NAME:______________________ 21/06/23. COMBN:____________

AHSN

S.6 TOPICAL TEST 1 TERM II 2023

ELECTROCHEMISTRY

1 hour 45 minutes

PROPOSED MARKING GUIDE by KIYUMBI Emmanuel.

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Instructions

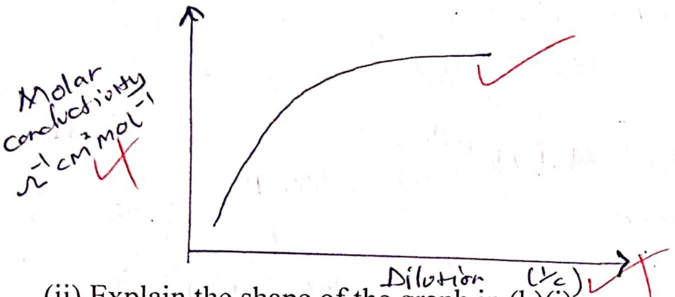
Attempt all questions

1. (a) Define the term molar conductivity. (01 mark)

OR: Electrolytic conductivity divided by concentration.

The conductance of an aqueous solution containing one mole of an electrolyte placed between electrodes of a unit distance apart and each of a unit cross sectional area.

(b) (i) Sketch a graph to show the variation of molar conductivity of sodium chloride with dilution. (02 marks)



(ii) Explain the shape of the graph in (b)(i). (2½ marks)

Molar conductivity increases with increase in dilution and reaches a constant value at infinite dilution. This is because increase in dilution makes the ions far apart and ionic interference is reduced hence the mobility of the ions increases hence increase in molar conductivity.

At infinite dilution, ionic interference has been eliminated and any further dilution results into no change in molar conductivity.

(c) The electrolytic conductivity of saturated solution of silver chloride at 25^0C is $1.5 \times 10^{-4}\Omega^{-1}m^{-1}$. The molar conductivities at infinite dilution of silver and chloride ions are 6.2×10^{-3} and 7.7×10^{-3} $\Omega^{-1}m^{-1}mol^{-1}$ respectively. Determine the solubility of silver chloride at 25^0C. 3½

$\Lambda_o AgCl = \Lambda_o Ag^+ + \Lambda_o Cl^-$

$= 6.2 \times 10^{-3} + 7.7 \times 10^{-3}$

$= 1.39 \times 10^{-2}\ \Omega^{-1}m^2mol^{-1}$

$\Lambda_o = \frac{K}{1000c}$

$\Lambda_o = 1.5 \times 10^{-4}$

$c = \frac{K}{\Lambda_o \times 1000}$

$C = \frac{1.5 \times 10^{-4}}{1000 \times 1.39 \times 10^{-2}}$

$c = 1.079 \times 10^{-5}$ moldm^{-3}

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2. (a) Silver chloride dissolves in water according to the following equation:

$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$

Write the expression for the solubility product ksp of silver chloride. (01 mark)

$K_{sp} = [Ag^+][Cl^-]$

(b) The electrolytic conductivity of a saturated solution of silver chloride in water at 25^0C is 3.41×10^{-6} $\Omega^{-1}cm^{-1}$ and that of pure water is 1.6×10^{-6} $\Omega^{-1}cm^{-1}$. Calculate the solubility product of a saturated solution of silver chloride at 25^0C. (The molar conductivity at infinite dilution of silver nitrate, Potassium nitrate and potassium chloride are 133.4, 145.0 and 149.9 $\Omega^{-1}cm^2mol^{-1}$ respectively at 25^0C. (4½ marks)

$\Lambda_o AgCl = \Lambda_o AgNO_3 + \Lambda_o KCl - \Lambda_o KNO_3$

$= 133.4 + 149.9 - 145.0$

$= 138.3\ \Omega^{-1}cm^2mol^{-1}$

$K_{AgCl} = K_{solution} - K_{water}$

$= 3.41 \times 10^{-6} - 1.6 \times 10^{-6}$

$= 1.81 \times 10^{-6}\ \Omega^{-1}cm^{-1}$

from $\Lambda_o = \frac{1000K}{c}$

$c = \frac{1000K}{\Lambda_o}$

$c = \frac{1000 \times 1.81 \times 10^{-6}}{138.3}$

$= 1.31 \times 10^{-5}\ mol dm^{-3}$

$ksp = (1.31 \times 10^{-5})^2$

$= 1.72 \times 10^{-10}\ mol^2 dm^{-6}$

3. (a) Write

(i) Equation for the ionization of methanoic acid in water. (1½ marks)

$HCOOH_{(aq)} \rightleftharpoons H^+_{(aq)} + HCOO^-_{(aq)}$

or $HCOOH_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + HCOO^-_{(aq)}$

(ii) The expression for the acid dissociation constant ka, for methanoic acid. (1 mark)

