H1

MINISTRY OF EDUCATION, SINGAPORE
in collaboration with
CAMBRIDGE INTERNATIONAL EDUCATION
General Certificate of Education Advanced Level

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CHEMISTRY **8873/02**

Paper 2 Structured Questions **For examination from 2026**

SPECIMEN PAPER **2 hours**

You must answer on the question paper.

You will need: Data booklet

INSTRUCTIONS

- Section A: answer **all** questions.
- Section B: answer **one** question.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen. Do **not** use correction fluid or tape.
- Do **not** write on any bar codes.
- You may use an approved calculator.

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **18** pages. Any blank pages are indicated.

Singapore Examinations and Assessment Board

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[Turn over

Section A

Answer **all** the questions in this section in the spaces provided.

1 **(a)** Sulfur can exist as a number of different isotopes.

Complete Table 1.1 for two isotopic species of sulfur.

Table 1.1

isotopic species	number of protons	number of neutrons	number of electrons	electronic configuration
$^{32}_{16}S$				$1s^2$ .....
		17	18	$1s^2$ .....

[4]

(b) Ionisation energy generally increases across Period 3 but decreases from phosphorus to sulfur.

Explain why sulfur has a lower first ionisation energy than phosphorus.

.....

.....

..... [2]

(c) Sulfur and fluorine form the compound SF_6.

(i) Draw a 'dot-and-cross' diagram for one molecule of SF_6. Show only the outer shell electrons.

[1]

(ii) Explain why the S–F bond is polar.

.....

..... [1]

[Total: 8]

2 Proteins are biological catalysts that are substrate specific. They are polymers made from amino acids and can be found in cells in the human body.

(a) Explain how enzymes catalyse the breakdown of a substrate.

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..... [2]

(b) The pH in the stomach of a human is approximately 3 and in the small intestine it is approximately 7.5.

Pepsin is an enzyme found in the stomach. Pepsin helps in the digestion of proteins in food.

Suggest a reason why the rate of food digestion slows down when pepsin enters the small intestine.

.....

..... [1]

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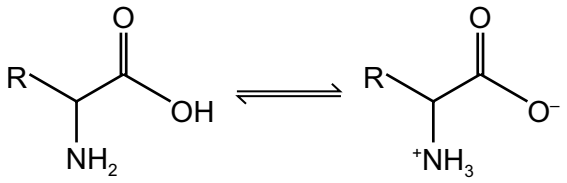
(c) An amino acid contains both an acidic group, CO_2H, and a basic group, NH_2.

When an amino acid is dissolved in water, the H^+ ion transfers to the NH_2 group to form a mobile species with a positive charge and a negative charge called a zwitterion, as shown in Figure 2.1. R represents an alkyl group in the amino acid and zwitterion structures.

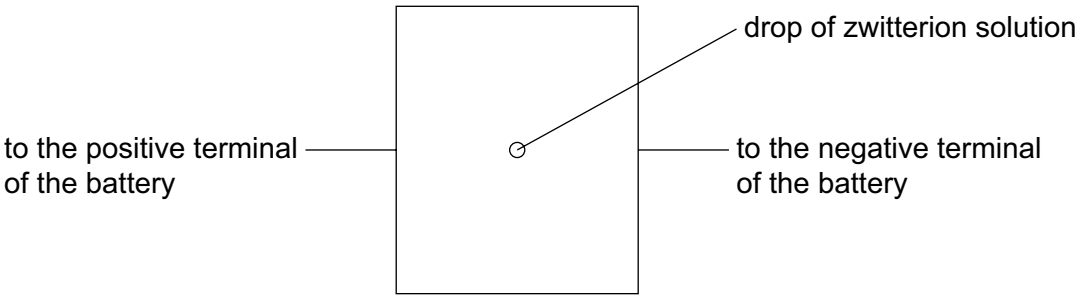


amino acid zwitterion

Figure 2.1

In an experiment, a piece of wet filter paper is placed between two terminals of a battery. This creates an electric field that can result in the movement of species that have an overall charge.

