Class	Register Number	Name

南洋女子中學校

NANYANG GIRLS' HIGH SCHOOL

Mid-Year Examination 2018
Secondary Three IP Chemistry

CHEMISTRY **Mark Scheme** **1 hour 30 minutes**

Monday **7 May 2018** **0845 - 1015**

READ THESE INSTRUCTIONS FIRST

Write your class, register number and name in the spaces at the top of this page.
Do not use paper clips, glue or correction fluid.

There are 3 sections in this paper.

Section A
Answer all questions.
For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the one you consider correct and record your choice in the Multiple-Choice Answer Sheet provided.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Section B and C
Answer all questions. The number of marks is given in brackets [ ] at the end of each question or part question.

Candidates are reminded that all quantitative answers should include appropriate units. The use of an approved scientific calculator is expected, where appropriate.
Candidates are advised to show all their working in a clear and orderly manner.

Section A (20 marks)	
Section B (30 marks)	
Section C (10 marks)	
Total (60 marks)	

Section A

Answer **all** questions.
Choose the answer you consider correct and record your choice in the Multiple-Choice Answer Sheet provided.

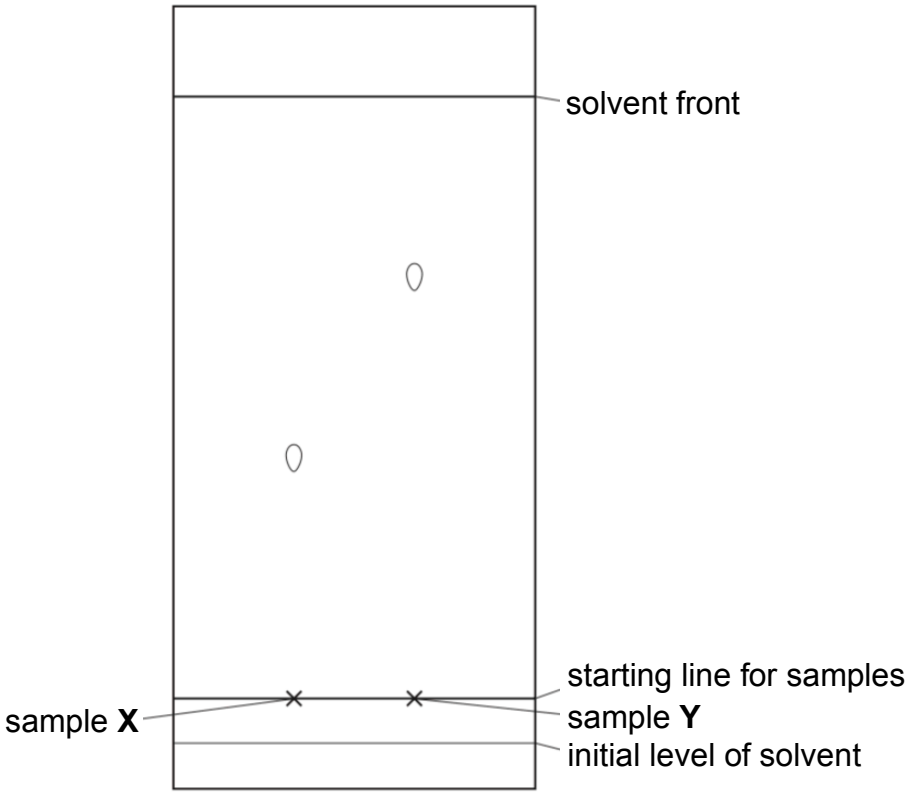
1	**D**	**2**	**B**	**3**	**D**	**4**	**B**	**5**	**C**
6	**B**	**7**	**B**	**8**	**C**	**9**	**D**	**10**	**B**
11	**D**	**12**	**A**	**13**	**C**	**14**	**B**	**15**	**D**
16	**D**	**17**	**D**	**18**	**C**	**19**	**B**	**20**	**B**

Section B

Answer **all** questions.
Write your answers in the spaces provided.

B1 Enzymes are biological catalysts and used in research laboratories and in industries.

Enzymes called proteases can break down proteins by water to amino acids. The amino acids can be separated and identified by chromatography. The diagram below shows a typical chromatogram.



