HWA CHONG INSTITUTION
C1 Promotional Examination
Higher 2

NAME | | CT GROUP | 17S

CHEMISTRY

9729/02

Paper 2 Structured questions

27 September 2017

1 hour 5 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet.

READ THESE INSTRUCTIONS FIRST

Write your name and CT group on all the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.

A Data Booklet is provided.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

FOR EXAMINERS' USE ONLY

Paper 1	Paper 2		Paper 3	
Multiple Choice	Structured		Free Response	
	Q1	/ 16	Q1	/ 15
	Q2	/ 15	Q2	/ 15
	Q3	/ 9	Q3 / 4	/ 20
	Deductions		Deductions	
/ 20	Subtotal:	/ 40	Subtotal:	/ 50

This document consists of 13 printed pages.

Answer **all** the questions.

For Examiner's use

1 (a) The hydrogen sulfide (H_2S) molecule can react in various ways: as an Arrhenius acid, as a Brønsted acid, as a Brønsted base, as a Lewis acid, and as a Lewis base.

Study the following reactions and decide in which way H_2S is reacting in each case. Explain your answers fully.

(i) $H_2S + NaOH \rightarrow NaSH + H_2O$

Role of H_2S: .....

Explanation: ..... [1]

(ii) $H_2S + H_2SO_4 \rightarrow H_3S^+ + HSO_4^-$

Role of H_2S: .....

Explanation: ..... [1]

(iii) $H_2S + H_2O \rightleftharpoons H_3O^+ + SH^-$

Role of H_2S: .....

Explanation: ..... [1]

(b) H_2S reacts with NO_3^- in acidic solution to form S and NO.

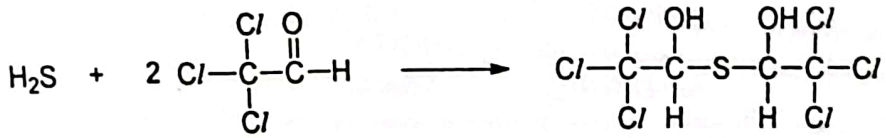
State the role of H_2S and write a balanced equation for the above reaction.

Role of H_2S: .....

Equation: ..... [2]

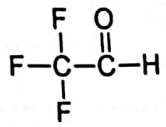
For Examiner's use

(c) H_2S reacts with trichloroacetaldehyde under mild conditions to form a product known as an adduct.

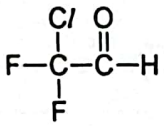


trichloroacetaldehyde adduct

When this reaction is carried out by adding H_2S to a 1:1 molar mixture of trifluoroacetaldehyde and chlorodifluoroacetaldehyde, a mixture of three adducts is formed.



trifloroacetaldehyde



chlorodifloroacetaldehyde

Suggest the structures of the three adducts, and the ratio in which they might be produced.

structure			
ratio			

[2]

(d) H_2S decomposes on a metal catalyst surface to form hydrogen and diatomic sulfur as shown in the equilibrium below.

$$2H_2S(g) \rightleftharpoons 2H_2(g) + S_2(g) \qquad \Delta H > 0$$

1.0 mol of H_2S was left to decompose in a flask at 400 K. When the system reached equilibrium at a total pressure of 2.0 atm, it was found that 0.10 mol of H_2 was present.

(i) Write an expression for the equilibrium constant, K_p, of the above reaction.

[1]

(ii) Calculate the equilibrium partial pressures of H_2S, H_2 and S_2, and hence the K_p, at 400 K.

