

THE UNITED REPUBLIC OF TANZANIA
NATIONAL EXAMINATIONS COUNCIL
ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION
132/3A **CHEMISTRY 3A**

(For Both School and Private Candidates)

Time: 3 Hours

ANSWERS

Year: 2012

Instructions

1. This paper consists of THREE questions.
2. Answer all questions.

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1. You are provided with the following solutions:

RR: A solution containing 1.48 g of a mixture of sodium carbonate and sodium bicarbonate in 0.25 dm³ of aqueous solution

SS: A solution containing 1.46 g of pure hydrochloric acid in 0.4 dm³ of aqueous solution

MO: Methyl orange indicator

POP: Phenolphthalein indicator

Procedure

- (i) Pipette 20 cm³ or 25 cm³ of solution RR into a 250 cm³ titration flask
- (ii) Add two drops of POP
- (iii) Titrate this solution against solution SS until a colour change is observed
- (iv) Record the first titre value
- (v) Add MO to the same solution
- (vi) Continue to titrate until a second colour change is observed
- (vii) Record the second titre value
- (viii) Repeat your titration procedures (i) to (vii) three times and record your results in a tabular form

Summary

_____ cm³ of solution RR required _____ cm³ of solution SS when POP was used as indicator and _____ cm³ of solution SS when MO was used as indicator

Questions

- (a) The colour changes during titrations were:
 - (i) From colourless to pink when POP was used
 - (ii) From yellow to orange-red when MO was used

(b) Calculate the concentration of solution SS in moles per litre

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

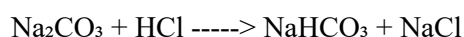
Moles of HCl = $1.46 \div 36.5 = 0.04$ mol

Volume = 0.4 dm³

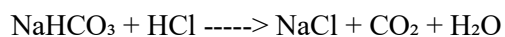
Concentration = $0.04 \div 0.4 = 0.1$ mol/dm³

(c) Indicate the chemical equation that is appropriate to the titre value found in:

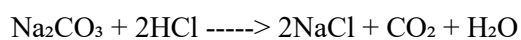
(i) 1st titre value (with POP)



(ii) 2nd titre value (with MO)



Overall equation (when both indicators used):



(d) Calculate the concentration of solution RR in moles per litre when:

(i) POP was used as the indicator

Let titre = 10.0 cm³

Moles of HCl = $0.1 \times 10.0 \div 1000 = 0.001$ mol

From equation, 1 mol HCl reacts with 1 mol Na₂CO₃

Moles of Na₂CO₃ = 0.001 mol

Volume of RR used = 25 cm³ = 0.025 dm³

Concentration of RR = $0.001 \div 0.025 = 0.04 \text{ mol/dm}^3$

(ii) MO was used as the indicator

Let total titre = 20.0 cm^3

Moles of HCl = $0.1 \times 20.0 \div 1000 = 0.002 \text{ mol}$

1 mol Na_2CO_3 reacts with 2 mol HCl

Moles of $\text{Na}_2\text{CO}_3 = 0.002 \div 2 = 0.001 \text{ mol}$

Concentration = $0.001 \div 0.025 = 0.04 \text{ mol/dm}^3$

(e) Calculate the percentage of sodium carbonate in the mixture RR

Moles of $\text{Na}_2\text{CO}_3 = 0.001 \text{ mol}$

Mass = $0.001 \times 106 = 0.106 \text{ g}$

Percentage = $(0.106 \div 1.48) \times 100 = 7.16\%$

2. You are provided with the following:

DD: 2 g of anhydrous copper (II) sulphate

EE: 3 g of hydrated copper (II) sulphate

Stop watch, Thermometer, Cotton wool

Theory

The dissolution of a salt in water is generally accompanied by a notable enthalpy change. It is possible to estimate the enthalpy change of solution of various salts by dissolving small known amounts of various salts in a volume of water and then recording the temperature change.

