{2-}$ (aq) + 2e $\rightleftharpoons$ SO_4^{2-} (aq) $E^0_{S_2O_8^{2-}/SO_4^{2-}}$ = +2.00 volt
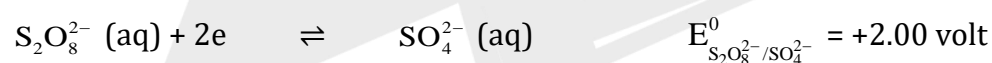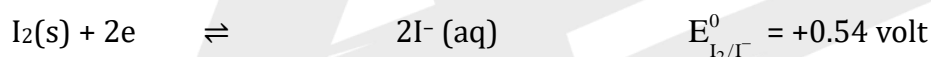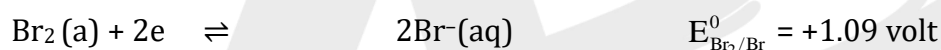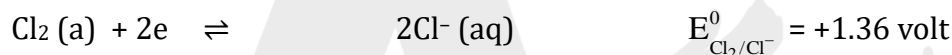
(A) Cl_2 can oxidise SO_4^{2-} from solution

(B) Cl_2 can oxidise Br^- and I^- from aqueous solution

(C) I_2 can oxidise Cl^- and Br^- from aqueous solution

(D) $S_2O_8^{2-}$ can oxidise Cl^-, Br^- and I^- from aqueous solution

7. Using the standard electrode potential values given below, decide which of the statements, I, II, III and IV are correct. Choose the right answer from (A), (B), (C) and (D).

$Fe^{2+}_{(aq)} + 2e^- \rightarrow Fe_{(s)}$; $E^° = -0.44$ V

$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$; $E^° = +0.34$ V

$Ag^+_{(aq)} + e^- \rightarrow Ag_{(s)}$; $E^° = +0.80$ V
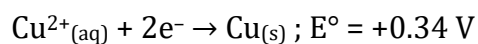
I. Copper can displace iron from $FeSO_4$ solution.

II. Iron can displace copper from $CuSO_4$ solution.

III. Silver can displace copper 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

8. The EMF of the following cell is 0.22 volt.

Ag(s) | AgCl(s) | KCl (1M) | H$^+$(1M) | H$_2$(g) (1atm) ; Pt(s).

Which of the following will decrease the EMF of cell.

(A) increasing pressure of H$_2$(g) from 1 atm to 2 atm

(B) increasing Cl$^-$ concentration in Anodic compartment

(C) increasing H$^+$ concentration in cathodic compartment

(D) decreasing KCl concentration in Anodic compartment.

9. Select correct statements for the cell

Ag | AgCl | HCl || AgNO$_3$ | Ag ; (ΔS)$_{reaction}$ = − ve

(A) $E^\circ_{Cell} > 0$

(B) $\Delta G^\circ < 0$

(C) E$_{cell}$ decrease by increasing temperature

(D) E$_{cell}$ decrease by diluting anodic solution

10. Which of the following arrangement will produce oxygen at anode during electrolysis ?

(A) Dilute H$_2$SO$_4$ solution with Cu electrodes.

(B) Dilute H$_2$SO$_4$ solution with inert electrodes.

(C) Fused NaOH with inert electrodes.

(D) Dilute NaCl solution with inert electrodes.

11. If 270.0 g of water is electrolysed during an experiment performed by miss Abhilasha with 75% current efficiency then

(A) 168 L of O$_2$ (g) will be evolved at anode at 1 atm & 273 K

(B) Total 504 L gases will be produced at 1 atm & 273 K.

(C) 336 L of H$_2$ (g) will be evolved at anode at 1 atm & 273 K

(D) 45 F electricity will be consumed

12. During discharging of lead storage battery, which of the following is/are true ?

(A) H$_2$SO$_4$ is produced   (B) H$_2$O is consumed

(C) PbSO$_4$ is formed at both electrodes   (D) Density of electrolytic solution decreases

13. Select the INCORRECT options (s) for electrolytic solution -

(A) Molar conductivity and equivalent conductivity both increases on increasing dilution for strong electrolyte as well as weak electrolyte solution

(B) Conductance and conductivity both increases on increasing dilution for strong electrolyte as well as weak electrolyte solution

(C) On increasing temperature conductivity & conductance increases.

(D) If conductivity of solution decreases then molar conductivity also decreases.

14. Select correct statement at infinite dilution for an electrolyte -

    (A) Λ_m is maximum

    (B) Resistance is zero

    (C) Λ_m° is constant for any temperature

    (D) No interaction remain among the ions

Paragraph for question nos. 6 to 8

A half cell is prepared by $K_2Cr_2O_7$ in a buffer solution of pH =1. Concentration of $K_2Cr_2O_7$ is 1 M.

To 3 litre of this solution 570 gm of $SnCl_2$ is added which is oxidised completely to $SnCl_4$.

Given : $E^{\circ}_{Cr_2O_7^{-2}/Cr^{+3},H^+} = 1.33\,V$; $\dfrac{2.303}{F}RT = 0.06$;

Atomic of mass Sn = 119 ; $E^{\circ}_{Sn^{+4}/Sn^{+2}} = 0.15$

15. Number of moles of Cr^{+3} formed are

    (A) 2   (B) 6   (C) 4   (D) 3

16. Half cell potential $E_{Cr_2O_7^{-2}/Cr^{+3}}$ after the reaction of $SnCl_2$ is

    (A) 1.187   (B) 1.191   (C) 1.285   (D) None of these

17. Emf of the cell $\,Pt\,|\,Sn^{+2},\ Sn^{+4}\ ,H^+\,||\,Cr_2O_7^{2-},\ Cr^{+3},\ H^+\,|\,Pt$
    $\qquad\qquad\quad\ \ _{(0.1M)\ (0.2\,M)\quad (1M)\,,\quad\ (0.2M)\quad (1M)\quad (1M)}$

    (A) –1.18 V   (B) 1.164 V   (C) 1.18 V   (D) None of these

Paragraph for Q.18 & Q.19

The cell Pt (H_2) (1 atm) | H^+(pH = ?) || I^- (a = 1) | AgI(s), Ag(s) | Pt has emf, $E_{298K} = 0$. The

standard electrode potential for the reaction $AgI + e^- \to Ag + I^{\Theta}$ is – 0.151 volt.

18. Calculate the pH value.

    (A) 3.37   (B) 5.26   (C) 2.56   (D) 4.62

19. Calculate the solubility product of AgI in water at 25°C [$E^{\circ}_{(Ag^+,Ag)}$ = + 0.799 volt]

    (A) 1.97×10^{-17} (B) 8.43×10^{-17} (C) 1.79×10^{-17} (D) 9.17×10^{-17}

Paragraph for Question 20 to 22

H_2O_2 can be produced by the Ammonium hydrogen sulphate.

Reactions occurring in electrolytic cell.

$NH_4HSO_4 \longrightarrow NH_4^+ + H^+ + SO_4^{2-}$

$2SO_4^{2-} \longrightarrow S_2O_8^{2-} + 2e^-$ (Anode)

$2H^+ + 2e^- \longrightarrow H_2$ (Cathode)
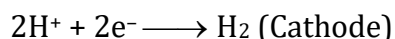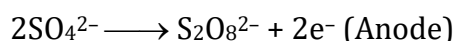
Hydrolysis of Ammonium persulphate

$(NH_4)_2S_2O_8 + 2H_2O \xrightarrow{\ 100\%yield\ } 2NH_4HSO_4 + H_2O_2$
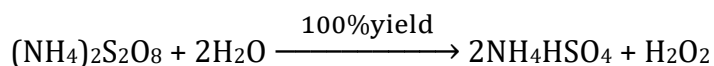
20. What is the current efficiency when 100 Amp current is passed for 965 sec. in order to produce 17 gm of H_2O_2.

(A) 20 %   (B) 40 %   (C) 80 %   (D) 100 %

21. What volume of hydrogen gas at 1 atm & 273 K will be produced at cathode in above question.

(A) 22.4 L   (B) 11.2 L   (C) 5.6 L   (D) 2.8 L

22. How many moles of electrons are to be passed in order to produce enough H_2O_2 which when reacted with excess of KI then liberated iodine required 100 ml of centimolar Hypo solution.

(A) 10^{-1} (B) 10^{-2} (C) 10^{-3} (D) 5×10^{-4}

Paragraph for Q.23 & Q.24

For the titration of a solution of HCl against NaOH solution, hydrogen electrode is dipped into HCl solution. Then this electrode is connected to normal calomel electrode (NCE).

