# 4. ELECTROCHEMISTRY

## Introduction

## Electrochemical Cells

1. Define an electrolytic cell, giving an example. 1
2. Define an electrochemical cell. 1
3. Distinguish between electrochemical cells and electrolytic cells. (Voltaic cell & Electrolytic cell) 2

## Electrode potential & standard electrode potential

4. How is a single electrode potential originated? 1
5. What is meant by single electrode potential? Name any two factors that affect the magnitude of the single electrode potential. 2
6. Define standard electrode potential. 2
7. What is a single electrode potential? How is it measured? 2

## Types of electrodes

## Standard Hydrogen Electrode (SHE)

8. What is meant by a primary reference electrode? Mention its one important use. 2
9. What is meant by the standard hydrogen electrode? Mentions its one use.
   Mention one important application of SHE with an example. 2
10. SHE can act as both anode and cathode. Give reason. 2
11. What is the function of platinized Pt in SHE? Write the half-reaction when SHE acts as the cathode and anode. 1+2
12. The standard hydrogen electrode can be used as a reference electrode. The standard electrode potential of the standard hydrogen electrode is taken as zero.
    A. Define the standard hydrogen electrode.
    B. What is the major application of the standard hydrogen electrode?
    C. Draw a well-labelled diagram of the standard hydrogen electrode.
    D. What is meant by standard electrode potential? (1+1+2+1)
13. What is meant by the standard reduction of Cu being 0.34V? 2

## Calomel electrode
## Electrochemical series

14. Define the term electrochemical series. 1

## Applications of the Electrochemical Series

15. Refer to the list of electrode potentials below to answer parts a to d. $Ag^+(aq) + e^- \rightleftharpoons Ag(s)$ voltage = +0.80 V
    $Co^{2+}(aq) + 2e^- \rightleftharpoons Co(s)$ voltage = –0.28 V
    $Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$ voltage = +0.34 V
    $Pb^{2+}(aq) + 2e^- \rightleftharpoons Pb(s)$ voltage = –0.13 V

$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$ voltage = –0.76 V

a Which metal in the list is the best reducing agent?

b Which metal ion in the list is most difficult to reduce?

c Which metal in the list is most reactive?

d Which metal ion in the list is the easiest to reduce? 4

## 1. Displacement Reactions

16. Four metals labeled A, B, C, and D react with each other and acids in the following way: B displaces only C from the solution. Only A and D displace hydrogen from 1M HCl. None of the metals will displace D from the solution. Arrange the four metals with hydrogen in the activity series. 3

## 2. Calculation of EMF of the Cell

17. Construct a Galvanic cell whose reaction is:
$Fe(s) + H_2SO_4(aq.) \rightarrow FeSO_4(aq.) + H_2(g)$ 2
You are given the standard reduction potential of $Cu^{+2}/Cu$ and $Fe^{+2}/Fe$ as -0.34V and -0.44 V, respectively.
a) Construct a galvanic cell, indicating anode and cathode.
b) Write the cell reaction and calculate the standard emf of the cell. 5
18. The standard electrode potentials for the following electrodes are;
$Zn^{++} + 2e^- \rightarrow Zn$, $E^o = -0.76V$
$Fe^{+++} + e^- \rightarrow Fe^{++}$, $E^o = 0.77V$
Represent a suitable galvanic cell and point out which one will be the cathode?
With 1M solutions of the ions, what will be the emf? (ans = 1.53 V)
Will the reaction $Zn^{++} + 2\,Fe^{++} \rightarrow Zn + 2\,Fe^{+++}$ occur? Give a reason. 4
19. The standard electrode potentials are given as:
$E^o_{Zn++/Zn} = -0.76$ V, $E^o_{Fe^{+++}/Fe^{++}} = +0.77$V
Construct a cell notation for a galvanic cell, indicating anode and cathode.
Calculate the emf at 1M solutions of ions.
Will the reaction $Zn^{+2} + 2Fe^{2+} \rightarrow Zn + 2Fe^{+3}$ occur? 3
20. The standard electrode potential for the following electrodes is:
$E^0\ Mg^{++}/Mg = -2.37V$ and $E^0\ Cu^{++}/Cu = +0.34V$
Construct a cell notation for an electrochemical cell.
Write the reactions taking place at the anode and cathode.
Calculate the emf of the cell. 3
21. The standard electrode potential for $Fe^{+3}/Fe^{+2}$ and $I_2/I^-$ are + 0.77 V and + 0.54 V respectively.
Draw the standard cell notation.
Identify the anode and cathode as the current drawn from it.
Write the cell reaction taking place at the electrodes.
Calculate the standard cell potential.
22. The standard electrode potentials of copper and silver are;
[$E^o_{Cu++/Cu} = +0.34$V and $E^o_{Ag+/A} = +0.80$V]
Construct cell notation for an electrochemical cell.
Calculate the emf at a 1M solution of its ions.
Will the reaction $Cu + 2\,Ag^+ \rightarrow Cu^{2+} + 2\,Ag$ occur? Give a reason. 3
23. An electrochemical cell (Galvanic cell) is designed by coupling a Zn electrode with a standard hydrogen electrode (SHE), given $E_{Zn2+/Zn} = -0.76$ V.
   i. Draw the galvanic cell. [2]
   ii. Write down the complete cell notation. [1]
   iii. Write cell notation. [1]
   iv. Calculate the emf of the cell. [1]