(a) Given that the amino acids have the following R_f values:

amino acid	glutamic acid	glycine	alanine	leucine
R_f values	0.4	0.5	0.7	0.9

Identify the two amino acids on the chromatogram. **[2]**

X is glutamic acid **[1]** and **Y** is alanine **[1].**

(b) A locating agent is used on the chromatogram. Explain why the chromatogram must be exposed to the locating agent. **[1]**

Locating agent is required as amino acids are colourless/ so as to make the amino acids visible/ to show the positions of the samples/ to show the distance travelled by the samples.

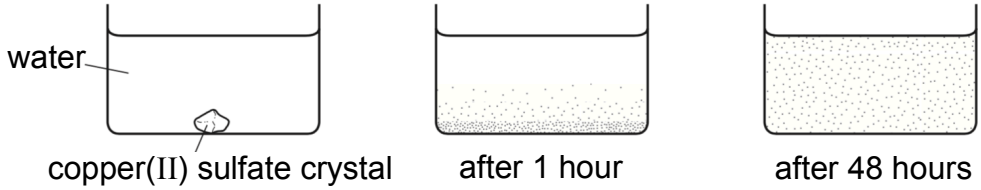
(c) Suggest another method to identify the amino acids on the chromatogram other than measuring R_f values. **[1]**

The chromatogram may be compared with that of known amino acids/ reference samples/ standards.

Total **[4]**

B2 A student placed a crystal of copper(II) sulfate in a beaker of water.

After one hour, the crystal had completely disappeared and a dense blue colour was observed in the water at the bottom of the beaker. After 48 hours, the blue colour had spread throughout the water.



Using the kinetic particle theory, explain the observations. **[2]**

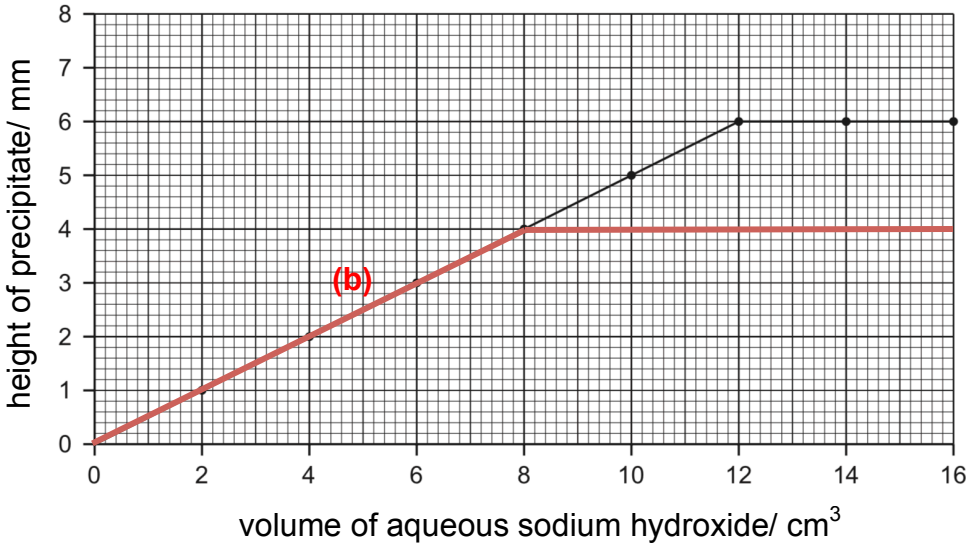
Copper(II) sulfate crystals being soluble in water dissolves to release copper(II) ions and sulfate ions in water **[1]**. The ions randomly diffuse from a region of higher concentration starting from the bottom of the beaker to a region of lower concentration at the top of the beaker **[1].** After 48 hours, the mixture is homogeneous with uniform concentration throughout the solution **[1]**.

Any 2 of the 3 points will be awarded full marks.

Total **[2]**

B3 2.0 cm^3 portions of aqueous sodium hydroxide were added to 4.0 cm^3 aqueous cobalt(III) nitrate. Both solutions had a concentration of 1.00 mol dm^{-3}.

After each addition, the mixture was stirred, centrifuged and the height of the precipitate was measured. The results are shown on the following graph.