In such experiment 25 ml of HCl (0.1M) is titrated against a standard 0.1 M NaOH solution

$E_{NCE.(reduction)} = 0.24V$; $\dfrac{2.303RT}{F} = 0.06$

23. Select the correct graph for titration

(A)   (B)

(C)   (D)
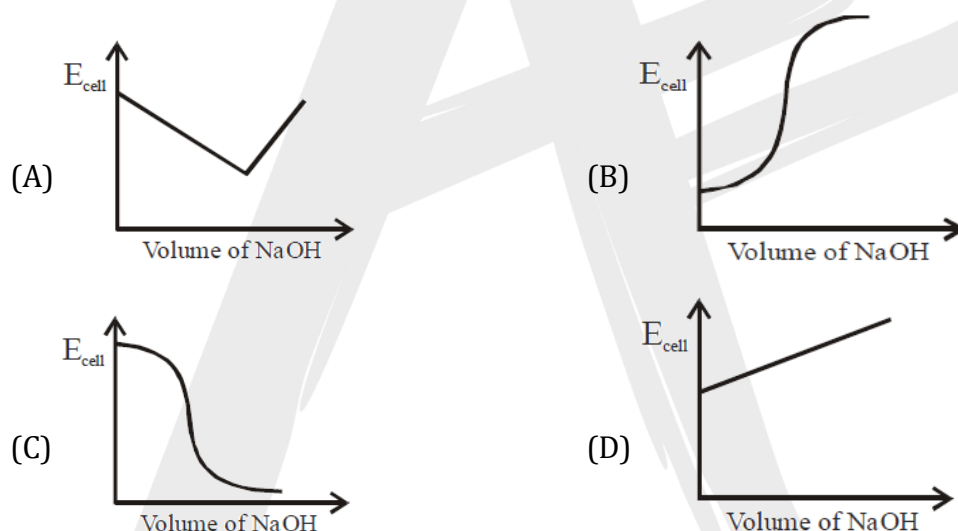
24. E_{cell} after adding 24.95 ml of NaOH

(A) 0.3   (B) 0 V   (C) 0.48 V   (D) 0.64 V

Assertion & Reasoning type questions :

25. Statement –1 : The voltage of mercury cell remains constant for long period of time.

Statement –2 : It is because net cell reaction does not involve active species.

(A) Statement–1 is true, statement–2 is true and statement–2 is correct explanation for statement–1.

(B) Statement–1 is true, statement–2 is true and statement–2 is NOT the correct explanation for statement–1.

(C) Statement–1 is true, statement–2 is false.

(D) Statement–1 is false, statement–2 is true.

26.   Statement–1 : The SRP of three metallic ions A^+, B^{2+}, C^{3+} are –0.3, –0.5, 0.8 volt respectively, so oxidising power of ions is $C^{3+} > A^+ > B^{2+}$.

Statement–2 : Higher the SRP, higher the oxidising power.

(A) Statement–1 is true, statement–2 is true and statement–2 is correct explanation for statement–1.

(B) Statement–1 is true, statement–2 is true and statement–2 is NOT the correct explanation for statement–1.

(C) Statement–1 is true, statement–2 is false.

(D) Statement–1 is false, statement–2 is true.

Match the column:

27.   **Column I**   **Column II**

                                                         (Electrolysis product using inert electrode)

(A)   Dilute solution of HCl   (P) O_2 evolved at anode

(B)   Dilute solution of NaCl   (Q) H_2 evolved at cathode

(C)   Concentrated solution of NaCl   (R) Cl_2 evolved at anode

(D) $AgNO_3$ solution   (S)   Ag deposition at cathode

28.   **List-I**   **List-II**

(P) Conductivity (k) increases   (1) Depends on cell constant as well as concentration

(Q) Molar conductance (λ_m) increases   (2) Independent of concentration as well as cell constant

(R) Conductance (G)   (3) With decreases in concentration but independent of cell constant

(S) Molar conductance λ_m^∞ at infinite   (4) With increase in concentration but independent dilution of cell constant

Code:

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

EXERCISE # (S-II)

1. From the standard potentials shown in the following diagram, calculate the potentials E_1^0 and E_2^0.
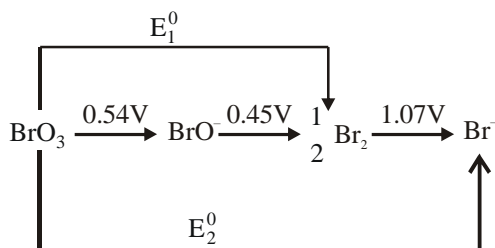
2. The EMF of the cell M | M^{n+} (0.02M) || H^+ (1M) | $H_2(g)$ (1 atm), Pt at 25°C is 0.81V. Calculate the valency of the metal if the standard oxidation of the metal is 0.76V

3. Calculate the EMF of the cell,

Zn – Hg(c_1M) | Zn^{2+} (aq)| Hg – Zn(c_2M)

at 25°C, if the concentrations of the zinc amalgam are: c_1 = 10g per 100g of mercury and c_2 = 1g per100 g of mercury.

4. Calculate the emf of the cell

Pt, H_2(1.0 atm) | CH_3COOH (0.1M) || NH_3(aq, 0.01M) | H_2 (1.0 atm),

Pt $K_a(CH_3COOH)$ = 1.8 × 10^{-5}, K_b (NH_3) = 1.8 × 10^{-5}.

5. The Edison storage cell is represented as Fe(s) | FeO(s) | KOH(aq) | Ni_2O_3 (s) | Ni(s) The half-cell reaction are

$Ni_2O_3(s) + H_2O(i) + 2e^- \rightleftharpoons 2NiO(s) + 2OH-, E^0 = + 0.40V$

$FeO(s) + H_2O(l) + 2e^- \rightleftharpoons Fe(s) + 2OH^-, \qquad E^0 = - 0.87V$

(i) What is the cell reaction?

(ii) What is the cell emf ? How does it depend on the concentration of KOH?

(iii) What is the maximum amount of electrical energy that can be obtained from one mole of Ni_2O_3?

6. For the galvanic cell : Ag | AgCl(s) | KCl (0.2M) || KBr (0.001 M) | AgBr(s) | Ag,

Calculate the EMF generated and assign correct polarity to each electrode for a spontaneous process after taking into account the cell reaction at 25^0C.

[$K_{sp(AgCl)}$ = 2.8 × 10^{-19} ; $K_{sp(AgBr)}$ = 3.3×10^{-13}]

7. Calculate the quantity of electricity that would be required to reduce 12.3 g of nitrobenzene to aniline, if the current efficiency for the process is 50 percent. If the potential drop across the cell is 3.0 volts, how much energy will be consumed?

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

9. 10g solution of $CuSO_4$ is electrolyzed using 0.01F of electricity. Calculate:

   (a)The weight of resulting solution (b)Equivalents of acid or alkali in the solution.

10. Cadmium 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 on a cathode of 2gm Hg (Cd=112.4)

11. One of the methods of preparation of per disulphuric acid, $H_2S_2O_8$, involve electrolytic oxidation of H_2SO_4 at anode ($2H_2SO_4 \rightarrow H_2S_2O_8 + 2H^+ + 2e^-$) with oxygen and hydrogen as by–products. In such an electrolysis, 9.722 L of H_2 and 2.35 L of O_2 were generated at STP. What is the weight of $H_2S_2O_8$ formed?

12. Dal lake has water 8.2×10^{12} litre approximately. A power reactor produces electricity at the rate of 1.5×10^6 coulomb per second at an appropriate voltage. How many years would it take to electrolyse the lake?

13. 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 electrode that are 1.5 cm^2 in surface area and 0.5 cm apart is filled with 0.1 N $MgCl_2$ solution. How much current will flow when potential difference between the electrodes is 5 volt.

14. The specific conductance at 25°C of a saturated solution of $SrSO_4$ is 1.482×10^{-4} ohm^{-1} cm^{-1} while that of water used is 1.5×10^{-6} mho cm^{-1}. Determine at 25°C the solubility in gm per litre of $SrSO_4$ in water. Molar ionic conductance of Sr^{2+} and SO_4^{2-} ions at infinite dilution are 59.46 and 79.8 ohm^{-1} cm^2 $mole^{-1}$ respectively. [Sr = 87.6 , S = 32 , O = 16]

EXERCISE # (JEE-MAINS)

1. The molar conductivity of a conductivity cell filled with 10 mole of 20 mL NaCl solution is Λ_{m1} and that of 20 moles another identical cell having 80 mL NaCl solution is Λ_{m2}, The conductivities exhibited by these two cells are same.

The relationship between Λ_{m2} and Λ_{m1} is

(A) $\Lambda_{m2} = 2\Lambda_{m1}$ (B) $\Lambda_{m2} = \Lambda_{m1}/2$ (C) $\Lambda_{m2} = 2\Lambda_{m1}$ (D) $\Lambda_{m2} = 4\Lambda_{m1}$

[JEE Main, July 2022]

2. The limiting molar conductivities of NaI, $NaNO_3$ and $AgNO_3$ are 12.7, 12.0 and 13.3 mS m^2 mol^{-1}, respectively (all at 25°C). The limiting molar conductivity of AgI at this temperature is ____ mS m^2 mol^{-1}

[JEE Main, June 2022]

3. A dilute solution of Sulphuric acid is electrolysed using a current of 0.10 A for 2 hours to produce hydrogen and oxygen gas. The total volume of gases produced at STP is _____ cm3. (Nearest integer) [Given : Faraday constant F = 96500 C mo1^{-1} at STP, molar volume of an ideal gas is 22.7 L mo1^{-1}]

[JEE Main, June 2022]

4. Given below are two statements:

Statement I: The limiting molar conductivity of KCl (strong electrolyte) is higher compared to that of CH_3COOH (weak electrolyte).

Statement II: Molar conductivity decreases with decrease in concentration of electrolyte.

In the light of the above statements, choose the most appropriate answer from the options given below: **[JEE Main, August 2021]**

(A) Statement I is true but Statement II is false.

(B) Statement I is false but Statement II is true.

(C) Both Statement I and Statement II are true.

(D) Both Statement I and Statement II are false.

5. For the reaction

$2Fe^{3+}(aq) + 2I^-(aq) \rightarrow 2Fe^{2+}(aq) + I_2(s)$
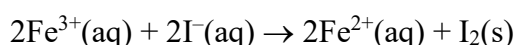
the magnitude of the standard molar free energy change, $\Delta_r G_m° = -$ _____ kJ.