A drop of the zwitterion solution is placed in the centre of the filter paper. Overall, the zwitterion is not attracted to the positive terminal or the negative terminal and so does **not** move.



(i) Suggest why the drop of zwitterion solution does **not** move on the filter paper.

.....

..... [1]

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(ii) The experiment is repeated twice.

- In experiment 1, an acid is added to the zwitterion solution.
- In experiment 2, an alkali is added to the zwitterion solution.

Suggest what happens to the movement, if any, of each drop of resulting solution in experiment 1 and experiment 2.

Explain your answer.

.....

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.....

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.....

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..... [3]

(iii) Alanine, $NH_2CH(CH_3)CO_2H$, is an amino acid.

Using the information in Figure 2.1, suggest the structure for the zwitterion form of alanine.

[1]

(iv) Suggest why the zwitterion form of alanine has a higher melting point than the non-zwitterion form of alanine.

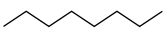
.....

..... [1]

[Total: 9]

3 **(a)** The polymer *Bakelite* was first made in 1907 and was one of the first synthetic polymers to be mass-produced. It is a hard polymer that chars (becomes blackened) on heating. It was used to make the outer cases of radios and telephones.

By the 1930s the synthetic polymer polystyrene was becoming widely used. Today it is used for many items such as vacuum cleaners, refrigerators and disposable cutlery. It is a hard polymer that melts on heating.

(i) Sketch the structure of each polymer using  as a simplified representation of the polymer chain. Include labels on your sketch. Classify each polymer and use its structure to explain its properties.

Bakelite structure diagram

class of polymer .....

explanation of properties .....

.....

.....

polystyrene structure diagram

class of polymer .....

explanation of properties .....

.....

.....

[8]

(ii) Predict whether or not each of these polymers can be recycled. Explain your answer.

.....

.....

.....

..... [2]

(b) The compound CH_2=CHCH(OH)CH_2CO_2H can be polymerised to form two different polymers.

Draw a repeat unit for each of the polymers. In each case, state the type of polymerisation involved.

repeat unit for polymer 1

type of polymerisation .....

repeat unit for polymer 2

type of polymerisation .....
[4]

[Total: 14]

4 (a) (i) Define standard enthalpy change of combustion.

.....

.....

..... [1]

(ii) The enthalpy change of combustion, ΔH_c, for hexane is $-4163\ kJ\ mol^{-1}$.

Draw an energy profile diagram for this reaction. Label ΔH_c and the activation energy, E_a.

[3]

(b) Octane is one of the alkanes found in petrol. Octane burns completely in air.

$$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$$

Use bond energy values from the data booklet to calculate the enthalpy change of combustion of octane.

[3]

(c) But-2-ene, C_4H_8, has two isomers with the same structural formula.

Draw the displayed formulae of the two isomers and state their names.

[2]

[Total: 9]

5 Ethanoic acid and ethanol react together to form ethyl ethanoate and water.

$$CH_3CO_2H(l) + C_2H_5OH(l) \rightleftharpoons CH_3CO_2C_2H_5(l) + H_2O(l)$$

A mixture containing 0.0200 mol of ethanoic acid, 0.107 mol of ethanol and 0.100 mol of water is prepared. To this mixture, 0.00500 mol of concentrated sulfuric acid, H_2SO_4, is added as a catalyst.

The reaction vessel is sealed and left at a constant temperature of 25 °C for 5 days to allow an equilibrium to be established.

The entire reaction mixture is transferred to a conical flask and quickly titrated with aqueous NaOH using phenolphthalein as the indicator. 23.30 cm^3 of 1.00 mol dm^{-3} NaOH solution is required for complete reaction.

(a) (i) Calculate the number of moles of NaOH used in the titration.

[1]

(ii) Determine the number of moles of NaOH that react with H_2SO_4.

[1]

(iii) Write a balanced equation for the reaction of ethanoic acid with NaOH.