Procedure

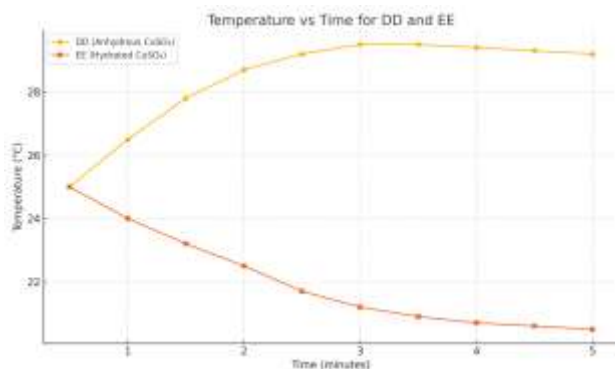
- (i) Take 100 ml beaker and put it into a 250 ml beaker. Fill the space between using cotton wool as insulator
- (ii) Transfer 50 cm³ of distilled water into 100 cm³ beaker in (i) and then record the temperature of the water
- (iii) Add DD into the water and immediately start a stopwatch while stirring gently to facilitate the dissolution of the salt. Record the temperature at half minute interval for five minutes
- (iv) Record your readings in a tabular form as indicated below
- (v) Repeat steps (i) to (iii) above with salt EE

Results

Temperature of cold water = ____ cm³

Questions

- (a)(i) Draw a graph of temperature versus time for each solution on the same graph



- (ii) Use the graphs to determine the temperature of each solution at the instant of its formation

Instant temperature = value at the steepest gradient or the average of first few rising temps. Suppose:

DD instant temperature = 29.5°C

EE instant temperature = 20.5°C

If initial temp was 25°C, then:

DD $\Delta T = +4.5^\circ\text{C}$

EE $\Delta T = -4.5^\circ\text{C}$

(b) State whether the process of dissolving DD and EE is endothermic or exothermic

For DD: temperature increased $\rightarrow$ exothermic

For EE: temperature decreased $\rightarrow$ endothermic

(c) Calculate the heat of solution when

(i) 2 g of DD dissolve in water

Molar mass $\text{CuSO}_4 = 159.5 \text{ g/mol}$

Moles = $2 \div 159.5 = 0.0125 \text{ mol}$

$Q = mc\Delta T = 50 \times 4.18 \times 4.5 = 940.5 \text{ J}$

$\Delta H = 940.5 \div 0.0125 = 75240 \text{ J/mol} = +75.24 \text{ kJ/mol}$

(ii) 3 g of EE dissolve in water

Molar mass $\text{CuSO}_4 \cdot 5\text{H}_2\text{O} = 249.5 \text{ g/mol}$

Moles = $3 \div 249.5 = 0.01202 \text{ mol}$

$\Delta T = -4.5^\circ\text{C} \rightarrow Q = 50 \times 4.18 \times 4.5 = -940.5 \text{ J}$

$\Delta H = -940.5 \div 0.01202 = -78236 \text{ J/mol} = -78.24 \text{ kJ/mol}$

These values reflect opposite energy changes based on hydration.

3. You are provided with the following:

L₁: 0.1 M sodium hydroxide

L₂: Succinic acid of unknown concentration

L₃: Isobutyl alcohol

POP: Phenolphthalein indicator

Distilled water

Theory

Succinic acid ($\text{HOOC}-\text{CH}_2\text{CH}_2-\text{COOH}$) dissolves in both water and isobutyl alcohol in a constant ratio at constant temperature.