For Examiner's use

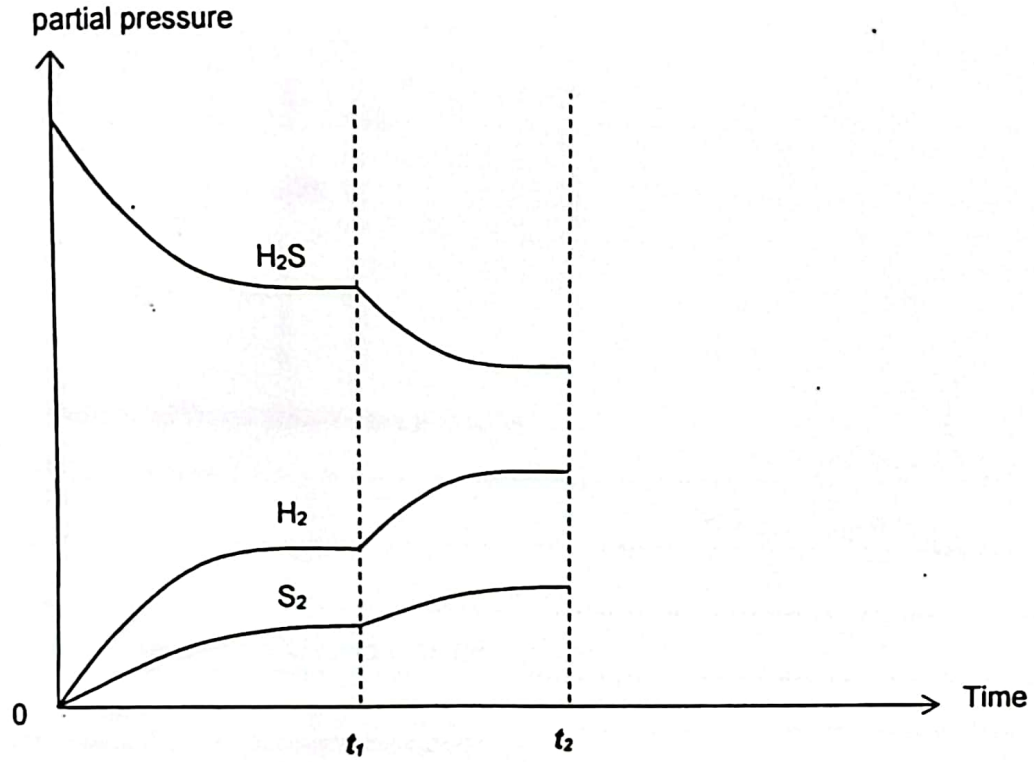
[2]

(iii) Some gaseous S_2 was injected into the equilibrium mixture above such that the partial pressure of S_2 increased by x atm. When the system was allowed to reach a new equilibrium, 1.8 atm of H_2S was found to be present in the mixture. Using your answer in **(d)(ii)**, calculate the value of x.

[2]

For Examiner's use

(e) In a separate flask, some H_2S was left to decompose and the following graph shows how the partial pressure of each gas varies with time.



(i) The temperature of the system was changed at t_1. Deduce whether the temperature was increased or decreased.

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..... [2]

(ii) The total pressure of the flask was increased at t_2. Complete the graph above to show the changes in partial pressure of H_2S, H_2 and S_2 until the system reaches equilibrium again.

[2]

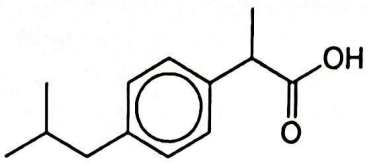
[Total: 16]

For Examiner's use

2 The (+)-ibuprofen enantiomer of ibuprofen is a nonsteroidal anti-inflammatory drug (NSAID). It reduces inflammation, pain, and fever in the body caused by many conditions such as headache, toothache, arthritis, menstrual cramps, or minor injury.

Some data on ibuprofen are provided in Table 2.1.

Table 2.1

Structure	
Chemical formula	$C_{13}H_{18}O_2$
Melting point	76 °C
Specific optical rotation of (+)-ibuprofen	+57°
Solubility in water	1.02×10^{-4} mol dm^{-3} (at 25 °C)

(a) Describe the structure and bonding in ibuprofen, and give two reasons in terms of intermolecular forces why ibuprofen has a relatively high melting point.

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..... [3]

(b) A drug with low solubility in water is considered fast acting while a highly water soluble drug is slow acting.