(Round off to the Nearest Integer)

$$\begin{bmatrix} E^0_{Fe^{2+}/Fe(s)} = -0.440V; & E^0_{Fe^{3+}/Fe(s)} = -0.036V \\ E^0_{I_2/2I^-} = 0.539V; & F = 96500C \end{bmatrix}$$

6. Consider the cell at 25°C   **[JEE Main, March 2021]**

Zn | Zn²⁺ (aq), (1M) || Fe³⁺ (aq), Fe²⁺ (aq)| Pt (s)

The fraction of total iron present as Fe^{3+} ion at the cell potential of 1.500 V is $x \times 10^{-2}$. The value of x is_____. (Nearest integer)

(Given: $E^0_{Fe^{3+}/Fe^{2+}} = 0.77V$, $E^0_{Zn^{2+}/Zn} = -0.76V$)   **[JEE Main, July 2021]**

7. The conductivity of a weak acid HA of concentration 0.001 mol L⁻¹ is 2.0×10^{-5} S cm⁻¹. If $\Lambda^0_m (HA) = 190$ S cm² mol⁻¹, the ionization constant (Kₐ) of HA is equal to ___ $\times 10^{-6}$.

(Round off to the nearest integer)   **[JEE Main, July 2021]**

8. The resistance of a conductivity cell with cell constant 1.14 cm⁻¹, containing 0.001 M KCl at 298 K is 1500 Ω. The molar conductivity of 0.001 M KCl solution at 298 K in S cm² mol⁻¹ is_____.

(Integer answer)   **[JEE Main, August 2021]**

9. 108g of silver (molar mass 108g mol⁻¹) is deposited at cathode from AgNO₃(aq) solution by a certain quantity of electricity. The volume (in L) of oxygen gas produced at 273 K and 1 bar pressure from water by the same quantity of electricity is _____.   **[Jee Main, 2020]**

10. An acidic solution of dichromate is electrolyzed for 8 minutes using 2A current. As per the following equation

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

The amount of Cr^{3+} obtained was 0.104 g. The efficiency of the process (in %) is

(Take : F = 96000 C, At. mass of chromium = 52) _____.

Given 60.31   **[Jee Main, 2020]**

11. Given that the standard potentials (E°) of Cu²⁺ /Cu and Cu⁺ /Cu are 0.34 V and 0.522 V respectively, the E° of Cu²⁺/Cu⁺ is :   **[Jee Main, 2020]**

(A) –0.182 V   (B) –0.158 V   (C) 0.182 V   (D) +0.158 V

12. For the given cell ;

Cu(s)|Cu²⁺ (C₁M)||Cu²⁺ (C₂M)|Cu(s) change in Gibbs energy (ΔG) is negative, if :

     [Jee Main, 2020]

(A) $C_1 = 2C_2$ (B) $C_2 = \dfrac{Cl}{\sqrt{2}}$ (C) $C_1 = C_2$ (D) $C_2 = \sqrt{2}C_1$

13. Given that $E^{\ominus}_{O_2/H_2O} = 1.23$ V;   **[JEE Mains 2019 (Apr.)]**

$E^{\ominus}_{S_2O_8^{2-}/SO_4^{2-}} = 2.05$ V

$E^{\ominus}_{Br_2/Br^-} = + 1.09$ V

$E^{\ominus}_{Au^{3+}/Au} = + 1.4$ V

The strongest oxidizing agent is :

(A) O₂   (B) $S_2O_8^{2-}$ (C) Br₂   (D) Au³⁺

14. Calculate the standard cell potential (in V) of the cell in which following reaction takes place :
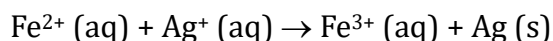
Fe^{2+} (aq) + Ag^+ (aq) → Fe^{3+} (aq) + Ag (s)   **[JEE Mains 2019 (Apr.)]**

Given that

$E^{\circ}_{Ag^+/Ag} = x$ V

$E^{\circ}_{Fe^{2+}/Fe} = y$ V

$E^{\circ}_{Fe^{3+}/Fe} = z$ V

(A) x – z   (B) x + 2y – 3z   (C) x – y   (D) x + y – z

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

Zn(s) + Cu^{2+}(aq) → Zn^{2+} (aq) + Cu(s), E°=2 V at 298 K

(Faraday's constant, F = 96000 C mol^{-1})   **[JEE Mains 2019 (Apr.)]**

(A) –384   (B) 384   (C) –192   (D) 192

16. A solution of $Ni(NO_3)_2$ is electrolysed between platinum electrodes using 0.1 Faraday electricity. How many mole of Ni will be deposited at the cathode? **[JEE Mains 2019 (Apr.)]**

(A) 0.20   (B) 0.15   (C) 0.10   (D) 0.05

17. Consider the statements S1 and S2 :

S1:   Conductivity always increases with decrease in the concentration of electrolyte.

S2:   Molar conductivity always increases with decrease in the concentration of electrolyte.

The correct option among the following is: **[JEE Mains 2019 (Apr.)]**

(A) Both S1 and S2 are wrong   (B) Both S1 and S2 are correct

(C) S1 is wrong and S2 is correct   (D) S1 is correct and S2 is wrong

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

[JEE Mains 2019 (Apr.)]
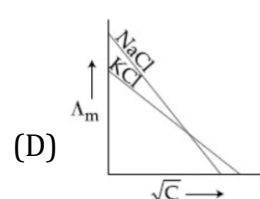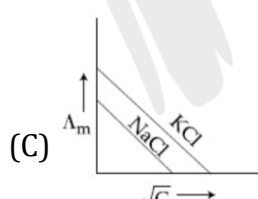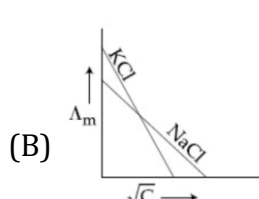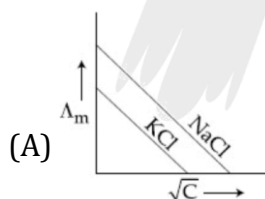
19. Given: **[JEE Mains 2019 (Apr.)]**

$Co^{3+} + e^- → CO^{2+}$; E° = + 1.81 V

$Pb^{4+} + 2e^- → Pb^{2+}$; E° = + 1.67 V

$Ce^{+4} + 3e → Ce^{3+}$; E° = + 1.61 V

$Bi^{3+} + 3e^- → Bi$; E° = + 0.20 V
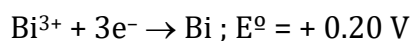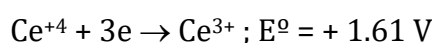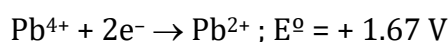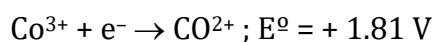
Oxidizing power of the species will increase in the order:

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

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

20. The decreasing order of electrical conductivity of the following aqueous solutions is:

0.1 M Formic acid (A),   **[JEE Mains 2019 (Apr.)]**

0.1 M Acetic acid (B),

0.1 M Benzoic acid (C).

(A) A > B > C   (B) C > A > B   (C) A > C > B   (D) C > B > A

21. 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 i : (Molar mass of $PbSO_4$ = 303 g mol^{-1})

[JEE Mains 2019 (Jan.)]

(A) 22.8   (B) 15.2   (C) 7.6   (D) 11.4

22. If the standard electrode potential for a cell is 2 V at 300 K, the equilibrium constant (K) for the reaction   **[JEE Mains 2019 (Jan.)]**

$Zn(s) + Cu^{2+}(aq) \rightleftharpoons Zn^{2+}(aq) + Cu(s)$ at 300 K is approximately.

(R = 8 JK^{-1} mol^{-1}, F = 96000 C mol^{-1})

(A) e^{-80} (B) e^{-160} (C) e^{160} (D) e^{320}

23. Consider the following reduction processes :   **[JEE Mains 2019 (Jan.)]**

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

$Ca^{2+} + 2e^- \rightarrow Ca(s);\ E^\circ = -2.87$ V

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

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

The reducing power of the metals increases in the order :

(A) Ca < Mg < Zn < Ni   (B) Zn < Mg < Ni < Ca

(C) Ni < Zn < Mg < Ca   (D) Ca < Zn < Mg < Ni

24. 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 :

$\left\{ \text{Given,}\ \dfrac{2.303RT}{F} = 0.06\,\text{V at}\ 298\,\text{K} \right\}$ **[JEE Mains 2019 (Jan.)]**

(A) 0.94 V   (B) 0.40 V   (C) 0.20 V   (D) 0.76 V

25. For the cell Zn(s) | Zn^{2+}(aq) || M^{x+} (aq) | M(s), different half cells and their standard electrode potentials are given below :   **[JEE Mains 2019 (Jan.)]**

$M^{x+}(aq/M(s)$	$Au^{3+}(aq)/$ $Au(s)$	$Ag^+(aq)/$ $Ag(s)$	$Fe^{3+}(aq)/$ $Fe^{2+}(aq)$	$Fe^{2+}(aq)/$ $Fe(s)$
$E^o_{M^{x+}/M^{(v)}}$	1.40	0.80	0.77	−0.44

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

(A) Fe^{2+} / Fe   (B) Ag^{3+} / Au   (C) Fe^{3+} / Fe^{2+} (D) Ag$^+$ / Ag

26. Given the equilibrium constant :   **[JEE Mains 2019 (Jan.)]**

K_C of the reaction :

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

10×10^{15}, calculate the E^0_{cell} of this reaction at 298 K

$[2.303 \dfrac{RT}{F}$ at 298K is 0.059V$]$

(A) 0.4736 V   (B) 0.04736 mV   (C) 0.4736 mV   (D) 0.04736 V

27. The standard electrode potential $E^{\ominus}$ and its temperature coefficient $\left(\dfrac{dE^{\ominus}}{dT}\right)$ for a cell are 2V

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 $\left(\Delta_r H^{\ominus}\right)$ at 300 K in kJ mol^{-1} is,

[Use R = 8 JK^{-1} mol^{-1} and F = 96,000 C mool^{-1}]   **[JEE Mains 2019 (Jan.)]**

(A) 192.0   (B) -384.0 (C) 206.4   (D) -412.8

28. $\wedge^o_m$ for NaCl, HCl and NaA are 126.4, 425.9 and 100.5 S cm^{2}mol^{-1}, respectively. If the

conductivity of 0.001 M HA is 5×10^{-5} S cm^{-1}, degree of dissociation of HA is:

[JEE Mains 2019 (Jan.)]

