EXERCISE 3.4

MODULE 3 TOPIC 3 Units 1 & 2, p. 131 – 137
Gr 10 Physical Sciences 3-in-1

QUESTION 1

Water is considered as a polar solvent.

1.1 Define the process of *dissociation*.

1.2 Explain the process of hydration of copper(I) chloride ($CuC\ell$) crystals.

QUESTION 2

Potassium chloride ($KC\ell$), barium nitrate ($Ba(NO_3)_2$) and copper sulphate ($CuSO_4$) are examples of ionic salts that respectively dissociates in water to form an electrolyte.

2.1 Define the term electrolyte.

2.2 Write a chemical equation to show how each of the following salts dissociate in water.

2.2.1 potassium chloride ($KC\ell$)

2.2.2 barium nitrate ($Ba(NO_3)_2$)

2.2.3 copper sulphate ($CuSO_4$)

2.3 If 2 moles of potassium ions form during the reaction in QUESTION 2.2.1, how many moles of the metal salt has dissolved?

QUESTION 3

Which of the following substances (**A** to **D**) can be classified as an electrolyte when it is in an aqueous solution? For each substance that is an electrolyte, write a balanced chemical equation to support your answer.

A – ammonia (NH_3)

B – magnesium chloride ($MgC\ell_2$)

C – sulphuric acid (H_2SO_4)

D – sugar ($C_{12}H_{22}O_{11}$)

QUESTION 4

Two investigations (**A** and **B**) were conducted in which the electrical conductivity of three different potassium chloride solutions and a calcium chloride solution was tested at 25ºC. The results are indicated in the table below. The distance between the electrodes and the voltage applied was kept constant.

Experiment	Formula of substance	Concentration of solution ($mol \cdot cm^{-3}$)	Current (A)
1	$KC\ell$	10	0,013
2	$KC\ell$	20	0,025
3	$KC\ell$	30	0,041
4	$CaC\ell_2$	20	0,040

4.1 For investigation **A**, compare Experiments **1**, **2** and **3**:

4.1.1 Name the independent and dependent variables.

4.1.2 List TWO variables which were controlled (kept constant).

4.1.3 Plot a graph showing the relationship between the concentration of the solution versus the current.

4.1.4 Write a justified conclusion for the investigation.

4.2 For investigation **B**, compare the results of Experiment **2** and **4**:

4.2.1 Write down the investigative question.

4.2.2 Name the independent and dependent variables.

4.2.3 Write a justified conclusion for the investigation.

4.3 In a third investigation (**C**) two solutions were prepared:

○ 2 g $KC\ell$ in 100 mℓ water ○ 2 g $CaC\ell_2$ in 100 mℓ water

The results are shown in the table below.

Experiment	Formula of substance	Mass of substance in 100 mℓ water (g)	Current (A)
1	$KC\ell$	2	?
2	$CaC\ell_2$	2	?

4.3.1 Which of the solutions (Experiment **1** or **2**) will yield the highest conductivity?

4.3.2 Give a detailed reason for your answer in QUESTION 4.3.1.

HINT

Refer to the number of moles of ions of each substance per 100 mℓ water.

EXERCISE ANSWERS

QUESTION 1

1.1 Dissociation is the process by which an ionic compound e.g. a salt or a strong base separates into its constituent ions.

1.2 ○ The process of hydration of the ionic compound $CuC\ell$ in water as solvent involves that

○ the Cu^+ and $C\ell^-$ ions are attracted to the polar H_2O molecules and

○ separated from the crystal lattice, after which

○ each ion becomes surrounded by water molecules.

QUESTION 2

2.1 Solutions or molten substances that contain free moving ions and can conduct electricity are called electrolytes.

2.2.1 $KC\ell(s) \xrightarrow{H_2O} K^+(aq) + C\ell^-(aq)$

2.2.2 $Ba(NO_3)_2(s) \xrightarrow{H_2O} Ba^{2+}(aq) + 2NO_3^-(aq)$

2.2.3 $CuSO_4(s) \xrightarrow{H_2O} Cu^{2+}(aq) + SO_4^{2-}(aq)$

2.3.2 moles of $KC\ell(s)$

QUESTION 3

A – electrolyte $NH_3(\ell) + H_2O(\ell) \rightarrow NH_4^+(aq) + OH^-(aq)$

B – electrolyte $MgC\ell_2(s) \rightarrow Mg^{2+}(aq) + 2C\ell^-(aq)$

C – electrolyte $H_2SO_4 + H_2O(\ell) \rightarrow H_3O^+(aq) + SO_4^{2-}(aq)$

D – not an electrolyte

QUESTION 4

4.1.1 independent variable: concentration of the solution

dependant variable: current, i.e. conductivity

4.1.2 ○ distance between the electrodes

○ voltage applied

○ the type of electrolyte, i.e. a $KC\ell$ solution

○ the temperature of the solutions

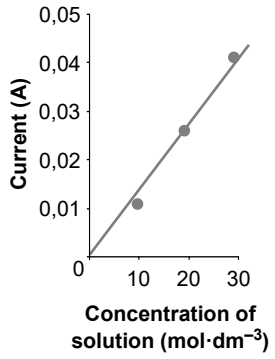
NOTE

These factors can influence the electric current because they affect the flow-rate of the ions through the electrolyte.

NOTE

Temperature can influence the solubility of the substances.

4.1.3 **Electric current (A) versus the concentration of the electrolyte (mol·dm^{-3}) in an electrolytical cell**



4.1.4 For the same type of solution at the same temperature, the conductivity of a solution increases as its concentration increases, because the number of ions per unit volume increases.

4.2.1 Which solution, $KC\ell(aq)$ or $CaC\ell_2(aq)$, will be the better conductor of electricity, if they have the same concentration and are at the same temperature?

4.2.2 independent variable: the type of electrolyte, i.e. the number of ions per formula unit of the salt

dependant variable: current strength, i.e. conductivity

4.2.3 If different solutions of the same concentration and temperature are compared, the salt that produces more ions per formula unit will have a higher ion concentration and therefore a better electrical conductivity in an aqueous solution.

4.3.1 They will have the same conductivity.

NOTE

Perform a calculation to show that the solutions contain the same number of ions per unit volume of an aqueous solution.

4.3.2 **STEP 1** – Calculate the **number of moles** of each substance per 100 mℓ solution

$$n(KC\ell) = \frac{m}{M} = \frac{2}{74,5} = 0,027$$

$$n(CaC\ell_2) = \frac{m}{M} = \frac{2}{111} = 0,018$$

$M(KC\ell) = 39 + 35,5 = 74,5$

$M(CaC\ell_2) = 40 + (2 \times 35,5) = 111$

STEP 2 – Give the **ratio** of the number of **ions per formula unit** of the substances

REMEMBER

$KC\ell(s) \xrightarrow{H_2O} K^+(aq) + C\ell^-(aq)$ *(dissociates into 2 ions per formula unit)*

$CaC\ell_2 \xrightarrow{H_2O} Ca^{2+}(aq) + 2C\ell^-(aq)$ *(dissociates into 3 ions per formula unit)*

ions per formula unit ($KC\ell : CaC\ell_2$) = 2 : 3

STEP 3 – Calculate the **ratio** of the number of **moles of ions per unit volume** of the solutions

moles of ions per 100 mℓ ($KC\ell : CaC\ell_2$): $0,027 \times 2 : 0,018 \times 3$

$= 0,054 : 0,054$

$= 1 : 1$

Conclusion

The 1:1 molar ratio of ions per 100 mℓ indicate that the two solutions have the same ion concentration and thus the same conductivity.