24. Design a Galvanic cell in which the reaction:
    $Zn(s) + 2\ Ag^{+} \rightarrow Zn^{++}(aq) + 2\ Ag(s)$ takes place. Further predict
    i. Which of the electrodes is negatively charged?
    ii. The carriers of the current in the cell.
    iii. Individual reaction in each electrode. 4
25. You are given a zinc rod, a copper rod, zinc sulphate and copper sulphate solutions, and the standard electrode potential of Zn and Cu are -0.76V and 0.34V, respectively.
    i. Represent an electrochemical cell, indicating anode and cathode.
    ii. Write cell notations.
    iii. What is the emf of the cell? 2+1+1
26. You are given a zinc rod, copper rod, zinc sulphate and copper sulphate solutions, and the standard electrode potential of zinc and copper are -0.76 V and +0.34 V, respectively.
    i) Represent an electrochemical cell, indicating anode and cathode.
    ii) Write net cell reactions. iii) What will be the emf of the cell? 3
27. An electrochemical cell is constructed by using aluminium and silver electrodes whose electrode potential values are
    $E^{0}_{Al3+/Al} = -1.67V$ $E^{0}_{Ag+/Ag} = 0.80\ V$
    a. What is meant by an electrochemical cell?
    b. Represent an electrochemical cell using the above electrodes.
    c. Write down complete cell reactions.
    d. Calculate the emf of the cell. 5
28. Cell notation for a reaction is $A|A^{++}(aq, 1\ M) \parallel B+(aq, 1\ M)|B$. The overall cell reaction is
    a. $A \rightarrow A++ + 2e–$ b. $B^{+} + e– \longrightarrow B$
    c. $A^{+} + B+ \rightarrow AB$ d. $A+2B+ \longrightarrow A+++2B$

### 3. Prediction of Feasibility of a Redox Reaction

29. Why does the $AgNO_3$ solution become bluish when the copper rod is dipped into it? (The standard reduction potentials of Cu and Ag are +0.3V and +0.8V, respectively.) 2
30. Why does the silver nitrate solution turn bluish when the copper rod is dipped into it? [given $E^{0}Cu^{+2}/Cu$ = 0.34Vand $E^{0}Ag^{+}/Ag$=0.80V] 2
31. Will the reaction occur? $Zn^{++} + 2Fe^{2+} \rightarrow Zn + 2Fe^{+++}$
    $E^{o}_{Zn^{++}/Zn} = -0.76V$ $E^{o}_{Fe^{3+}/Fe^{2+}} = 0.80V$ 2
32. Predict whether the following reaction will occur spontaneously or not. $Pb^{+2} + 2\ Ag \rightarrow 2Ag^{+} + Pb$
    Given, $E_{Ag^{+}/Ag} = 0.80\ V$; $E^{0}_{Pb^{++}/Pb} = -0.13\ V$ 2
33. Predict which of the following reactions occurs spontaneously.
    i) $2\ Fe^{+2} + Sn^{+4} \rightarrow 2\ Fe^{+3} + Sn^{+2}$
    ii) $2\ Fe^{+3} + Sn^{+2} \rightarrow 2\ Fe^{+2} + Sn^{+4}$
    Given standard reduction potentials of:
    $Fe^{+3}/Fe^{+2}$ and $Sn^{+4}/Sn^{+2}$ are +0.77 V and +0.15V respectively. 4
34. Can a solution of 1M $CuSO_4$ be stored in a vessel made up of Nickel? If not, why? (Given: $E^{o}_{Ni^{++}/Ni} = -0.25V$ $E^{o}_{Cu^{++}/Cu} = 0.34V$) 2
35. Can $CuSO_4$ be stored in a Zinc vessel?
    $E^{0}_{Cu+2/Cu} = 0.34\ V$ $E^{0}_{Zn+2/Zn} = -0.76\ V$ 2
36. Two metallic elements X and Y have the following standard electrode potential. X= + 0.40V Y= - 0.80V
    What would you expect to occur if X is added to an aqueous solution of the salt of Y? Why? 2

37. Four metals A, B, C, and D react in the following way:
    **B** displaces only **A** from its solution. Only **D** and **C** displace hydrogen from 1M HCl solution. None of the metals will displace **C** from its solution.
    i) Make the activity series of the above four metals with hydrogen. 1

ii) The standard potentials for the following electrodes are:
$C^{++} + 2e^- \rightarrow C$; Eo= -0.76V
$D^{+++} + e^- \rightarrow D^{++}$; Eo= +0.77V

a) Construct the galvanic cell by pointing out the cathode and anode.
b) With 1M solution of the ions, what will be the EMF of the cell?

c) Will the reaction $C^{++} + 2D^{++} \rightarrow C + D^{+++}$, Occur? Give a reason.

## Examples of Voltaic cell

**Zn-Cu cell**

## Cell potential and standard cell potential

## Relationship between cell potential and free energy

## Commercial batteries

38. Why is a dry cell not rechargeable?

1. **Secondary cells** (Rechargeable cell/Battery):

**The acid lead storage battery**

**Lithium – ion battery** (Lithium-polymer):

# Fuel cells (hydrogen/oxygen)

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