Procedure 1

- (i) Pipette 20 cm³ or 25 cm³ of L₂ into a clean conical flask. Add 2 or 3 drops of POP
- (ii) Put L₁ in the burette
- (iii) Titrate L₁ against L₂ in the presence of POP until colour change is observed
- (iv) Record the volume of L₁ used as well as the room temperature

Summary 1

Volume of the pipette used _____ cm³

Volume of L₁ used was _____ cm³

Room temperature _____ °C

Procedure 2

- (i) Place 50 cm³ of L₃ into a separating funnel. Add to it 50 cm³ of water

(ii) Measure 50 cm³ of L₂ using a measuring cylinder and put it into a separating funnel in (i) above. Shake the mixture well

(iii) Run off the lower aqueous layer into a clean beaker

(iv) Measure 20 cm³ or 25 cm³ of the aqueous layer into a clean conical flask

(v) Titrate carefully this aliquot against L₁

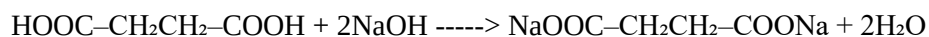
Summary 2

Volume of the aqueous layer used was _____ cm³

Volume of L₁ used was _____ cm³

Questions

(a) Write a balanced chemical equation representing the reaction taking place in the titration



Succinic acid reacts with sodium hydroxide in a 1:2 molar ratio.

(b)(i) The initial concentration of L₂ in water

Suppose 25 cm³ of L₂ required 20 cm³ of 0.1 M NaOH

Moles of NaOH = $(0.1 \times 20)/1000 = 0.002 \text{ mol}$

Moles of succinic acid = $0.002 \div 2 = 0.001 \text{ mol}$

Concentration = $(0.001 \times 1000)/25 = 0.04 \text{ mol/dm}^3$

Molar mass of succinic acid = 118 g/mol

$$\text{Concentration in g/dm}^3 = 0.04 \times 118 = 4.72 \text{ g/dm}^3$$

(ii) The final concentration of L₂ in the aqueous layer

Suppose 25 cm³ of aqueous layer required 10 cm³ of 0.1 M NaOH

$$\text{Moles of NaOH} = 0.001 \text{ mol}$$

$$\text{Moles of succinic acid} = 0.0005 \text{ mol}$$

$$\text{Concentration} = (0.0005 \times 1000)/25 = 0.02 \text{ mol/dm}^3$$

$$\text{Concentration in g/dm}^3 = 0.02 \times 118 = 2.36 \text{ g/dm}^3$$

(iii) The acid concentration in the organic layer

$$\text{Initial mass} = 4.72 \text{ g}$$

$$\text{Aqueous mass} = 2.36 \text{ g}$$

$$\text{Mass in organic} = 4.72 - 2.36 = 2.36 \text{ g}$$

$$\text{Volume of organic layer} = 50 \text{ cm}^3 = 0.05 \text{ dm}^3$$

$$\text{Concentration} = 2.36 \div 0.05 = 47.2 \text{ g/dm}^3$$

(c) Calculate the partition coefficient of L₂ between water and isobutyl alcohol

$$K = \text{concentration in organic} / \text{concentration in aqueous}$$

$$K = 47.2 \div 2.36 = 20$$

This indicates succinic acid is far more soluble in the organic layer than in water.

4. Using systematic qualitative analysis methods identify two cations and one anion in the mixture B provided. Record carefully all your procedures, observations and inferences in a tabular form as shown below.

S/n	Experiment	Observations	Inferences
1	Appearance	Blue crystalline solid	Possible presence of copper salt
2	Flame test	Green flame	Presence of barium ion
3	Add conc. H_2SO_4 and warm	Brown gas evolved (NO_2)	pungent smell Presence of nitrate (NO_3^-) ion
4(i)	Add AgNO_3 solution	No precipitate	Absence of Cl^-
4(ii)	Add fresh FeSO_4 and conc. H_2SO_4	Brown ring at junction	Confirm presence of NO_3^-
4(iii)	Add BaCl_2 solution	White precipitate formed	Presence of SO_4^{2-} ion
4(iv)	Add aqueous ammonia till excess	Deep blue solution	Presence of Cu^{2+} ion
5	Confirmatory tests	Ba^{2+} gives green flame	Cu^{2+} gives deep blue with NH_3

Conclusion

The two cations in the mixture B are Cu^{2+} and Ba^{2+} and the anion is NO_3^- .