Suggest whether ibuprofen would be a fast or slow acting drug. Support your answer with appropriate evidence.

.....

..... [1]

(c) Draw the pair of enantiomers of ibuprofen, and hence explain why ibuprofen is able to exhibit enantiomerism.

For Examiner's use

.....

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..... [2]

(d) An analytical chemist from the Health Sciences Authority obtained some commercially sold ibuprofen pills. The chemist isolated some ibuprofen from the pills. The sample was found to have a melting point of 76 °C and a specific optical rotation of +52°.

(i) Discuss whether these pills should be allowed to continue to be on sale in pharmacies, considering the information provided.

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..... [2]

For Examiner's use

(ii) Enantiomeric excess (e.e.) is defined as:

% of one enantiomer in a sample – % of the other enantiomer in the sample

The enantiomeric excess of one enantiomer can also be calculated using the formula:

$$e.e. = \frac{\text{Specific optical rotation of sample}}{\text{Specific optical rotation of pure enantiomer}} \times 100\%$$

Show that the percentage of (+)-ibuprofen in the sample is 95.6%.

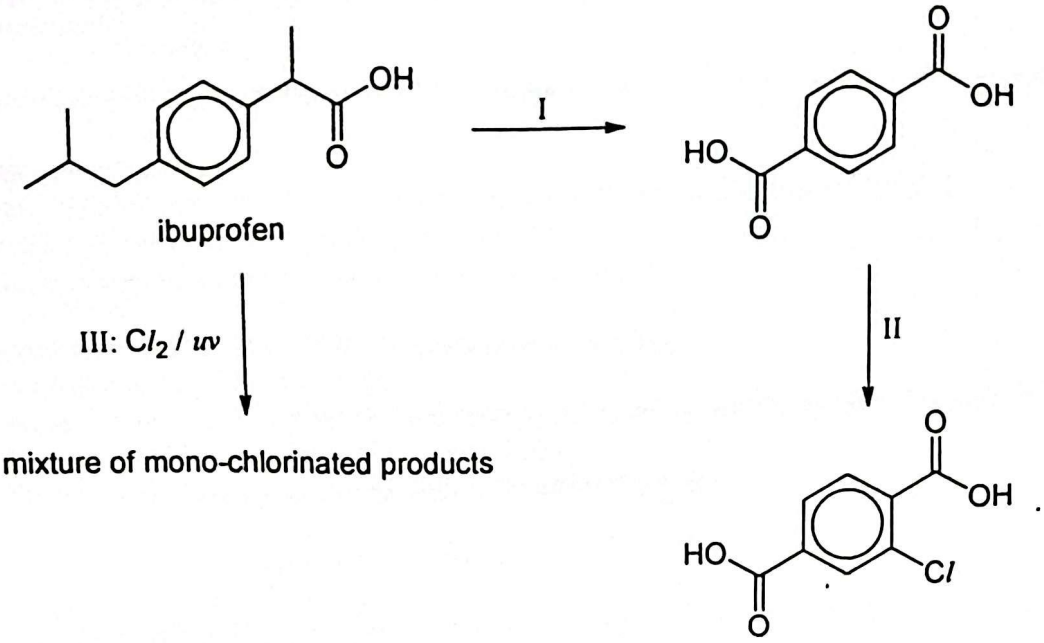
[2]

(iii) Hence, calculate the concentration of (+)-ibuprofen if 400 mg of the ibuprofen sample was dissolved in 100 cm^3 of solvent.

[1]

For Examiner's use

(e) Ibuprofen can undergo the following reactions.



(i) State the reagents and conditions for:

Reaction I: .....

Reaction II: .....

[2]

(ii) State the number of possible mono-chlorinated products in Reaction II.

.....

[1]

(iii) State the number of possible mono-chlorinated products that are constitutional isomers in Reaction III.

.....