(A) 0.50   (B) 0.125   (C) 0.25   (D) 0.75

29. How long (approximate) should water be electrolysed by passing through 100 amperes

current so that the oxygen released can completely burn 27.66 g of diborane ?

(Atomic weight of B = 10.8 u)   **[JEE Mains 2018]**

(A) 1.6 hours   (B) 6.4 hours   (C) 0.8 hours   (D) 3.2 hours

30. Given

$E^0_{Cl^2/Cl^-} = 1.36\,V,\ E^0_{Cl^{3+}/Cr} = -0.74\,V$

$E^0_{Cl^2/Cl_7^{2-}/Cr^{3+}} = 1.33\,V,\ E^0_{MnO_4^-/Mn^{2+}} = 1.51\,V$

Among the following, the strongest reducing agent is   **[JEE Mains 2017]**

(A) Cr   (B) Mn^{2+} (C) Cr^{3+} (D) Cl$^-$

31. Oxidation of succinate ion produces ethylene and carbon dioxide gases. On passing 0.2 Faraday

electricity through on aqueous solution of potassium succinate, the total volume of gases (at

both cathode and anode) at STP (1 atm and 273 K) is :   **[JEE-MAINS (ONLINE) 2016]**

(A) 8.96 L   (B) 2.24 L   (C) 4.48 L   (D) 6.72 L

32. What will occur if a block of copper metal is dropped into a beaker containing a solution of 1M
    ZnSO$_4$ **[JEE-MAINS (ONLINE) 2016]**
    (A) The copper metal will dissolve and zinc metal will be deposited
    (B) No reaction will occur
    (C) The copper metal will dissolve with evolution of oxygen gas
    (D) The copper metal will dissolve with evolution of hydrogen gas

33. 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-MAINS 2015]**
    (A) 2g   (B) 127 g   (C) 0 g   (D) 63.5 g

34. A variable, opposite external potential (E$_{ext}$) is applied to the cell
    Zn|Zn^{2+} (1 M) || Cu^{2+} (1 M) | Cu, of potential 1.1 V. When E$_{ext}$ < 1.1 V and E$_{ext}$ > 1.1 V, respectively
    electrons flow from :   **[JEE-MAINS (ONLINE) 2015]**
    (A) anode to cathode in both cases   (B) anode to cathode and cathode to anode
    (C) cathode to anode in both cases   (D) cathode to anode and anode to cathode

35. 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 $\left(\dfrac{RT}{F} = 0.059V \right)$:

    [JEE-MAINS (ONLINE) 2015]

    (A) Cl$^-$ and Br$^-$ (B) Cl$^-$, Br$^-$ and I$^-$ (C) Br$^-$ and I$^-$ (D) I$^-$ only

36. 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-MAINS 2014]**
    (A) 5 × 10^3 (B) 5 × 10^2 (C) 5 × 10^{-4} (D) 5 × 10^{-3}

37. 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 :   **[JEE-MAINS 2014]**
    (where the constant B is positive)
    (A) λ$_C$ = λ$_∞$ – (B) $\sqrt{C}$ (B) λ$_C$ = λ$_∞$ + (B) $\sqrt{C}$
    (C) λ$_C$ = λ$_∞$ + (B) C   (D) λ$_C$ = λ$_∞$ – (B) (C)

38. 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 :
    (A) Cl$^-$ (B) Cr^{3+} (C) Mn^{2+} (D) MnO$_4^-$

39. 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]**

(A) X = Zn, Y = Ni   (B) X = Ni, Y = Fe   (C) X = Ni, Y = Zn   (D) X = Fe, Y = Zn

40. The reduction potential of hydrogen half-cell will be negative if :–   **[AIEEE 2011]**

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

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

41. Resistance of 0.2 M solution of an electrolyte is 50 Ω. The specific conductance of the solution is 1.3 S m^{-1}. If resistance of the 0.4M solution of the same electrolyte is 260 Ω, its molar conductivity is :–   **[AIEEE 2011]**

(A) 6250 S m^2 mol^{-1} (B) 6.25×10^{-4} S m^2 mol^{-1}

(C) 625×10^{-4} S m^2 mol^{-1} (D) 62.5 S m^2 mol^{-1}

42. The Gibbs energy for the decomposition of Al_2O_3 at 500 °C is as follows :   **[AIEEE 2010]**

$$\frac{2}{3}\ Al_2O_3 \longrightarrow \frac{4}{3}\ Al + O_2, \Delta_rG = +966\ kJ\ mol^{-1}$$

The potential difference needed for electrolytic reduction of Al2O3 at 500 °C is at least :-

(A) 5.0 V   (B) 4.5 V   (C) 3.0 V   (D) 2.5 V

43. Given :   **[AIEEE-2009]**

$E^0_{Fe^{+3}/Fe} = -0.036V$, $E^0_{Fe^{+2}/Fe} = -0.439V$. The value of standard electrode potential for the change.

$Fe^{+3}_{(aq)} + e^- \longrightarrow Fe^{+2}_{(aq)}$ will be :–

(A) 0.770 V   (B) –0.27 V   (C) –0.072 V   (D) 0.385 V

44. Given : $E^0_{Cr^{+3}/Cr} = -0.72$ V, $E^0_{Fe^{2+}/Fe} = -0.42$ V. The potential for the cell,   **[AIEEE 2008]**

$Cr_{(s)} | Cr^{3+}_{(aq)} (0.1\ M) || Fe^{2+}_{(aq)} (0.01\ M) | Fe_{(s)}$ is

(A) 0.26 V   (B) 0.339 V   (C) – 0.339 V   (D) – 0.26 V

45. The cell $Zn | Zn^{+2}_{(aq)}(1M) || Cu^{+2}_{(aq)}(1M) | Cu$ ($E°_{cell} = 1.10$ V) was allowed to be completely discharged at 298 K. The relative concentration of Zn^{+2} to Cu^{+2}, $\left\{ \dfrac{\left[Zn^{+2}\right]}{\left[Cu^{+2}\right]} \right\}$ is : **[AIEEE 2007]**

(A) 9.65×10^4 (B) Antilog (24.08)   (C) 37.3   (D) 1037.3

46. Given the data at 25°C,

$Ag_{(s)} + I^-_{(aq)} \rightarrow AgI_{(s)} + e^-, E° = 0.152V$

$Ag_{(s)} \rightarrow Ag^+_{(aq)} + e^-, E° = -0.800$ V

What is the value of log K_{sp} for AgI ?

(Where K_{sp}= solubility product)   **[AIEEE 2006]**

$$\left(2.303\frac{RT}{F} = 0.59V \right)$$

(A) –8.12   (B) +8.612   (C) –37.83   (D) –16.13

47. Resistance of a conductivity cell filled with a solution of an electrolyte of concentration 0.1M is 100Ω. The conductivity of this solution is 1.29 Sm⁻¹. Resistance of the same cell when filled with 0.02M of the same solution is 520Ω. The molar conductivity of 0.02M solution of the electrolyte will be. **[AIEEE 2006]**

(A) 124×10^{-4} Sm² mol⁻¹   (B) 1240×10^{-4} Sm² mol⁻¹

(C) 1.24×10^4 Sm² mol⁻¹   (D) 12.4×10^{-4} Sm² mol⁻¹

48. The molar conductivities, Λ^0_{NaOAC} and Λ^0_{HCl} at infinite dilution in water at 25°C are 91.0 and 426.2 S cm²/mol respectively. To calculate Λ^0_{HOAc} the additional value required is :

[AIEEE 2006]

(A) KCl   (B) NaOH   (C) NaCl   (D) H_2O

49. For a spontaneous reaction the ΔG, equilibrium constant (K) and E^0_{Cell} will be respectively

[AIEEE 2005]

(A) –ve, < 1, –ve   (B) –ve, >1, –ve   (C) –ve, >1, +ve   (D) +ve, >1, –ve

50. Aluminium oxide may be electrolysed at 1000°C to furnish aluminium metal (1 Faraday = 96500 Coulombs). The cathode reaction is   **[AIEEE 2005]**

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

To prepare 5.12 kg of aluminium metal by this method would require,

(A) 5.49×10^4 C of electric charge   (B) 5.49×10^1 C of electric charge

(C) 5.49×10^7 C of electric charge   (D) 1.83×10^7 C of electric charge

51. The highest electrical conducitivity of the following aqueous solution is of   **[AIEEE 2005]**

(A) 0.1 M fluoroacetic acid   (B) 0.1 M difluoroacetic acid

(C) 0.1 M acetic acid   (D) 0.1 M chloroacetic acid

52.

