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# CHEMISTRY

TARGET : JEE Advanced - 2023

# CAPS – 10

# Electrochemistry

**1.** Based on the following information arrange four metals A,B, C and D in order of dereasing ability to act as reducing agents :

(I) Only A, B and C react with 1 MHCl to give $H_2(g)$

(II) When C is added to solutions of the other metal ions, metallic B and D are formed

(III) Metal C does not reduce $A^{n+}$.

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

**2.** A solution containing $H^+$ and $D^+$ ions is in equilibrium with a mixture of $H_2$ and $D_2$ gases at 25ºC. If the partial pressures of both the gases the 1.0 atm, find the ratio of $[D^+]/[H^+]$ :

$\left(\text{Given : } E^0_{D^+/D_2} = -0.003 \text{ V}\right)$

(A) 1.23 (B) 1.12 (C) 0.11 (D)1.0

**3.** The standared electrode potential for the following reaction is +1.33 V. What is the potential at pH = 2.0 ?

$Cr_2O_7^{2-}$ (aq, 1 M) + 14 $H^+$ (aq) + 6$e^-$ $\longrightarrow$ 2$Cr^{3+}$ (aq. 1 M) + 7$H_2O$ ($\ell$)

(A) +1.820 V (B) +1.990 V (C) +1.608 V (D) +1.0542 V

**4.** The electrolysis of acetate solution produces ethane according to reaction :

$$2CH_3COO^- \longrightarrow C_2H_6(g) + 2CO_2(g) + 2e^-$$

The current efficiency of the process is 80%. What volume of gases would be produced at 27ºC and 740 torr, if the current of 0.5 amp is passed through the solution for 96.45 min ?

(A) 6.0 L (B) 0.60 L (C) 1.365 L (D) 0.91 L

**5.** 100 mL of 0.05 M $CuSO_4$ (aq) solution was electrolyzed using inert electrodes by passing current till the pH of the resulting solution was 2. The solution after electrolysis was neutralized and then rtrated with excess KI and formed $I_2$ titrated with 0.04 M $Na_2S_2O_3$. Calcualte the required volume (in mL) of $Na_2S_2O_3$ :

(A) 112.5 mL (B) 100 mL (C) 125 mL (D) None of these

**6.** If a 100 mL solution of 0.1 M HBr is titrated using a very concentrated solution of NaOH, then the conductivity (specific conductance) of this solution at the equivalence point will be (assume volume change is negligible due to addition of NaOH). Report your answer after multiplying it with 10 in S $m^{-1}$. Assume a very little variation in molar conductance of NaBr between given concentration and at infinite dilution.

$\left[\text{Given } \lambda^\circ_{(Na^+)} = 8\times10^{-3}\,Sm^2mol^{-1}, \lambda^\circ_{(Br^-)} = 4\times10^{-3}\,Sm^2mol^{-1}\right]$

(A) 6 (B) 12 (C) 15 (D) 24

**7.** For electrolyte $MCl_2$ in water at $25^0$C the following data is given:

| conc mole/lit | : 0.16 | 1 |
|---|---|---|
| $\lambda_m\left(\Omega^{-1}cm^2mol^{-1}\right)$ | : 282 | 240 |

calculate $\lambda_m^\infty$ at 25°C in $\Omega^{-1}$ cm$^2$ mol$^{-1}$

(A) 300 (B) 320 (C) 310 (D) 290

**8.** The standard reduction potential of a silver chloride electrode is 0.2 V and that of a silver electrode is 0.79 V.

The maximum amount of AgCl that can dissolve in $10^6$ L of a 0.1 M $AgNO_3$ solution is

(A) 0.5 mmol (B) 1.0 mmol (C) 2.0 mmol (D) 2.5 mmol

**9.** Standard electrode potential of two half–reactions are given below

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

$Fe^{3+} \rightleftharpoons Fe^{2+}$; $E^o = +0.77$ V

If $Fe^{2+}$, $Fe^{3+}$ and Fe are kept together,

(A) The concentration of $Fe^{3+}$ increases. (B) The concentration of $Fe^{3+}$ decreases.