$Ka = \frac{[HCOO^-][H^+]}{[HCOOH]}$ or $Ka = \frac{[H_3O^+][HCOO^-]}{[HCOOH]}$

(b) The molar conductivities of some electrolytes at infinite dilution at 25^0C are given in the table below:

Electrolyte	Molar conductivity at infinite dilution (Scm^2mol^{-1})
Sodium chloride	113.0
Sodium methanoate	101.0
Sodium hydroxide	252.2
Hydrochloric acid	397.8

Calculate the molar conductivity of methanoic acid at infinite dilution. (03 marks)

from ~~$NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$~~ $HCOONa_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + HCOOH_{(aq)}$

$\Lambda_o(HCOOH) = \Lambda_o(HCOONa) + \Lambda_o HCl - \Lambda_o NaCl$

$= 101.0 + 397.8 - 113.0$

$= 385.8\ Scm^2mol^{-1}$

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(c) The molar conductivity of a 0.05M methanoic acid solution is $24.318 Scm^2mol^{-1}$ at 25^0C.

Calculate

(i) Degree of ionization of methanoic acid at 25^0C (1½ marks)

Degree of ionisation $\alpha = \frac{\Lambda_c}{\Lambda_o}$

$= \frac{24.318}{385.8}$

$= 0.063$ or 6.3%

(ii) Dissociation constant, ka of methanoic acid at 25^0C. (02 marks)

$k_a = \frac{\alpha^2 c}{1-\alpha}$

$= \frac{(0.063)^2 \times 0.05}{1-0.063}$ $= 2.118 \times 10^{-4} moldm^{-3}$

4. The table blow shows the atomic radius and the first ionization energy of some elements in period (III) of the periodic table.

Element	**Mg**	**Ca**	**Sr**	**Ba**
Standard electrode potential E°(v)	-2.37	-2.87	-2.89	-2.91

(a) (i) Identify the element which is the most powerful reducing agent. (1 mark)

~~B~~ Ba or Barium.

(ii) Give a reason for your answer in (a)(i) (1½ marks)

Barium has the highest negative electrode potential.

(b) (i) State the trend in standard electrode potential of the elements?. (1 mark)

The electrode potential of elements becomes more negative from magnesium to barium. OR Electrode potential increases from magnesium to barium.

(ii) Explain your answer in (b) (i) (2 marks)

From magnesium to Barium, atomisation energy, ionisation energy and hydration energy decrease. However both atomisation energy and ionisation energy decrease more rapidly than hydration energy thus making the electrode potential negative.

5. ~~What is meant by the term~~: The standard electrode potential for some half cells are shown below energy

$Fe^{3+}(aq) / Fe^{2+}(aq)$ ⟶ +0.76V

$I^2(aq) / I^-(aq)$ ⟶ +0.54V

(a) Write

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(i) the cell convention for the combined cell. (1 mark)

$Pt_{(s)} / I^-_{(aq)}, I_{2(aq)} // Fe^{3+}_{(aq)}, Fe^{2+}_{(aq)} / Pt_{(s)}$

(ii) the equation for the overall cell reaction (1½ mark)

$2I^-_{(aq)} + 2Fe^{3+}_{(aq)} \longrightarrow I_{2(aq)} + 2Fe^{2+}_{(aq)}$

(b) Calculate the overall electrode potential for the cell. (1½ marks)

$E^\theta_{cell} = E^\theta_{cathode} - E^\theta_{anode}$

$= +0.76 - +0.54$

$= +0.22$ volts.

(c) (i) State whether the reaction is feasible or not (½ mark)

The reaction is feasible

(ii) Give a reason for your answer. (½ mark)

The overall electrode potential (emf) of the cell is postive.

6. (a) (i) Define **standard electrode potential.** (02 marks)

Standard electrode potential is the potential difference or reduction potential established when a metal electrode is dipped in a 1 molar solution of its ions measured relative to the standard hydrogen electrode at 25°C and 1 atmosphere.

(ii) Why is it not possible to measure standard electrode potential absolutely? (02 marks)

This is because it is necessary to have a second electrode which also has its own potential difference with respect to its solution thus making the measurement relative rather than absolute.

(iii) Discuss the factors which affect the value of standard electrode potential. (5½ marks)

Atomisation energy or sublimation energy:

The higher the atomisation energy, the lower the electrode potential value because it becomes difficult to convert the element into gaseous atoms.

Ionisation energy

The higher the ionisation energy, the lower the electrode potential of the element because it becomes difficult to convert gaseous atoms into gaseous ions.

Hydration energy.

The higher the hydration energy, the higher the electrode potential because the gaseous ions can easily be hydrated in aqueous solution.

END.

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