(a) Write the ionic equation of the reaction between aqueous sodium hydroxide and aqueous cobalt(III) nitrate. **[1]**

$Co^{3+}(aq) + 3OH^-(aq) \rightarrow Co(OH)_3(s)$

(b) On the same grid of the graph above, sketch the graph that would have been obtained if 4.0 cm^3 of 1.00 mol dm^{-3} cobalt(II) nitrate had been used instead of cobalt(III) nitrate. **[2]**

Height of precipitate at 4 mm **[1],** turning point at 8 cm^3 **[1]**

(c) The experiment is repeated with aluminium nitrate and aqueous sodium hydroxide of the same concentration and volume.

Given that aluminium nitrate forms a precipitate that dissolves in excess aqueous sodium hydroxide to form a colourless solution, describe the shape of the graph obtained. **[2]**

Starting from the origin, the height of the precipitate increases linearly as the volume of aqueous sodium hydroxide increases **[1]**. When more than 12 cm^3 of aqueous sodium hydroxide is added, the height of the precipitate decreases and becomes zero **[1]**.

Total [5]

B4 Iron(II) sulfate is one of the cheapest industrial chemicals and is used to make inks and pigments of iron(III) oxide and prussian blue. Two experiments using iron(II) sulfate were conducted.

(a) Experiment 1:
Iron(II) sulfate crystallises as a green hydrated salt $FeSO_4 \cdot xH_2O$. To determine the extent of hydration, 4.16 g of the hydrated crystals were heated carefully until the mass of the anhydrous iron(II) sulfate remains constant at 2.28 g.

(i) Calculate the number of moles in 2.28 g of anhydrous iron(II) sulfate. **[1]**

Molar mass of anhydrous $FeSO_4$
$= 55.8 + 32.1 + 16.0 \times 4 = 151.9$ g mol^{-1}

No. of moles of anhydrous $FeSO_4$ $= \dfrac{2.28}{151.9} = 0.0150$ (3 s.f.)

(ii) Calculate the number of moles of water lost. **[2]**

Mass of H_2O lost $= (4.16 - 2.28)$ g $= 1.88$ g **[1]**

No. of moles of H_2O lost $= \dfrac{1.88}{1.0 \times 2 + 16.0}$

$= 0.10444$ (5 s.f.)

$= 0.104$ (3 s.f.) **[1]**

(iii) Calculate the number of moles of water of crystallisation in one mole of the hydrated salt. **[1]**

In 0.0150 mol of $FeSO_4$, there is 0.10444 mol of H_2O

No. of moles of water of crystallisation $= \dfrac{0.10444}{0.0150} = 6.96$
$= 7$

(b) Experiment 2:
A nail containing iron reacted completely with dilute sulfuric acid to produce a solution of iron(II) sulfate. The solution was made up to 250 cm^3 in a volumetric flask.

In a titration, 25.0 cm^3 of the iron(II) sulfate solution required 29.50 cm^3 of 0.0200 mol dm^{-3} acidified potassium dichromate(VI), $K_2Cr_2O_7$ for complete reaction.

The reaction between acidifed potassium dichromate(VI) and iron(II) sulfate is as follows:

$$Cr_2O_7^{2-}(aq) + 6Fe^{2+}(aq) + 14H^+(aq) \rightarrow 2Cr^{3+}(aq) + 6Fe^{3+}(aq) + 7H_2O(l)$$

(i) Calculate the number of moles of potassium dichromate(VI) used in the titration. **[1]**

$$\textbf{No. of moles of } K_2Cr_2O_7 = 0.0200 \times \frac{29.50}{1000}$$

$$= 0.000590 \text{ (3 s.f.) } [\mathbf{1}]$$

(ii) Calculate the number of moles of iron(II) sulfate from the solution in the volumetric flask. **[2]**

1 mol of $Cr_2O_7^{2-}$ reacts with 6 mol of Fe^{2+}.

$$\textbf{No. of moles of } Fe^{2+} = 0.000590 \times 6 = 0.00354 \ [\mathbf{1}]$$

$$\textbf{No. of moles of } Fe^{2+} \textbf{ in the nail} = 0.00354 \times \frac{250}{25.0}$$

$$= 0.0354 \ [\mathbf{1}]$$

(iii) Given that the mass of the nail is 2.00 g, calculate the percentage by mass of iron in the nail. **[1]**

$$\textbf{Mass of iron} = 0.0354 \times 55.8 = 1.9753 \text{ g}$$

$$\textbf{Percentage by mass of iron} = \frac{1.9753}{2.00} \times 100\%$$

$$= 98.8\% \ [\mathbf{1}]$$

Total **[8]**

***Deduct one mark from the overall paper for not leaving final answer in 3 significant figures a or for not using the 4 or 5 significant figure values for subsequent parts or for not writing units**