(C) The mass of Fe increases. (D) The concentration of $Fe^{2+}$ decreases.

## MULTIPLE CHOICE QUESTIONS

**10.** Given : $\underset{1\,bar}{Pt(s)\,|\,H_2(g)\,|\,0.1\,M\,NH_4OH(aq)}\,||\,\underset{1bar}{0.1\,M\,CH_3COOH(aq)\,|\,H_2(g)\,|\,Pt(s)}$

$pK_b(NH_4OH) = 5$; $pK_q\,(CH_3COOH) = 5$; $\frac{2.303RT}{F} = 0.06$

Volume of 0.1 M $NH_4$ OH in anode half cell = 100 mL.

Volume of 0.1 M $CH_3$ COOH in cathode half cell = 100 mL.

Which is/are correct statement ?

(A) The emf of given cell is 0.48 V.

(B) The emf of given cell is 0.36 V when 50 mL, 0.1 M NaOH added to cathode compartment

(C) The emf of given cell is 0.36 V when 50 mL, 0.1M HCl added to anode compartment

(D) The emf of given cell is 0.192 V when 100 mL 0.1M NaOH added to anode compartment

**11.** Consider the cell $Pt\left|H_2\left(p_1\,atm\right)H^+\left(x_1M\right)\right|\left|H^+\left(x_2M\right)\right|H_2\left(p_2atm\right)Pt$. The cell reaction will be spontaneous if

(A) $p_1 = p_2$ and $x_1 > x_2$ (B) $p_1 = p_2$ and $x_1 < x_2$ (C) $x_1 = x_2$ and $p_1 > p_2$ (D) $x_1 = x_2$ and $p_1 < p_2$

**12.** Which of the following statement is correct?

If $E^\circ_{Cu^{2+}|Cu} = 0.34V$ and $E^\circ_{Sn^{2+}|Sn} = 0.136V$, $E^\circ_{H^+|H_2} = 0.0V$

(A) $Cu^{2+}$ ions can be reduced by $H_2$(g)

(B) Cu can be oxidized by $H^+$

(C) $Sn^{2+}$ ions can be reduced by $H_2$

(D) Sn can be oxidized by $Cu^{2+}$

**13.** Which is/are correct statement?

(A) No corrosion takes place in vacuum

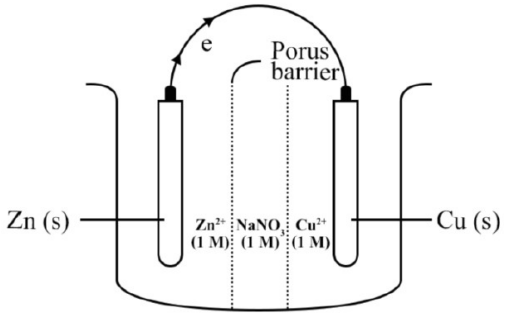
(B) Corrosion is protected by electroplating

(C) During rusting $Fe_2O_3 \cdot xH_2O$ formed

(D) In presence of electrolyte, corrosion takes place with greater rate

## COMPREHENSION # 3 (FOR Q. 14 TO Q.16)

A Galvanic cell consist of three compartments as shown in figure. The first compartment contains $ZnSO_4$ (1 M) and III compartment contain $CuSO_4$(1M). The mid compartment contains $NaNO_3$ (1 M). Each. compartments contain 1 L solution: $E^\circ_{Zn^{2+}/Zn} = -0.76; E^\circ_{Cu^{2+}/Cu} = +0.34$