Electrolyte	Λ^∞ (S cm² mol⁻¹)
KCl	149.9
KNO₃	145.0
HCl	426.2
NaOAC	91.0
NaCl	126.5

Calculate Λ^∞_{HOAc} using appropriate molar conductances of the electrolytes listed above at infinite dilution in H2O at 25°C   **[AIEEE 2005]**

(A) 390.7   (B) 217.5   (C) 517.2   (D) 552.7

53. Consider the following E0 values,   **[AIEEE 2004]**

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

Under standard conditions the potential for the reaction,

$Sn(s) + 2Fe^{3+}$ (aq) $\longrightarrow 2Fe^{2+}$(aq) $+ Sn^{2+}$(aq) is:

(A) 0.91V   (B) 1.40V   (C) 1.68V   (D) 0.63V

54. The standard e.m.f. of a cell, involving one electron change is found to be 0.591 V at 25°C. The equilibrium constant of the reaction is (F = 96,500C mol^{-1} ; R = 8.314 JK^{-1} mol^{-1})

   [AIEEE 2004]

   (A) 1.0×10^{10} (B) 1.0×10^5 (C) 1.0×10^1 (D) 1.0×10^{30}

55. The limiting molar conductivities Λ^0 for NaCl, KBr and KCl are 126,152 and 150Scm^2 mol^{-1} respectively. The Λ_m^0 for NaBr is :   **[AIEEE 2004]**

   (A) 278 S cm^2 mol^{-1} (B) 176 S cm^2 mol^{-1} (C) 128 S cm^2 mol^{-1} (D) 302 S cm^2 mol^{-1}

56. In a cell that utilises the reaction,   **[AIEEE 2004]**

   Zn(s) + 2H$^+$(a) $\longrightarrow$ Zn^{2+}(aq) + H$_2$(g) addition of H$_2$SO$_4$ to cathode compartment, will :

   (A) increase the E$_{cell}$ and shift equilibrium to the right

   (B) lower the E$_{cell}$ and shift equilibrium to the right

   (C) lower the E$_{cell}$ and shift equilibrium to the left

   (D) increase the E$_{cell}$ and shift equilibrium to the left

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

   [AIEEE 2004]

   (A) Fe   (B) Mn   (C) Cr   (D) Co

58. For a cell reaction involving a two-electron change, the standard e.m.f. of the cell is found to be 0.295V at 25° C. The equilibrium constant of the reaction at 25°C will be :   **[AIEEE 2003]**

   (A) 10   (B) 1×10^{10} (C) 1×10^{-10} (D) 29.5×10^{-2}

59. Standard reduction electrode potentials of three metals A, B and C are respectively + 0.5V, – 3.0V and –1.2 V. The reducing powers of these metals are :   **[AIEEE 2003]**

   (A) C > B > A   (B) A > C > B   (C) B > C > A   (D) A > B > C

60. For the redox reaction :

   Zn(s) + Cu^{2+} (0.1M) $\rightarrow$ Zn^{2+} (1M) + Cu(s) taking place in a cell,

   E°$_{Cell}$ is 1.10 volt. E$_{Cell}$ for the cell will be $\left(2.303\dfrac{RT}{F} = 0.0591 \right)$ **[AIEEE 2003]**

   (A) 1.07 volt   (B) 0.82 volt   (C) 2.14 volt   (D) 1.80 volt

61. When, during electrolysis of a solution of AgNO$_3$ 9650 coulombs of charge pass through the electroplating bath, the mass of silver deposited on the cathode will be :   **[AIEEE 2003]**

   (A) 21.6g   (B) 108g   (C) 1.08g   (D) 10.8g

EXERCISE # (JEE-ADVANCED)

1. Plotting $1/\Lambda_m$ against $c\Lambda_m$ for aqueous solutions of a monobasic weak acid (HX) resulted in a straight line with y-axis intercept of P and slope of S. The ratio P/S is   **[JEE Adv.2023]**

[Λ_m = molar conductivity

Λ_m° = limiting molar conductivity

c = molar concentration

K_a = dissociation constant of HX]

(A) $K_a\Lambda_m^\circ$ (B) $K_a\Lambda_m^\circ/2$ (C) $2\,K_a\Lambda_m^\circ$ (D) $1/(K_a\Lambda_m^\circ)$

2. The reduction potential (E^0, in V) of $MnO_4^-(aq)/Mn(s)$ is

$\left[\text{Given: } E^0_{(M_4O_4^-(aq)/MnO_2(s))} = 1.68\text{ V}; E^0_{(MnO_2(s)/Mn^{2+}(aq))} = 1.21\text{ V}; E^0_{(Mn^{2+}(aq)/Mn(s))} = -1.03\text{ V}\right]$

[JEE Adv.2022]

3. Consider the strong electrolytes Z_mX_n, U_mY_p and V_mX_n. Limiting molar conductivity (Λ^0) of U_mY_p and V_mX_n are 250 and 440 S cm^2 mol^{-1}, respectively. The value of (m + n + p) is

Given:

Ion	Z^{n+}	U^{p+}	V^{n+}	X^{m-}	Y^{m-}
λ^0(S cm^2 mol^{-1})	50.0	25.0	100.0	80.0	100.0

λ^0 is the limiting molar conductivity of ions

The plot of molar conductivity (Λ) of Z_mX_n vs $c^{1/2}$ is given below.   **[JEE Adv.2022]**
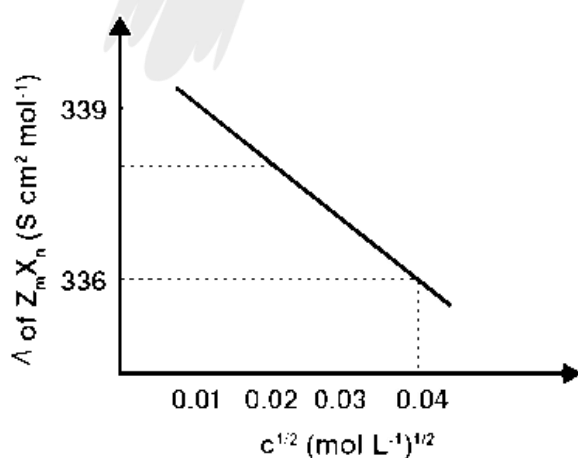
4. Consider a 70% efficient hydrogen-oxygen fuel cell working under standard conditions at 1 bar and 298 K. Its cell reaction is   **[JEE Adv.2020]**

$$H_2(g) + 1/2O_2(g) \rightarrow H_2O(I)$$
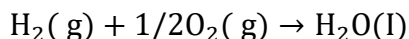
The work derived from the cell on the consumption of 1.0×10^{-3} mol of $H_2(g)$ is used to compress 1.00 mol of a monoatomic ideal gas in a thermally insulated container. What is the change in the temperature (in K) of the ideal gas?

The standard reduction potentials for the two half-cells are given below.

$$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l), E^0 = 1.23 \text{ V}$$
$$2H^+(aq) + 2e^- \rightarrow H_2(g), E^0 = 0.00 \text{ V}$$
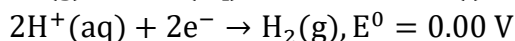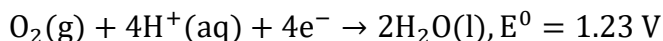
Use $F = 96500 \text{ Cmol}^{-1}, R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$.

Passage 5 and 6

At 298 K, the limiting molar conductivity of a weak monobasic acid is 4×10^2 S cm^2 mol^{-1}. At 298 K, for an aqueous solution of the acid, the degree of dissociation is a and the molar conductivity is $y \times 10^2$ S cm^2 mol^{-1}. At 298 K, upon 20 times dilution with water, the molar conductivity of the solution becomes $3y \times 10^2$ S cm^2 mol$^-$ **[JEE Adv.2020]**

5. The value of α is _____ .

6. The value of y is _____.

7. For the electrochemical cell,

Mg(s)|Mg^{2+} (aq, 1 M) || Cu^{2+} (aq, 1 M)|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, $\dfrac{F}{R} = 11500$ KV^{-1}) , where F is the Faraday constant and R is the gas constant,

ln(10) = 2.30)   **[JEE Adv. 2018]**

8. Consider an electrochemical cell: A(s) | A^{n+} (aq, 2 M) || B^{2n+} (aq, 1 M)| B(s). The value of ΔH^θ for the cell reaction is twice that of ΔG^θ at 300 K. If the emf of the cell is zero, the $\Delta S\theta$ (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.)R   **[JEE Adv. 2018]**

9. The conductance of a 0.0015 M aqueous solution of a weak monobasic acid was determined by using a conductivity cell consisting of plantinized Pt electrodes. The diatcane between the elecrodes is 120 cm with an area of cross section of 1cm^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 $\left(\Lambda_m^0\right)$ of this weak monobasic acid in aqueous solution is Z $\times 10^2$ S cm^{-1}mol^{-1}. The value of Z is

[JEE Adv. 2017]

10. For the following cell,

Zn(s) $\left|ZnSO_4\,(aq)\right|\left|CuSO_4\,(aq)\right|$ Cu (s)

when the concentration of Zn^{2+} is 10 times the concentration of Cu^{2+}, then expression for ΔG

(in J mol⁻¹) is [F is faraday constant ; R is gas constant; T is temperature; E° (cell) = 1.1V]

[JEE Adv. 2017]

(A) 2.303RT – 2.2 F   (B) – 2.2 F

(C) 1.1F   (D) 2.303RT + 1.1 F

11. For the following electrochemical cell at 298K,   **[JEE-Adv. 2016]**

Pt(s) | H₂(g, 1bar) | H⁺ (aq, 1M) || M⁴⁺(a), M²⁺(a) | Pt(s)
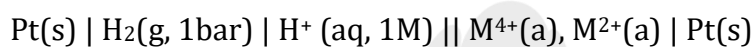
$E_{cell} = 0.092$ V when $\dfrac{\left[M^{2+}\,(aq.)\right]}{\left[M^{4+}\,(aq)\right]} = 10^x$

Given : $E^0_{M^{4+}/M^{2+}} = 0.151$ V ; $2.303\,\dfrac{RT}{F} = 0.059$ V

The value of x is -

(A) –2   (B) –1   (C) 1   (D) 2

12. All the energy released from the reaction $X \rightarrow Y$, $\Delta_r G^o = -193$ kJ mol⁻¹ is used for the oxidizing

M^+ and $M^+ \rightarrow M^{3+} + 2e^-$, $E^o = -0.25$ 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-Adv. 2015]**

13. 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 (0.1 M). If $\lambda^0_{X^-} \approx \lambda^0_{Y^-}$, the difference in their

pKₐ values , pKₐ(HX) – pKₐ(HY), is (consider degree of ionization of both acids to be <<1).

