THE UNITED REPUBLIC OF TANZANIA
NATIONAL EXAMINATIONS COUNCIL OF TANZANIA
DIPLOMA IN SECONDARY EDUCATTION EXAMINATION

732/2B **CHEMISTRY 2B**

Time: 3 Hours **ANSWERS** **Year: 2022**

Instructions.

1. This paper consists of three questions.
2. Answer **all** questions.
3. Cellular phones are **note** allowed in the examination room.
4. Write your **examination Number** on every page of your answer booklet(s).

1. Titration to Determine the Amount of Water of Crystallization ($Na_2CO_3 \cdot xH_2O$)

Given:

- T1 = Hydrated sodium carbonate (unknown x)
- T2 = 3.65 g of HCl in 1 dm^3
- 10 cm^3 of T1 diluted to 150 cm^3
- Volume of pipette: 20.00 cm^3
- Volume of acid used = 20.00 cm^3 (average)
- Methyl orange used as indicator
- 2.145 g of hydrated sodium carbonate in 10 cm^3 diluted

(a)(i) What is the volume of the pipette used?

Answer: 20.00 cm^3

(ii) Tabular Form for Titration:

Titration	Final Burette Reading (cm^3)	Initial Burette Reading (cm^3)	Volume Used (cm^3)
Rough	20.30	0.00	20.30
1st	40.30	20.30	20.00
2nd	60.30	40.30	20.00
3rd	80.30	60.30	20.00

(b) Why must a burette and pipette be rinsed with the solution which they are to be filled with?

To avoid dilution or contamination of the solution by water or any other substance that might have remained in the apparatus, which would alter the concentration and affect accuracy.

(c) Why should a titration flask not be rinsed with the solution to be filled in it?

Because it already contains a measured volume of the solution. Rinsing would introduce extra unknown volume, altering the actual amount and making the titration inaccurate.

(d) Calculate the concentration of T2 (HCl) in mol/dm³.

Molar mass of HCl = 1 + 35.5 = **36.5 g/mol**

Moles of HCl = 3.65 g / 36.5 g/mol = **0.1 mol**

Concentration = 0.1 mol / 1 dm³ = **0.1 mol/dm³**

(e) Calculate the concentration of diluted T1 in mol/dm³.

From titration:

- Equation: $Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$
- Mole ratio: $Na_2CO_3 : HCl = 1 : 2$

Let concentration of diluted T1 = C mol/dm³

Then,
C × 20.00 = (0.1 × 20.00)/2
C = 2 / 20 = **0.1 mol/dm³**

(f) Determine "x" in $Na_2CO_3 \cdot xH_2O$, given 2.145 g of salt in 10 cm³ diluted solution.

We found that:

- Concentration of $Na_2CO_3 \cdot xH_2O$ = 0.1 mol/dm³
- Volume = 0.150 dm³
- Moles = 0.1 mol/dm³ × 0.150 dm³ = **0.015 mol**

Molar mass = 2.145 g / 0.015 mol = **143 g/mol**

Molar mass of anhydrous Na_2CO_3 = 106 g/mol
Mass of water = 143 − 106 = 37 g
Moles of water = 37 / 18 = 2.06

x = 2

Final formula: $Na_2CO_3 \cdot 2H_2O$

2. Heat of Reaction for Dissolving $CuSO_4$ and $Na_2S_2O_3 \cdot 5H_2O$

(a) Table of Temperatures:

Time (min)	$CuSO_4$ Temp (°C)	$Na_2S_2O_3 \cdot 5H_2O$ Temp (°C)
0	33	24
1	34	25
2	35	26
3	36	27
4	37	28

(b) Plot graph of temperature vs. time for both reactions.

(c) State which salt caused exothermic or endothermic reaction.

- **$CuSO_4$**: Exothermic — temperature increased from 33°C to 37°C
- **$Na_2S_2O_3 \cdot 5H_2O$**: Endothermic — temperature increased from 24°C to 28°C, but if initial temp of water was 28°C, it absorbed heat.

(d) Calculate heat change using:

$Q = mc\Delta T$
Where:
m = mass of water = 50 g (since 50 cm^3, ρ = 1 g/cm^3)
cp = 4.2 J/g°C

For $CuSO_4$:
$\Delta T = 37 - 33 = 4°C$
$Q = 50 \times 4.2 \times 4 =$ **840 J**

For $Na_2S_2O_3 \cdot 5H_2O$:
$\Delta T = 28 - 24 = 4°C$
$Q = 50 \times 4.2 \times 4 =$ **840 J**

However, if temp decreased instead, it would be **−840 J**, indicating heat absorbed.

3. Qualitative Analysis — Sample R (Zinc Nitrate)

(a) Analysis Table:

Test	Observation	Inference
(i) Appearance	White crystalline solid	Possible metal nitrate
(ii) Action of heat	Brown gas, residue remains	Nitrate (NO_3^-) decomposed
(iii) Dil. H_2SO_4 on solid	Effervescence, colorless gas	Presence of carbonate (but here, nitrate gives no gas)
(iv) Conc. H_2SO_4 on solid	Brown gas with choking smell	Presence of nitrate
(v) Flame test	Bluish-green flame	Presence of zinc (Zn^{2+})
(vi) Solubility in water	Soluble	Confirms ionic compound
(vii) Confirmatory test for NO_3^- (Brown ring)	Brown ring formed	Confirms nitrate ion
(viii) Confirmatory test for Zn^{2+}	White ppt with NaOH, dissolves in excess	Confirms Zn^{2+}

(b) What are the cation and anion present in the sample?
- **Cation:** Zn^{2+}
- **Anion:** NO_3^-

(c) Write the reaction equation for test (iv):
$Zn(NO_3)_2 + H_2SO_4 \rightarrow ZnSO_4 + 2HNO_3$
On heating:
$2HNO_3 \rightarrow 2NO_2 + H_2O + \frac{1}{2}O_2$ (decomposition of nitric acid to NO_2 gas)