**14.** The concentration of $Zn^{2+}$ in first compartment after passage of 0.1 F charge will be?

(A) 1 M (B) 1.05 M (C) 1.025 M (D) 0.5 M

**15.** The concentration of $NO_3^-$ in mid compartment after passage of 0.1 F of charge will be?

(A) 0.95 M (B) 0.90 M (C) 0.975 M (D) 1.05 M

**16.** The concentration of $SO_4^{2-}$ ion in III compartment after passage of 0.1F of charge will be?

(A) 1.05 M (B) 1.025 M (C) 0.95 M (D) 0.975 M

## NUMERIC ANSWER TYPE

**17.** Calculate the emf of the cell in mV (at least first two digits must match with correct answer)

Ag (s), $AgIO_3$ (s) | $Ag^+$ (xM), $HIO_3$ (1M)|| $Zn^{+2}$ (1M)| Zn (s)

If $K_{sp} = 3 \times 10^{-8}$ for $AgIO_3$ and $K_a = \frac{1}{6}$ for $HIO_3$ and $E^\circ_{cell}$ for $2Ag + Zn^{+2} \rightarrow 2Ag^+ + Zn$ is –1.56

K. (log 3 = 0.48) (Take $\frac{RT}{F} = 0.059$ ) (giving your answer in magnitude only)

**18.** During the discharge of a lead storage battery, the density of sulphuric acid fell from 1.294 to 1.139 g $ml^{-1}$. $H_2SO_4$ of density 1.294 gm $L^{-1}$ is 39% and that of density 1.139 gm $L^{-1}$ is 20% by weight. The battery holds 3.5 L of acid and the volume practically remains constant during discharge. Calculate the number of ampere hours for which the battery must have been used. The discharging reactions are:

$Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$ (Anodic reaction)

$PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4 + 2H_2O$ (Cathode reaction)

**19.** The conductivity of 0.1 M solution of a weak monoprotic acid is $2.19 \times 10^{-4}$ S $cm^{-1}$. The limiting molar conductivity of it is 400 S $cm^2$ $mol^{-1}$. If the dissociation constant of the acid is $y \times 10^{-6}$, what is the value of y?

**20.** Molar conductivity of aqueous solution of HA is 200 S $cm^2$ $mol^{-1}$, pH of this solution is 4. Calculate the value of $pK_a$ (HA) at 25ºC.

Given : $\Lambda_M^\infty(NaA) = 100\,S\,cm^2\,mol^{-1}$; $\Lambda_M^\infty(HCl) = 425\,S\,cm^2\,mol^{-1}$; $\Lambda_M^\infty(NaCl) = 125\,S\,cm^2\,mol^{-1}$

**21.** Match the Following:

| **Column-I** | **Column-II** |
|---|---|
| (A) $Au \left\| AuCl_4^- (1M) \right\| Li^+_{(aq)} (1M) \left\| Li \right.$ | (p) Spontaneous |
| (B) $Zn \left\| Zn^{2+}_{(aq)} (1M) \right\| Al^{3+}_{(aq)} (1M) \left\| Al \right.$ | (q) Non-spontaneous |
| (C) $Cu \left\| Cu^{2+} (C_1) \right\| Cu^{2+} (C_2) \left\| Cu \right.$, $C_1 > C_2$ | (r) $E^\circ_{cell} > 0$ |
| (D) $Ni \left\| Ni^{2+}_{(aq)} (1M) \right\| Cu^{2+}_{(aq)} (1M) \left\| Cu \right.$ | (s) $E^\circ_{cell} < 0$ |
| | (t) galvanic cell |

(A) (A - s; B - q, s; C -p; D - p, r)
(B) (A - q, s; B - q, s; C - q; D - p, r, t)
(C) (A - q; B - q; C - q; D - t)
(D) (A – p, q; B - r, s; C - q; D -t)

**22.** Column–I and Column–II contains four entries each. Entries of Column–I are to be matched with some entries of Column–II. One or more than one entries of Column–I may have the matching with the same entries of Column–II

| **Column-I** | **Column-II** |
|---|---|
| (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) Fairly concentrated solution of AgNO3 | (S) Ag deposition at cathode |