[1]

[Total: 15]

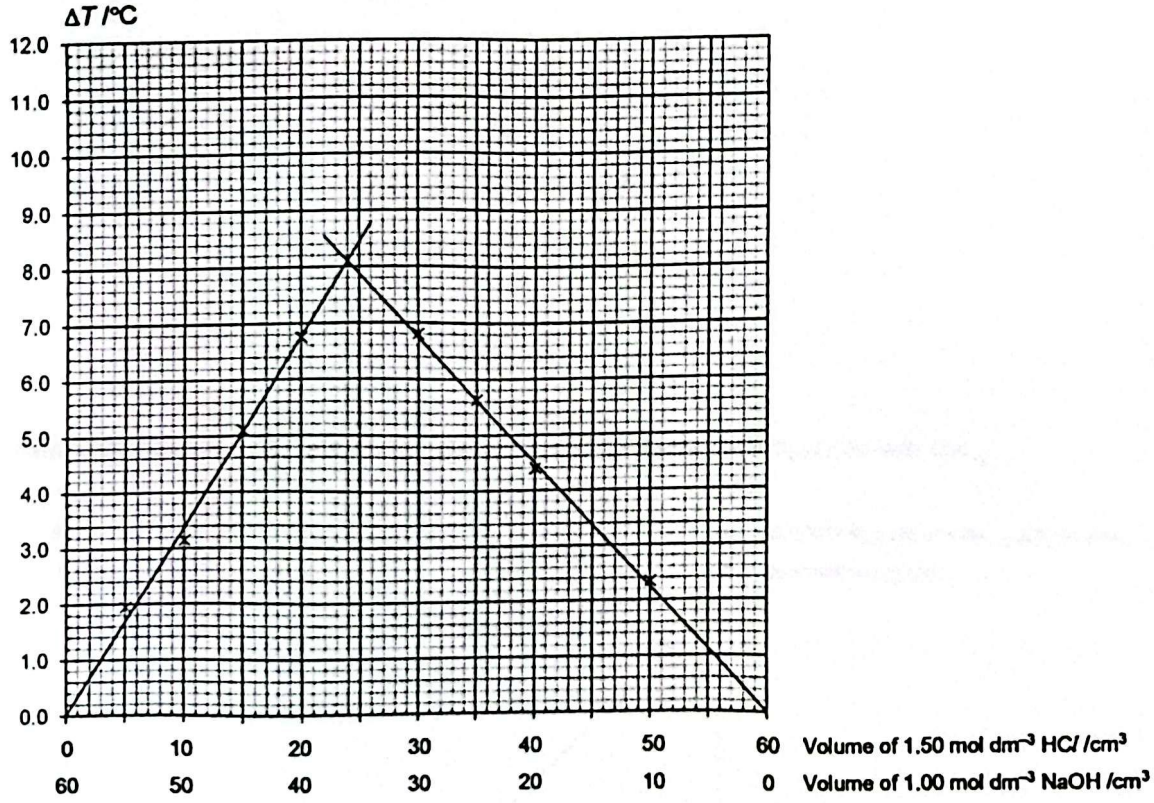
3 (a) A series of experiments were carried out to determine the enthalpy change of neutralisation between hydrochloric acid and aqueous sodium hydroxide, ΔH_{neut}.

For Examiner's use

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l) \qquad \Delta H_{neut}$$

Different volumes of 1.50 mol dm^{-3} hydrochloric acid and 1.00 mol dm^{-3} aqueous sodium hydroxide were mixed together. The total volume for each mixture was 60 cm^3.

A graph of temperature change, ΔT, for each mixture was plotted against volume. As shown below, the graph consists of two intersecting lines.



(i) Explain why the highest ΔT would be obtained only when 24 cm^3 of hydrochloric acid and 36 cm^3 of sodium hydroxide were mixed.

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..... [1]

For Examiner's use

(ii) Use the graph and the information in **(a)(i)** to calculate ΔH_{neut}.

You should assume that the specific heat capacity of the solution is 4.2 J g^{-1} K^{-1}, and that its density is 1.00 g cm^{-3}.