B5 Rancid butter contains a carboxylic acid that has the following composition by mass. Carboxylic acids are weak organic acids and form salts with alkalis.

carbon 62.1%; hydrogen: 10.3%; oxygen: 27.6%

(a) (i) Determine the empirical formula of the carboxylic acid in the rancid butter. **[2]**

	Carbon	Hydrogen	Oxygen
% by mass	62.1	10.3	27.6
A_r	12.0	1.0	16.0
No of moles of atoms	5.175	10.3	1.725
Simplest integer ratio	3	6	1

Calculation of number of moles **[1]**

Empirical formula = C_3H_6O **[1]** (accept any order of atoms)

(ii) A sample of 0.30 g of the pure carboxylic acid requires 25.90 cm^3 of 0.100 mol dm^{-3} of potassium hydroxide for complete neutralisation in the presence of phenolphthalein.

Given that the carboxylic acid is a monobasic acid, determine the molecular formula of the carboxylic acid. **[3]**

Amount of KOH = (25.90/1000) dm^3 × 0.100 mol dm^{-3}
= 0.00259 mol **[1]**

(Amount of KOH = amount of carboxylic acid)

Molecular mass of acid = 0.30 g/0.00259 mol = 116 g mol^{-1} **[1]**

Hence, molecular formula is $C_6H_{12}O_2$ **[1]**

(b) Write the ionic equation for the reaction of the carboxylic acid with potassium hydroxide. **[1]**

$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ **[1]**

(c) Given the following information,

indicator	colour at pH of 1	pH at which colour changes	colour at pH of 14
phenolphthalein	colourless	8.2 – 10.0	pink
methyl orange	red	3.1 – 4.4	yellow

Suggest why methyl orange is **not** a suitable indicator. **[1]**

Setter: KXY, NHK, CT

The reaction between the carboxylic acid and potassium hydroxide is that of a weak acid with a strong alkali. Methyl orange whose pH changes colour at 3.1 – 4.4 does not intercept the vertical sharp change of pH at the end-point [1].

B6 Photochromic sunglasses contain small amounts of the salt silver chloride.

(a) Explain why a poor yield of silver chloride is obtained when silver oxide is reacted with hydrochloric acid. **[2]**

Dilute hydrochloric acid reacts with the insoluble silver oxide to form a layer of insoluble and unreactive layer of silver chloride **[1]**

The silver chloride prevents the silver oxide from further reaction with the hydrochloric acid/protons. **[1]**

(b) Write two balanced chemical equations to show how pure silver chloride is prepared from silver oxide. **[2]**

$Ag_2O(s) + 2HNO_3(aq) \rightarrow 2AgNO_3(aq) + H_2O(l)$ **[1]**

$AgNO_3(aq) + HCl(aq) \rightarrow AgCl(aq) + H_2O(l)$ **[1]**

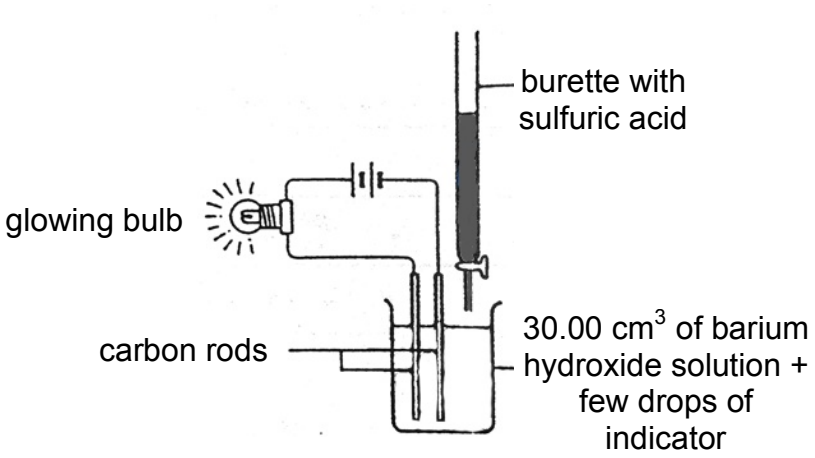
State symbols are not required.

