Instruction:
1- Use the following constants where applicable. Faraday constant F = 96485 C/mol, gas constant R = 8.314 J/mol K, Temperature T = 298 °K . 2- Use the back of the page if more space needed.

PART I: Multi-choice questions, circle the right answer. (10 Marks)

1- Determine the cell notation for the redox reaction given below.

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

a) $Ag^+(aq)$ | $Ag(s)$ || $Sn(s)$ | $Sn^{2+}(aq)$, b) $Sn(s)$ | $Sn^{2+}(aq)$ || $Ag^+(aq)$ | $Ag(s)$,

c) $Ag(s)$ | $Ag^+(aq)$ || $Sn^{2+}(aq)$ | $Sn(s)$ d) $Sn^{2+}(aq)$ | $Sn(s)$ || $Ag(s)$ | $Ag^+(aq)$

2- When the energy of Fermi level E_f > lumo energy for the reactant [O] then,

a) Electrons are transferred from reactant to the electrode. b) Electrode is at the equilibrium.

c) No electron transfer at all. d) Electrons are transferred from electrode to reactant.

3- The movement of solution ionic species due to the concentration gradient is called

b) Convection a) Diffusion c) Reaction d) Migration

4- Which of the following reactions would be the most spontaneous at 298 K?

a) $A + 2\,B \rightarrow C$; $E°_{cell} = +0.98$ V, b) $A + B \rightarrow 2\,C$; $E°_{cell} = -0.30$ V,

c) $A + B \rightarrow C$; $E°_{cell} = +1.22$ V d) $A + B \rightarrow 3\,C$; $E°_{cell} = -0.15$ V

5- Electrode activation polarization is originating from,

a) Formation of a diffusion layer at the electrode surface. b) The high resistance of the electrolyte.

c) The energy required to overcome the energy barrier of the rate-determining step.

d) all of the above.

6- Which of the following reactions would have the smallest value of equilibrium constant (K) at 298 °K?

a) $A + B \rightarrow C$; $E°_{cell} = +1.10$ V, b) $A + 2\,B \rightarrow C$; $E°_{cell} = +0.85$ V

c) $A + B \rightarrow 2\,C$; $E°_{cell} = -0.30$ V, d) $A + B \rightarrow 3\,C$; $E°_{cell} = -0.15$ V

7- In Cyclic Voltammetry (CV), the voltage is scanned from a lower limit to an upper limit during time and the current is then measured as a function of:

a) Concentration, b) Time, c) Scan rate, d) Potential

8 - In the Potential Step Voltammetry (PSV) the applied voltage is jumped from V_1 to V_2 and the resulting current is then measured as a function of:

a) Potential, b) Concentration, c) Scan rate, d) Time.

9- For the fast one-electron reversible reaction at room temperature, the anodic and cathodic peak separation (ΔE_{peak}) equals about

a) 0.118 V b) 0.059 V c) 0.045 V

d) 0.236 V

10- The sum of cation transport number (t^+) and the anion transport number (t^-) is equal to

a) 10 b) 0.5 c) 1.0 d) 0.0

PART II: Answer true or false the following (10 Marks)

1- The diffusion controlled reaction occurs when the rate depends on the rate the rate of charge transfer while the kinetic controlled reaction occurs when depends on the spontaneous transfer of the electroactive species. [ ]

2- The cathodic reaction rate becomes faster when the applied potential is more positive than equilibrium potential.

[ ]

3- The overpotential (η) is the potential applied to the working electrode relative to the redox equilibrium potential.

[ ]

4- The exchange current (I_o) is the current at equilibrium is an intensive parameter and is not influenced by the electrode surface area and the kinetics or speed of the reaction.

[ ]

5- Galvanic corrosion occurs in the area when the ion concentration gradient is existing. [ ]

6- In linear sweep voltammetry (LSV) the ions flux to the electrode surface is considerably smaller at high scan rates and is high at low scan rates.

[ ]

7- The difference of limiting molar conductivity (Λ°) of different pairs of electrolytes having a common cation or a common anion is almost same.