[JEE-Adv. 2015]

14. In a galvanic cell , the salt bridge –   **[JEE-Adv. 2014]**

(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 occurence of the cell reaction

(D) Ensures mixing of the two electrolytic solutions

15. 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-Adv. 2013]**

	List-I			List-II
(P)	$(C_2H_5)_3N + CH_3COOH$ X ⠀⠀⠀ Y	(1)		Conductivity decreases and then increases
(Q)	KI(0.1M) + AgNO$_3$(0.01M) X ⠀⠀⠀ Y	(2)		Conductivity decreases and then does not change much
(R)	$CH_3COOH + KOH$ X ⠀⠀⠀ Y	(3)		Conductivity increases and then does not change much
(S)	NaOH + HI X ⠀⠀ Y	(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

16. The standard reduction potential data at 25ºC is given below   **[JEE-Adv. 2013]**

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$^-$ → 2H$_2$O] = +1.23 V ;

E^o [(O$_2$(g) + 2H$_2$O + 4e$^-$ → 4OH$^-$)] = +0.40 V ;

E^o (Cr^{3+}, Cr) = –0.74 V ;

E^o (Cr^{2+}, Cr) = –0.91 V ;

Match E^o of the redox 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)		– 0.18 V
(Q)	E^o(4H$_2$O ⇌ 4H$^+$ + 4OH$^+$)	(2)		– 0.4 V
(R)	E^o(Cu^{2+} + Cu → 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

Paragraph for Question 17 and 18

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 concentrations of M2+ ions at the two electrodes. The emf of the cell at 298 K is 0.059V.   **[JEE 2012]**

17.   The value of ΔG (kJ mol^{-1}) for the given cell is (take If = 96500 C mol^{-1})

(A) −5.7   (B) 5.7   (C) 11.4   (D) −11.4.

18.   The solubility product (K_{sp} ; mol^3 dm^{-9}) of MX_2 at 298 K based on the information available for the given concentration cell is (take $2.303 \times R \times 298/F = 0.059$ V)

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

19. $AgNO_3$ (a) 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]

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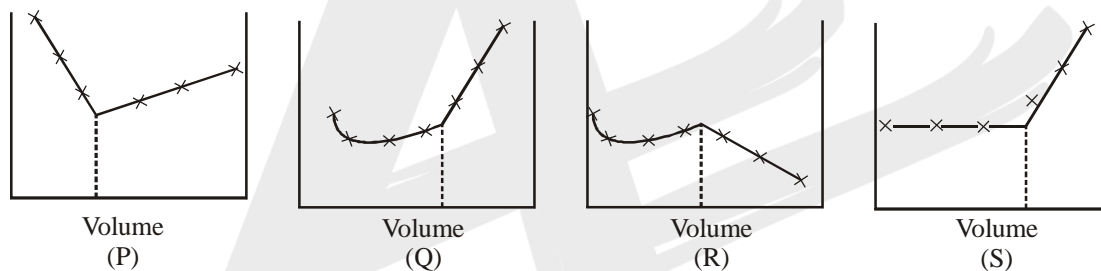
(A) (P)   (B) (Q)   (C) (R)   (D) (S)

20.   Consider the following cell reaction :   **[JEE 2011]**

$2Fe_{(s)}+O_{2(g)}+4H^{+}_{(aq)} \rightarrow 2Fe^{2+}_{(a)}+ 2H_2O(\lambda)$ E° = 1.67 V

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

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

Paragraph for Questions 21 to 22

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 :   **[JEE 2010]**

M(s)| M^{+}(aq ; 0.05 molar) || M^{+}(aq ; 1 molar) | M(s)

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

21.   For the above cell :–

(A) E_{cell} < 0 ; ΔG > 0   (B) E_{cell} > 0 ; ΔG < 0   (C) E_{cell} < 0 ; $\Delta G0$ > 0 (D) E_{cell} > 0 ; ⬜G0 < 0

22.   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 :–

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

23. For the reaction of NO_3^- ion in an aqueous solution, $E°$ is +0.96 V. Values of $E°$ for some metal ions are given below

$$V^{2+} (aq) + 2e^- \rightarrow V \qquad\qquad E° = -1.19 \text{ V}$$

$$Fe^{3+} (aq) + 3e^- \rightarrow Fe \qquad\qquad E° = -0.04 \text{ V}$$

$$Au^{3+} (aq) + 3e^- \rightarrow Au \qquad E° = +1.40 \text{ V}$$

$$Hg^{2+} (aq) + 2e^- \rightarrow Hg \qquad\qquad E° = +0.86 \text{ V} \qquad\qquad \textbf{[JEE 2009]}$$

The pair(s) of metal that is(are) oxidised by NO_3^- in aqueous solution is(are)

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

24. Electrolysis of dilute aqueous NaCl solution was carried out by passing 10 milli ampere current. The time required to liberate 0.01 mol of H_2 gas at the cathode is (1 Faraday = 96500 C mol^{-1})

[JEE 2008]

(A) 9.65×10^4 sec   (B) 19.3×10^4 sec   (C) 28.95×10^4 sec   (D) 38.6×10^4 sec

Paragraph for Question Nos. 25 & 26 (2 questions)

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 are a set of half-cell reactions (acidic medium) along with their $E°$ (V with respect to normal hydrogen electrode) values. Using this data obtain the correct explanations to Questions 14-16.

$$I_2 + 2e^- \rightarrow 2I^- \qquad\qquad E° = 0.54$$

$$Cl_2 + 2e^- \rightarrow 2Cl^- \qquad\qquad E° = 1.36$$

$$Mn^{3+} + e^- \rightarrow Mn^{2+} \qquad\qquad E° = 1.50$$

$$Fe^{3+} + e^- \rightarrow Fe^{2+} \qquad\qquad E° = 0.77$$

$$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O \qquad\qquad E° = 1.23 \qquad\qquad \textbf{[JEE 2007]}$$

25. Among the following, identify the correct statement.

(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

26. While Fe^{3+} is stable, Mn^{3+} is not stable in acid solution because

(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

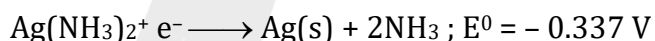(D) Mn^{3+} oxidises H_2O to O_2

Paragraph for Question Nos. 27 to 29 (3 questions)

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 their atomic/molecular masses. To handle such large numbers 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 (atomic mass : Na = 23, Hg = 200; 1 Faraday = 96500 coulombs)   **[JEE 2007]**

27. The total number of moles of chlorine gas evolved is

(A) 0.5   (B) 1.0   (C) 2.0   (D) 3.0

28. If the cathode is a Hg electrode, the maximum weight (g) of amalgam formed from this solution is

(A) 200   (B) 225   (C) 400   (D) 446

29. The total charge (coulombs) required for complete electrolysis is

(A) 24125   (B) 48250   (C) 96500   (D) 193000

Question No. 30 to 31 (3 questions)

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

$Ag^+ + e^- \longrightarrow Ag$; $E^0_{red} = 0.8$ V

$C_6H_{12}O_6 + H_2O \longrightarrow C_6H_{12}O_7$ (Gluconic acid) $+ 2H^+ + 2e^-$; $E^0 = 0.05$ V

$Ag(NH_3)_2^+ e^- \longrightarrow Ag(s) + 2NH_3$; $E^0 = - 0.337$ V

[Use $2.303 \times \dfrac{RT}{F} = 0.0592$ and $\dfrac{F}{RT} = 38.92$ at 298 K]   **[JEE 2006]**

30. $2Ag^+ + C_6H_{12}O_6 + H_2O \longrightarrow 2Ag(s) + C_6H_{12}O_7 + 2H^+$

Find ln K of this reaction

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

31. When ammonia is added to the solution, pH is raised to 11. Which half-cell reaction is affected by pH and by how much?

(A) E_{oxd} will increase by a factor of 0.65 from E^0_{oxd}

(B) E_{oxd} will decrease by a factor of 0.65 from E^0_{oxd}

(C) E_{red} will increase by a factor of 0.65 from E^0_{red}

(D) E_{red} will decrease by a factor of 0.65 from E^0_{red}

32. 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.

(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) NH3 has affected the standard reduction potential of glucose/gluconic acid electrode.