Total [10]

Section C

Answer **all** questions.
Write your answers in the spaces provided.

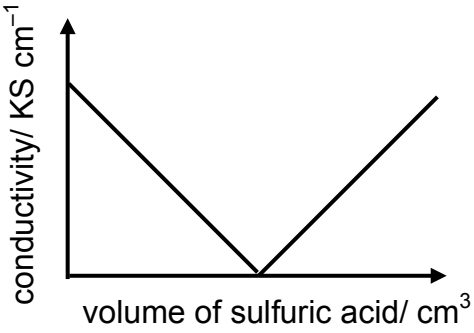
C1 **(a)** The experiment illustrated in the diagram below was carried out using an indicator. 0.100 mol dm^{-3} sulfuric acid was added from the burette into the beaker.



As the acid was added, a white precipitate appeared in the beaker. When exactly 15.00 cm^3 of the acid had been added, the bulb went out. When more acid was added, the bulb glowed brightly again.

The brightness of the bulb is an indication of the conductivity of the solution in the beaker which varies with the concentration of ions in the solution.

The diagram below shows the changes in conductivity as sulfuric acid was added to the beaker.



(a) Give the formula of the ions/ molecules present in the beaker of solution after adding 15.00 cm^3 of the acid from the burette. **[1]**

The ions present are H^+ and OH^-./ The molecule present is H_2O.

(b) Write a balanced chemical equation, including state symbols, for the formation of the white precipitate. **[2]**

$Ba(OH)_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2H_2O(l)$

Setter: KXY, NHK, CT

1 mark for correct formula and balanced chemical equation,
1 mark for correct state symbols

(c) Explain why the light bulb stopped glowing when 15.00 cm^3 of the acid has been added into the beaker. **[2]**

On adding 15.00 cm^3 of the acid, it reacts completely with aqueous barium hydroxide forming only insoluble barium sulfate **[1].** The concentrations of H^+ and OH^- are very low which does not allow the solution to conduct electricity/ There are no mobile ions in the solution to conduct electricity **[1].**

(d) Calculate the number of moles in 15.00 cm^3 of sulfuric acid added. **[1]**

$$\textbf{No. of moles of } H_2SO_4 \textbf{ added} = 0.100 \times \frac{15.00}{1000} = 0.00150$$

(e) Calculate the concentration, in mol dm^{-3}, of aqueous barium hydroxide used in the reaction. **[2]**

1 mol of H_2SO_4 reacts with 1 mol of $Ba(OH)_2$.

$$\textbf{No. of moles of } Ba(OH)_2 = 0.00150 \ [\mathbf{1}]$$

$$\textbf{Concentration of } Ba(OH)_2 = \frac{0.00150}{30.0/1000}$$
$$= 0.0500 \text{ mol dm}^{-3} \ [\mathbf{1}]$$

(f) Given that the solubility of barium hydroxide at 25 °C is 0.240 g dm^{-3}, calculate the concentration, in mol dm^{-3}, of the saturated aqueous solution. **[1]**

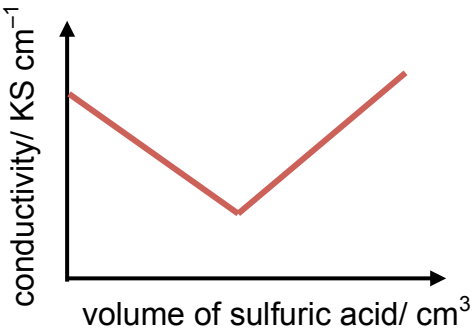
Molar mass of anhydrous $Ba(OH)_2$
= 137.3 + 16.0 × 2 + 1.0 × 2 = 171.3 g mol^{-1}

$$\textbf{Concentration of saturated } Ba(OH)_2 = \frac{0.24}{171.3}$$
$$= 0.00140 \text{ mol dm}^{-3} \ [\mathbf{1}]$$

(g) The experiment was repeated by using aqueous sodium hydroxide instead of aqueous barium hydroxide.

Sketch the graph of conductivity against volume of sulfuric acid added.

[1]



Shape sf graph with conductivity above 0 at turning point [1]

Total [10]