(A) A $\rightarrow$ P, Q; B $\rightarrow$ R, Q; C $\rightarrow$ Q, R; D $\rightarrow$ P, S
(B) A $\rightarrow$ P, Q; B $\rightarrow$ P, Q; C $\rightarrow$ Q, R; D $\rightarrow$ P, Q
(C) A $\rightarrow$ P, Q; B $\rightarrow$ R, Q; C $\rightarrow$ Q, R; D $\rightarrow$ P, S
(D) A $\rightarrow$ P, Q; B $\rightarrow$ P, Q; C $\rightarrow$ Q, R; D $\rightarrow$ P, S

**23.** In the Hall process, aluminum is produced by the electrolysis of molten $Al_2O_3$. How many seconds would it take to produce enough aluminum by the Hall process to make a case of 24 cans of aluminum soft drink, if each can use 5.0 g of Al, a current of 9650 amp is employed, and the current efficiency of the cell is 90.0%.

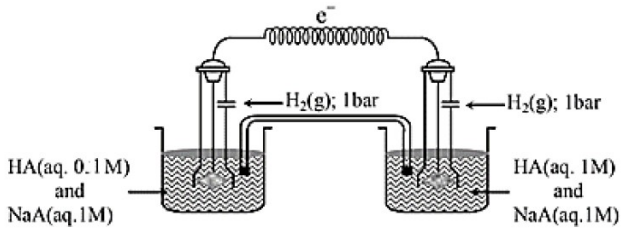
(A) 203.2 (B) 148.14 (C) 333 (D) 6.17

**24.** Copper reduces $NO_3^-$ into NO and $NO_2$ depending upon concentration of $HNO_3$ in solution. Assuming $[Cu^{2+}]$ = 0.1 M, and PNO = $P_{NO2}$ = $10^{-3}$ bar. At which concentration of $HNO_3$, thermodynamic tendency for reduction of $NO_3^-$ into NO and $NO_2$ by copper is same?

$\left[\text{Given}: E^{\circ}_{Cu^{2+}|Cu} = +0.3\text{volt}, E^{\circ}_{NO_3^-|NO} = +0.96\text{volt}, E^{\circ}_{NO_3^-|NO_2} = +0.79\text{volt}\right]$

(A) $10^{1.23}$ M (B) $10^{0.56}$ M (C) $10^{0.66}$ M (D) $10^{0.12}$ M

**25.** A cell diagram shown below contains one litre of buffer solution of HA ($pK_a$ = 4) and NaA in both compartments. What is the cell EMF?




(A) 0.03 V (B) 0.06 V (C) –0.06 V (D) None of these

## SUBJECTIVE ANSWER TYPE

**26.** Determine potential (in mV) of the cell : Pt | $Fe^{2+}$, $Fe^{3+}$ || $Cr_2O_7^{2-}$, $Cr^{3+}$, $H^+$ | Pt in which $[Fe^{2+}]$ = 0.75 M, $[Fe^{3+}]$ = 0.75 M, $[Cr_2O_7^{2-}]$ = 2 M, $[Cr^{3+}]$ = 4 M and $[H^+]$ = 1 M.

Given : $Fe^{3+} + e^- \longrightarrow Fe^{2+}$; E° = 0.77 V

$14\ H^+ + 6e + Cr_2O_7^{2-} \longrightarrow 2Cr^{3+} + 7H_2O$; E° = 1.35 V

2.303 RT/F = 0.06, log 2 = 0.3, log 3 = 0.48

**27.** A sample of water from a large swimming pool has a resistance of 9200Ω at 25°C when placed in a certain conductance cell. When filled with 0.02 M KCl solution, the cell has a resistance of 85 Ω at 25°C. 500 gm of NaCl were dissolved in the pool, which was thoroughly stirred. A sample of this solution gave a resistance of 7600 Ω . Calculate the volume of water in the pool.

Given: Molar conductance of NaCl at that concentration is 126.5 $\Omega^{-1}$ cm2 $mol^{-1}$ and molar conductivity of KCl at 0.02 M is 138 $\Omega^{-1}$ $cm^2$ $mol^{-1}$.