33. 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} S m^{-1} mol^{-1}. **[JEE 2006]**

Given : $\lambda^0_{(Ag^+)} = 6 \times 10^{-3}$ S m^2 mol^{-1} ; $\lambda^0_{(Br^-)} = 8 \times 10^{-3}$ S m^2 mol^{-1} ; $\lambda^0_{(NO_3^-)} = 7 \times 10^{-3}$ S m^2 mol^{-1}

34. The half cell reactions for rusting of iron are: **[JEE 2005]**

$2H^+ \dfrac{1}{2} + O_2 + 2e^- \longrightarrow H_2O$; $E^0 = +1.23$ V, $Fe^{2+} + 2e^- \longrightarrow Fe$; $E^0 = -0.44$ V
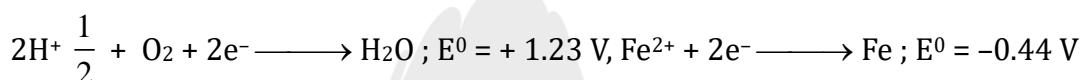
ΔG^0 (in kJ) for the reaction is :

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

35. (a) Calculate ΔG^0_f of the following reaction **[JEE 2005]**

Ag^+ (aq) + Cl^- (aq) $\longrightarrow$ AgCl(s)
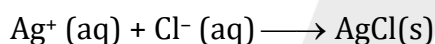
Given : ΔG^0_f (AgCl) = –109 kJ/mole, ΔG^0_f (Cl$^-$) = –129 kJ/mole, ΔG^0_f (Ag$^+$) = 77 kJ/mole

Represent the above reaction in form of a cell

Calculate E^0 of the cell. Find $\log_{10}K_{SP}$ of AgCl

(B) (b) 6.539×10^{-2} g of metallic Zn (amu = 65.39) was added to 100 ml of saturated solution of AgCl. Calculate $\dfrac{\left[Zn^{2+}\right]}{\left[Ag^+\right]^2} \log_{10}$, given that

$Ag^+ + e^- \longrightarrow Ag \qquad E^0 = 0.80$ V ; $\qquad Zn^{2+} + 2e^- \longrightarrow Zn \quad E^0 = -0.76V$

Also find how many moles of Ag will be formed ?

36. Zn | Zn^{2+} (a = 0.1M) || Fe^{2+} (a = 0.01M)|Fe. The emf of the above cell is 0.2905 V. Equilibrium constant for the cell reaction is **[JEE 2004]**

(A) $10^{0.32/0.0591}$ (B) $10^{0.32/0.0295}$ (C) $10^{0.26/0.0295}$ (D) $e^{0.32/0.295}$

37. Find the equilibrium constant at 298 K for the reaction,

$Cu^{2+}(aq) + In^{2+}(aq) \rightleftharpoons Cu^+(aq) + In^{3+}(aq)$
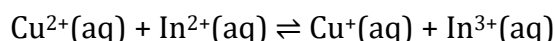
Given that $E^0_{Cu^{2+}|Cu^+} = 0.15V$, $E^0_{In^{3+}|In^+} = -0.42V$, $E^0_{In^{2+}|In^+} = -0.40$ V **[JEE 2004]**

38. In the electrolytic cell, flow of electrons is from:

(A) Cathode to anode in solution   (B) Cathode to anode through external supply

(C) Cathode to anode through internal supply   (D) Anode to cathode through internal supply.

39. Two students use same stock solution of $ZnSO_4$ and a solution of $CuSO_4$. The e.m.f of one cell is 0.03 V higher than the other. The conc. of $CuSO_4$ in the cell with higher e.m.f value is 0.5 M. Find out the conc. of $CuSO_4$ in the other cell $\left(\dfrac{2.303\,RT}{F} = 0.06 \right)$. **[JEE 2003]**

40. Standard electrode potential data are useful for understanding the suitablilty of an oxidant in a redox titration. Some half cell reactions and their standard potentials are given below:

    MnO^-_4 (aq) + 8H$^+$(aq) + 5e$^-$ $\longrightarrow$ Mn^{2+} (aq) + 4H$_2$O (l); E° = 1.51 V   **[JEE 2002]**

    $Cr_2O_7^{2-}$ (aq) + 14 H$^+$ (aq) + 6e$^-$ $\longrightarrow$ 2Cr^{3+} (aq) +7H$_2$O (λ); E° = 1.38 V

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

    Cl$_2$ (g) + 2e$^-$ $\longrightarrow$ 2Cl$^-$ (aq); E° = 1.40 V

    Identify the only incorrect statement regarding 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$_2$SO$_4$ (D) $Cr_2O_7^{2-}$ can be used in aqueous H$_2$SO$_4$

41. The reaction,   **[JEE 2001]**

    3ClO$^-$(aq) $\longrightarrow$ ClO$^-_3$ (aq) + 2Cl$^-$(aq)

    is an example of

    (A) Oxidation reaction   (B) Reduction reaction

    (C) Disproportionation reaction   (D) Decomposition reaction

42. The correct order of equivalent conductance at infinite dilution of LiCl, NaCl and KCl is

    (A) LiCl > NaCl > KCl   (B) KCl > NaCl > LiCl [JEE 2001]

    (C) NaCl > KCl > LiCl   (D) LiCl > KCl > NaCl

43. Saturated solution of KNO$_3$ is used to make salt bridge because

    (A) velocity of K$^+$ is greater than that of NO$^-_3$

    (B) velocity of NO$^-_3$ is greater than that of K$^+$

    (C) velocities of both K$^+$ and NO$^-_3$ are nearly the same

    (D) KNO$_3$ is highly soluble in water   **[JEE 2001]**

44. The standard potential of the following cell is 0.23 V at 15° C & 0.21 V at 35° C

    Pt | H$_2$(g) | HCl (aq) | AgCl(s) | Ag(s)

    (i) Write the cell reaction.

    (ii) Calculate ΔH^0, ΔS^0 for the cell reaction by assuming that these quantities remain unchanged in the range 15°C to 35°C.

    (iii) Calculate the solubility of AgCl in water at 25°C. Given standard reduction potential of the Ag$^+$/Ag couple is 0.80 V at 25°C.   **[JEE 2001]**

45. For the electrochemical cell, $M \mid M^+ \parallel X^- \mid X$, $E°$ (M^+/M) = 0.44 V and $E°$ (X/X^-) = 0.33V. From this data , one can deduce that **[JEE 2000]**

(A) $M + X \longrightarrow M^+ + X^-$ is the spontaneous reaction

(B) $M^+ + X^- \longrightarrow M + X$ is the spontaneous reaction

(C) E_{cell} = 0.77 V

(D) E_{cell} = −0.77 V

46. Copper sulphate solution (250 mL) was electrolysed using a platinum anode and a copper cathode. A constant current of 2 mA was passed for 16 mintue. It was found that after electrolysis, the absorbance (concentration) of the solution was reduced to 50% of its original value. Calculate the concentration of copper sulphate in the solution to begin with.

[JEE 2000]

47. The following electrochemical cell has been set up

$Pt_{(I)} \mid Fe^{3+}, Fe^{2+}(a = 1) \parallel Ce^{4+}, Ce^{3+} (a = 1) \mid Pt_{(II)}$

$E^0_{Fe^{3+}/Fe^{2+}}$ = 0.77 V and $E^0_{Ce^{4+}/Ce^{3+}}$ = 1.61 V

If an ammetter is connected between the two platinum electrodes. predict the direction of flow of current. Will the current increase or decrease with time? **[JEE 2000]**

48. A gas X at 1 atm is bubbled through a solution containing a mixture of 1 M Y and 1 M Z at 25°C. If the reduction potential of Z > Y > X, then **[JEE 1999]**

(A) Y will oxidise X and not Z   (B) Y will oxidise Z and X

(C) Y will oxidise both X and Z   (D) Y will reduce both X and Z.

49. Calculate the equilibrium constant for the reaction, $2Fe^{3+} + 3I^- \rightleftharpoons 2Fe^{2+} + I_3^-$. The standard reduction potentials in acidic conditions are 0.77 and 0.54 V respectively for Fe^{3+} / Fe^{2+} and I_3^- / I^- couples. **[JEE 1998]**

50. Find the solubility product of a saturated solution of Ag_2CrO_4 in water at 298 K if the emf of the cell $Ag \mid Ag^+$ (satd.$Ag_2 CrO_4$ soln.) $\parallel Ag +(0.1 M) \mid Ag$ is 0.164 V at 298K. **[JEE 1998]**

ANSWER KEY

EXERCISE # (O-I)

1.	(A)	**2.**	(C)	**3.**	(D)	**4.**	(B)	**5.**	(B)	**6.**	(D)	**7.**	(A)
8.	(C)	**9.**	(A)	**10.**	(D)	**11.**	(C)	**12.**	(1.61 V)			**13.**	(A)
14.	(C)	**15.**	(C)	**16.**	(C)	**17.**	(C)	**18.**	($K_c = 2.18 \times 10^{26}$)			**19.**	(C)
20.	(A)	**21.**	(A)	**22.**	(A)	**23.**	(C)	**24.**	(A)	**25.**	(B)	**26.**	(B)
27.	(A)	**28.**	(B)	**29.**	(B)	**30.**	(D)	**31.**	(B)	**32.**	(D)	**33.**	(A)
34.	(C)	**35.**	(D)	**36.**	(C)	**37.**	(B)	**38.**	(A)	**39.**	(B)	**40.**	(C)
41.	(A)	**42.**	(C)	**43.**	(C)	**44.**	(B)	**45.**	(D)	**46.**	(A)	**47.**	(C)
48.	(D)	**49.**	(D)	**50.**	(D)	**51.**	(C)	**52.**	(D)	**53.**	(C)	**54.**	(D)
55.	(D)	**56.**	(A)	**57.**	(C)	**58.**	(C)	**59.**	(A)	**60.**	(C)	**61.**	(B)
62.	(B)	**63.**	(B)	**64.**	(A)	**65.**	(C)	**66.**	(C)	**67.**	(C)	**68.**	(B)
69.	(C)	**70.**	(B)	**71.**	(A)	**72.**	(A)	**73.**	(D)	**74.**	(B)	**75.**	(D)
76.	(B)	**77.**	(D)	**78.**	(A)	**79.**	(C)	**80.**	(C)	**81.**	(A)	**82.**	(B)
83.	(B)	**84.**	(C)	**85.**	(B)	**86.**	(C)	**87.**	(B)	**88.**	(D)	**89.**	(A)