[3]

(b) On the same grid in **(a)**, sketch the expected graph if the experiment was repeated using 1.50 mol dm^{-3} ethanoic acid instead of hydrochloric acid.

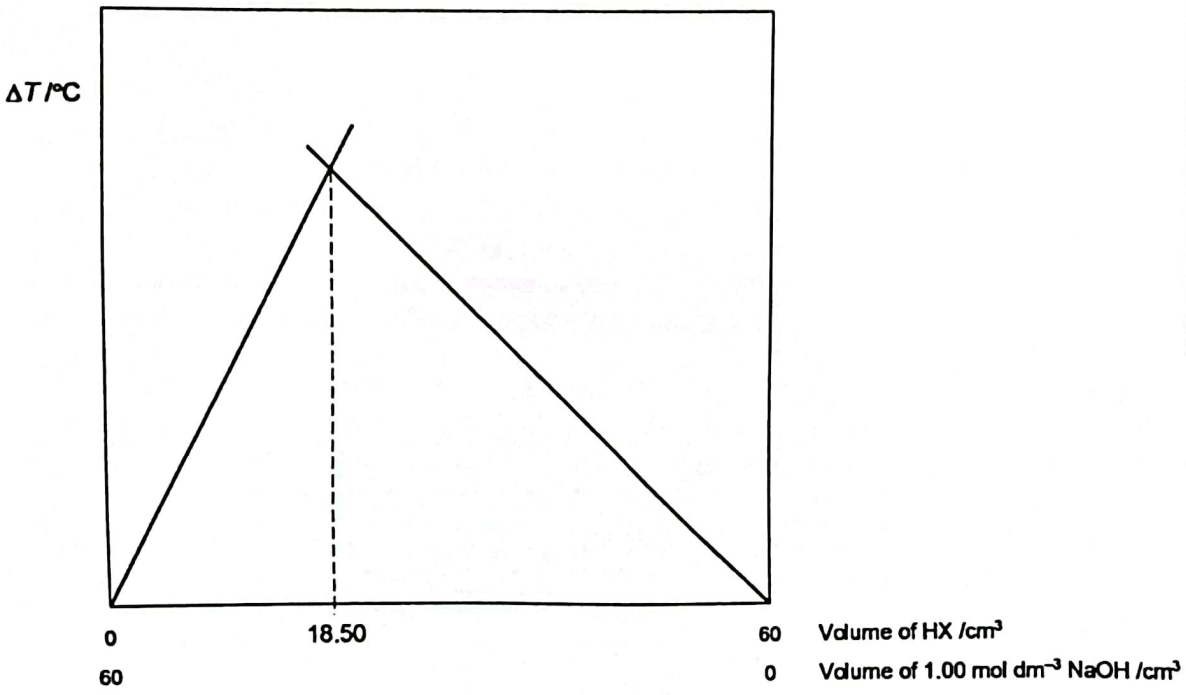
Label the expected graph as **(b)**.

[1]

(c) This kind of experiment can also be used to determine the concentration of either the acid or alkali.

For Examiner's use

The experiment in **(a)** was repeated using another monobasic (monoprotic) acid, HX, instead of hydrochloric acid. A similar graph was obtained.



Using information from this graph, calculate the concentration of HX in mol dm^{-3}.

[1]

(d) You are given a solution of hydrochloric acid, **FA 1**, with concentration between 1.50 and 2.00 mol dm^{-3}.

For Examiner's use

You are required to write a plan to collect data so as to plot a similar graph to that in **(a)**.

You are provided with:
- hydrochloric acid, **FA 1**, with concentration between 1.50 and 2.00 mol dm^{-3};
- 1.00 mol dm^{-3} aqueous sodium hydroxide;
- the equipment normally found in a school laboratory.

Describe briefly your experimental procedure including:
- the apparatus you would use;
- the volumes of **FA 1** and sodium hydroxide to be mixed to obtain **at least three** data points for each of the two intersecting lines;
- the measurements you would record for each mixture.

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[Total: 9]

~END OF PAPER~