[ ]

8 - Match between the following parameters:

a) Q = 1	i) $E_{cell} > 0$
b) Q > K	ii) $E_{cell} = 0$
c) Q < K	iii) $E°_{cell} < 0$
d) $\Delta G° < 0$	iv) $E_{cell} = E°_{cell}$
e) $\Delta G° > 0$	v) $E_{cell} < 0$

f) Q = K

vi) $E°_{cell} > 0$

PART III: Answer only four questions from the following: **(10 Marks)**

1- Define the following terms:

a- Diffusion:

b- Ion Transport number

c- Strong and Weak Electrolytes

2- Balance the following redox reaction and identify the anodic and cathodic reactions.

$$MnO_4^-(aq) + Fe^{2+}(aq) + H^+(aq) \rightarrow Mn^{2+}(aq) + Fe^{3+}(aq) + H_2O(l)$$

Anodic :

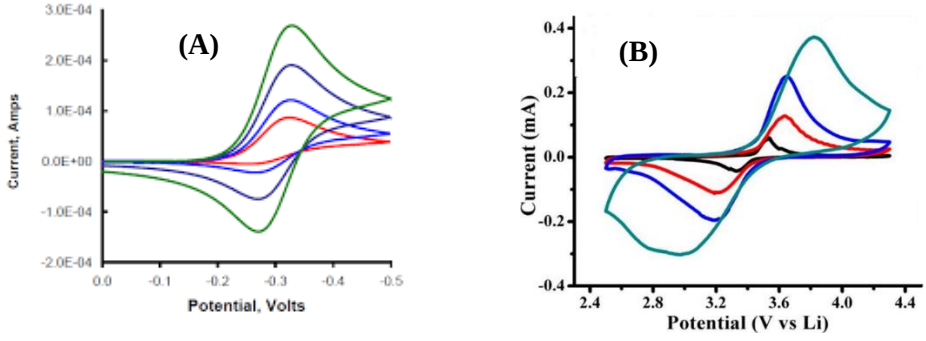
Cathodic:

Overall :

3- Explain the mechanisms for iron corrosion process in the air by sketching a diagram and writing down the relevant anodic, cathodic and overall electrochemical reactions.

4- Briefly list and explain only four types of the metal corrosion.

5- The diagrams below show the cyclic voltammetry of two electrochemical reactions (a and b) at increasing scan rate.



a -Indicate the anodic and cathodic reactions on each diagram, peak potential and peak current on the diagram.

b- Discuss the anodic-cathodic peaks separation, reversibility and reaction kinetics of each reaction.

6- Sketch the diagram showing the concentration profile at the electrode surface of the reactant and product for the electrochemical reaction $O + ne \rightarrow R$ at time of $0 < t1 < t2 < t3$ of the reaction progress.

PART IV: Problem solving. Answer only four questions from the following. (10 Marks)

1- Calculate the activation polarization η_{act} if the current density (i) equals 8 times the exchange current density (i_o). Given that Tafel slope β = 0.118 V/dec

2- Calculate the mean activity co-efficient ($\gamma\pm$) of Na_2SO_4 at a molality of 0.001 in aqueous solution at 25°C.

3- An electrochemical galvanic cell is based on the following two half-reactions:

Zn^{2+}(aq, 0.01 M) + $2e^-$ → Zn(s) **E°= – 0.76 V**

Cu^{2+}(aq, 0.1 M) + $2e^-$ → Cu(s) **E°= + 0.34 V**

a- Identify the anodic, cathodic reaction and the cell overall reaction.

b- Calculate the E^{o}_{cell}, and E_{cell} for the cell

c- Calculate the Gibbs free energy change ΔG and the equilibrium constant (K) at 298 ^{o}K .

4- Using the Tafel equation, calculate the current flowing at overpotentials (η) of 0.3 V for a reaction at 298 K in which n = 1, α = 0.5, i_0 = 2.0 x 10^{-6} A.

5- Calculate the limiting molar conductivity (Λ^0) at 25 °C for sodium sulphate (Na_2SO_4) and lanthanum sulphate ($La_2(SO_4)_3$ giving the following individual ionic conductivity (λ^0) for Na^+ (aq) = 50.1 S cm^2/mol, La^{3+} (aq) = 209.1 S cm^2/mol and SO_4^{2-} (aq) = 160.0 cm^2/mol.