EXERCISE S-I

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 maintain electrical neutrality in solution

2. (1.68 V) **3.** (1.35 V) **4.** (– 0.0367 V) **5.** (0.53 V)

6. (-0.756 V) **7.** (yes) **8.** (Spontaneous, - 48250 J)

9. ($K_c = 7.6 \times 10^{12}$) **10.** ($K_C = 2.868 \times 10^{107}$, $\Delta G^0 = -611.8$ kJ)

11. (log $[Zn^{2+}] / [Cu^{2+}]$ = 37.22) **12.** ($K_w \gg 10^{-14}$)

13. (K = 10^{268}) **14.** (–1.30 $\times 10^3$ kJ mol^{-1}) **15.** (Mg) **16.** (Y > Z > X)

17. Zn **18.** (– 0.80 V, NO)

19. (a) $2Ag + Cu^{2+} \rightarrow 2Ag^+ + Cu$, (b) $MnO^-_4 + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$

(c) $2Cl^- + 2Ag^+ \rightarrow 2Ag + Cl_2$, (d) $H_2 + Cd^{2+} \rightarrow Cd + 2H^+$

20 (a) Zn | Zn^{2+} | | Cd^{2+} | Cd,

(b) Pt, H_2 | H^+ | | Ag^+ | Ag ,

(c) Pt | Fe^{2+}, Fe^{3+} | | $Cr_2O^{2-}_7$, H^+ , Cr^{3+} | Pt

21. (0.059 volt)   **22.** ([Cu^{2+}] = 2.97 × 10^{-12}M for E =0)   **23.** (E = −0.81 V)

24. (− 0.22 V)   **25.** (E =1.159V)

26. (E^0_{cell} = +0.01V, E_{cell} = −0.0785V,

No, correct representation is Pb|Pb^{2+} (10^{-3}M)||Sn^{2+}(1M)|Sn)

27. (a) The spontaneous cell reaction : Zn + 2Ag^+ (aq) Zn^{2+} (aq) + 2Ag (s)

(b) 1.56 V   (c) [Zn^{2+}] = 4 × 10^{-4} M

(d) As we add KI to cathode chamber, some Ag^+ will precipitate out as :

Ag^+ + I^- AgI

The above reaction reducing [Ag^+] from cathode chamber. This will reduce E_{cell} according to

Nernst's equation.

28. (0.0295 V)   **29.** (pH = 4)   **30.** (E = 0.059)

31. (E = 0.413 V)

32. (A) Hg_2Cl_2(s) + Cu(s) Cu^{2+}(aq) + 2Cl^- (aq) + 2Hg(l)

(B) $2Ag_{(s)} + 2IO_3^- + Zn^{2+} \longrightarrow 2AgIO_{3_{(s)}} + Zn_{(s)}$

(C) $Mn_{(s)} + 2OH^- + Cu^{2+} \longrightarrow Mn(OH)_{2_{(s)}} + Cu_{(s)}$

33. (0.42 V)

34. (K_{sp} = 1.1 × 10^{-16})

35. ([Br^-] : [Cl^-] = 1 : 200)

36. (K_{SP} = 10^{-5})

37. (−0.16V)

38. (a) 6 × 10^{22} electrons lost,

(b) 1.2 × 10^{24} electrons gained,

(c) 1.80 × 10^{23} electrons gained

39. (a) 0.75 F, (b) 0.69 F, (c)1.1 F

40. (i) 54 gm, (ii) 16.35 gm

41. (n = 4)

42. (0.112 litre)

43. (Rs. 0.75 x)

44. (i) 2.17 gm ; (ii) 1336. 15 sec

45. (42.2 %)

46. (1.023 × 10^5 sec)

47. (71.5 amp)

48.

	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

49. (1.12 mol, 12.535 litre)

50. (60 %)

51. (1.825g)

52. (2M)

53. (4.25×10^{-2} m)

54. (400 S cm^2 mol^{-1})

55. (i) 250 mho cm^2 mol^{-1} , (ii) 125 mho cm^2 equivalent^{-1}

56. (0.0125 mho g eq^{-1} m^2, 1.25×10^{-3} mho cm^{-1}

57. (0.00040 S cm^{-1} ; 2500 ohm cm)

58. (i) 6.25×10^5 ohm, (ii) 1.6×10^{-6} amp

59. (510×10^{-4} mho cm^2 mol^{-1})

60. (i) 400 S cm^2 mol^{-1} (ii) 12 %

61. (0.8)

62. (a = 0.5 , k = 10×10^{-4})

63. (10^{-10} mole^2 /litre^2)

64. (9.4×10^{-4} gm/litre)

65. (i) 7 (ii) 1×10^{-14}

EXERCISE # (O-II)

1. (D) **2.** (A) **3.** (B) **4.** (A) **5.** (B, D) **6.** (B,D)

7. (C) **8.** (A,D) **9.** (A,B,C,D) **10.** (B,C,D) **11.** (A,B)

12. (C,D) **13.** (B,D) **14.** (A,D) **15.** (A) **16.** (B)

17. (B) **18.** (C) **19.** (B) **20.** (D) **21.** (B)

22. (C) **23.** (B) **24.** (C) **25.** (A) **26.** (A)

27. (A) P, Q (B) P, Q (C) Q, R, (D) P,S **28.** (D)

EXERCISE # (S-II)

1.	(0.52 V, 0.61 V)	**2.**	(n = 2)	**3.**	(0.0295 V)	**4.**	(– 0.46 V)

5. (ii). 1.27 V, (iii) 245.1 kJ   **6.** (–0.037 V)

7. (115800C, 347.4 kJ)   **8.** (t = 193 sec)

9. (Final weight = 9.6g, 0.01 Eq of acid)   **10.** (t = 93.65 sec.)   **11.** (43.456g)

12. (1.9×10^6 year)   **13.** (0.1456 ampere)   **14.** (0.1934 gm/litre)

EXERCISE # (JEE–MAINS)

1. (A)	**2.**	(14)	**3.**	(127)			**4.**	(D)	**5.**	(46)	**6.**	(24)
7. (12)	**8.**	(760)	**9.**	(5.67 or 5.68)			**10.**	60	**11.**	(D)	**12.**	(D)
13. (B)	**14.**	(B)	**15.**	(A)	**16.**	(D)	**17.**	(C)	**18.**	(C)	**19.**	(C)
20. (C)	**21.**	(C)	**22.**	(C)	**23.**	(C)	**24.**	(C)	**25.**	(B)	**26.**	(A)
27. (D)	**28.**	(B)	**29.**	(D)	**30.**	(A)	**31.**	(A)	**32.**	(B)	**33.**	(D)
34. (B)	**35.**	(C)	**36.**	(C)	**37.**	(A)	**38.**	(D)	**39.**	(A)	**40.**	(A)
41. (B)	**42.**	(D)	**43.**	(A)	**44.**	(A)	**45.**	(D)	**46.**	(D)	**47.**	(A)
48. (C)	**49.**	(C)	**50.**	(C)	**51.**	(B)	**52.**	(A)	**53.**	(A)	**54.**	(A)
55. (C)	**56.**	(A)	**57.**	(C)	**58.**	(B)	**59.**	(C)	**60.**	(A)	**61.**	(D)

EXERCISE # (JEE-ADVANCED)

1. (A)	**2.**	(0.77)	**3.**	(7)	**4.**	(13.32)	**5.**	(0.215) **6.** (0.86)
7. (10)	**8.**	(–11.62)	**9.**	(6)	**10.**	(A)	**11.**	(D) **12.** (4)
13. (3)	**14.**	(A,B)	**15.**	(A)	**16.**	(D)	**17.** (D)	**18.** (B)
19. (D)	**20.**	(D)	**21.**	(B)	**22.**	(C)	**23.** (A,B,D)	**24.** (B)
25. (C)	**26.**	(D)	**27.**	(B)	**28.**	(D)	**29.** (D)	**30.** (A)
31. (A)	**32.**	(D)	**33.**	(55 S m^{-1})	**34.**	(B)		

35. (a) $E^0 = 0.59$ V, $\log_{10}K_{SP} = -10$ (b) 52.8, 10^{-6} moles   **36.** (B)

37. ($K_C = 10^{10}$)   **38.** (C)   **39.** (0.05)   **40.** (A)   **41.** (C)   **42.** (B)

43. (C)   **44.** ($\Delta H^0 = -49987$ Jmol^{-1}, $\Delta S^0 = -96.5$ J mol^{-1} K^{-1}, s = 1.47×10^{-5} M)

45. (B)   **46.** (7.95×10^{-5}M)   **47.** (decrease with time)

48. (A)   **49.** ($K_C = 6.26 \times 10^7$)   **50.** ($K_{sp} = 2.287 \times 10^{-12}$)