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.

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 dm^3 of aqueous solution

SS: A solution containing 1.46 g of pure hydrochloric acid in 0.4 dm^3 of aqueous solution

MO: Methyl orange indicator

POP: Phenolphthalein indicator

Procedure

(i) Pipette 20 cm^3 or 25 cm^3 of solution RR into a 250 cm^3 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

_____ cm^3 of solution RR required _____ cm^3 of solution SS when POP was used as indicator and _____ cm^3 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 ÷ 36.5 = 0.04 mol

Volume = 0.4 dm^3

Concentration = 0.04 ÷ 0.4 = 0.1 mol/dm^3

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

(i) 1st titre value (with POP)

$Na_2CO_3 + HCl \text{ -----> } NaHCO_3 + NaCl$

(ii) 2nd titre value (with MO)

$NaHCO_3 + HCl \text{ -----> } NaCl + CO_2 + H_2O$

Overall equation (when both indicators used):

$Na_2CO_3 + 2HCl \text{ -----> } 2NaCl + CO_2 + H_2O$

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

(i) POP was used as the indicator

Let titre = 10.0 cm^3

Moles of HCl = 0.1 × 10.0 ÷ 1000 = 0.001 mol

From equation, 1 mol HCl reacts with 1 mol Na_2CO_3

Moles of Na_2CO_3 = 0.001 mol

Volume of RR used = 25 cm^3 = 0.025 dm^3

Concentration of RR = 0.001 ÷ 0.025 = 0.04 mol/dm³

(ii) MO was used as the indicator

Let total titre = 20.0 cm³

Moles of HCl = 0.1 × 20.0 ÷ 1000 = 0.002 mol

1 mol Na_2CO_3 reacts with 2 mol HCl

Moles of Na_2CO_3 = 0.002 ÷ 2 = 0.001 mol

Concentration = 0.001 ÷ 0.025 = 0.04 mol/dm³

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

Moles of Na_2CO_3 = 0.001 mol

Mass = 0.001 × 106 = 0.106 g

Percentage = (0.106 ÷ 1.48) × 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 cm^3 of distilled water into 100 cm^3 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

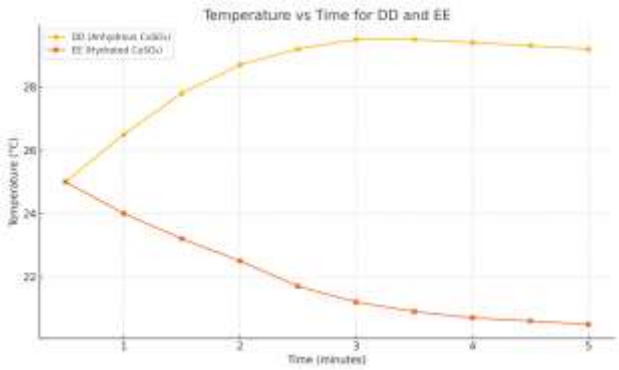
(v) Repeat steps (i) to (iii) above with salt EE

Results

Temperature of cold water = ____ cm^3

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 $\Delta T = +4.5°C$

EE $\Delta T = -4.5°C$

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

For DD: temperature increased → exothermic

For EE: temperature decreased → endothermic

(c) Calculate the heat of solution when

(i) 2 g of DD dissolve in water

Molar mass $CuSO_4$ = 159.5 g/mol

Moles = 2 ÷ 159.5 = 0.0125 mol

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

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

(ii) 3 g of EE dissolve in water

Molar mass $CuSO_4 \cdot 5H_2O$ = 249.5 g/mol

Moles = 3 ÷ 249.5 = 0.01202 mol

$\Delta T = -4.5°C \rightarrow Q = 50 \times 4.18 \times 4.5 = -940.5$ J

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

These values reflect opposite energy changes based on hydration.

3. You are provided with the following:

L_1: 0.1 M sodium hydroxide

L_2: Succinic acid of unknown concentration

L_3: Isobutyl alcohol

POP: Phenolphthalein indicator

Distilled water

Theory

Succinic acid ($HOOC–CH_2CH_2–COOH$) dissolves in both water and isobutyl alcohol in a constant ratio at constant temperature.

Procedure 1

(i) Pipette 20 cm^3 or 25 cm^3 of L_2 into a clean conical flask. Add 2 or 3 drops of POP

(ii) Put L_1 in the burette

(iii) Titrate L_1 against L_2 in the presence of POP until colour change is observed

(iv) Record the volume of L_1 used as well as the room temperature

Summary 1

Volume of the pipette used _____ cm^3

Volume of L_1 used was _____ cm^3

Room temperature _____ °C

Procedure 2

(i) Place 50 cm^3 of L_3 into a separating funnel. Add to it 50 cm^3 of water

(ii) Measure 50 cm^3 of L_2 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 cm^3 or 25 cm^3 of the aqueous layer into a clean conical flask

(v) Titrate carefully this aliquot against L_1

Summary 2

Volume of the aqueous layer used was _____ cm^3

Volume of L_1 used was _____ cm^3

Questions

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

$HOOC–CH_2CH_2–COOH + 2NaOH \text{ -----> } NaOOC–CH_2CH_2–COONa + 2H_2O$

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

(b)(i) The initial concentration of L_2 in water

Suppose 25 cm^3 of L_2 required 20 cm^3 of 0.1 M NaOH

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

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

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

Molar mass of succinic acid = 118 g/mol

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

(ii) The final concentration of L_2 in the aqueous layer

Suppose 25 cm^3 of aqueous layer required 10 cm^3 of 0.1 M NaOH

Moles of NaOH = 0.001 mol

Moles of succinic acid = 0.0005 mol

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

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

(iii) The acid concentration in the organic layer

Initial mass = 4.72 g

Aqueous mass = 2.36 g

Mass in organic = 4.72 − 2.36 = 2.36 g

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

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

(c) Calculate the partition coefficient of L_2 between water and isobutyl alcohol

K = concentration in organic / concentration in aqueous

K = 47.2 ÷ 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^-.