..... [1]

(iv) Calculate the number of moles of ethanoic acid present at equilibrium.

[1]

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(b) (i) Use the information given and the answer from **5(a)(iv)** to complete Table 5.1.

Table 5.1

	CH_3CO_2H	C_2H_5OH	$CH_3CO_2C_2H_5$	H_2O
initial amount / mol				
equilibrium amount / mol				

[3]

(ii) Write an expression for the equilibrium constant, K_c.

[1]

(iii) Calculate the value of K_c. State the units of K_c.

[2]

(c) Predict what would happen to the position of the equilibrium if more ethanoic acid was added to the equilibrium mixture in the conical flask. Explain your answer.

prediction .....

.....

explanation .....

.....

[2]

[Total: 12]

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6 The reaction between $H_2(g)$ and NO(g) is studied.

$$2H_2(g) + 2NO(g) \rightarrow 2H_2O(g) + N_2(g)$$

The data in Table 6.1 was obtained at a constant temperature.

Table 6.1

experiment	initial concentration of $H_2(g)$ / mol dm^{-3}	initial concentration of NO(g) / mol dm^{-3}	initial rate / mol dm^{-3} h^{-1}
1	2.0×10^{-3}	3.0×10^{-3}	3.0×10^{-3}
2	4.0×10^{-3}	6.0×10^{-3}	2.4×10^{-2}
3	1.0×10^{-3}	6.0×10^{-3}	6.0×10^{-3}

(a) Using the data in Table 6.1, deduce the order of reaction with respect to each reactant. Explain your reasoning.

H_2 .....

.....

.....

.....

NO .....

.....

.....

.....

[4]

(b) Write the rate equation for this reaction.

..... [1]

(c) Using data from Table 6.1, calculate the value for the rate constant, *k*. State the units for *k*.

[3]

[Total: 8]

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Section B

Answer **one** question from this section in the spaces provided.

7 **(a)** Sodium, silicon and chlorine are all elements in Period 3 of the Periodic Table.

State the structure and bonding present in the elements sodium, silicon and chlorine. Explain the variation in electrical conductivity of these elements.

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.....

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..... [5]

(b) Three of the oxides of Period 3 elements are sodium oxide, phosphorus(V) oxide and sulfur trioxide.

(i) Write equations for the reactions of each of these oxides with water. State the pH of the resulting solutions.

.....

.....

.....

..... [3]

(ii) Write an equation for the reaction of each oxide with either sodium hydroxide or hydrochloric acid.

.....

.....

.....

..... [3]

(iii) Describe the variation in behaviour shown by these oxides across Period 3 as shown in **7(b)(ii)**.

.....

..... [1]

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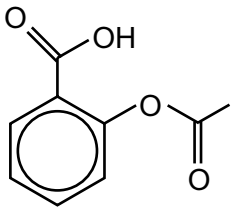
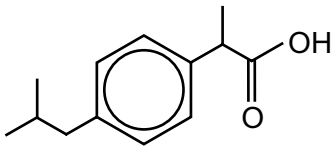
(c) The table of characteristic values for infra-red absorption in the *Data Booklet* should be used to answer some parts of this question.

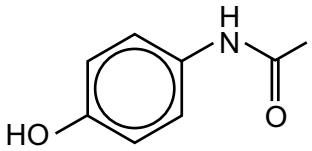
The compounds aspirin, ibuprofen and paracetamol are all painkillers.



aspirin

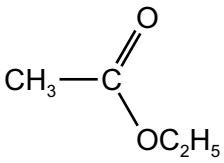


ibuprofen



paracetamol

Infra-red absorptions can be used to identify functional groups in organic compounds. For example, ethyl ethanoate shows absorptions at 1050–1330 cm^{-1} and 1710–1750 cm^{-1}.



ethyl ethanoate

(i) Calculate the percentage by mass of carbon in the aspirin molecule.

[2]

(ii) Identify an infra-red absorption range that will be shown by aspirin and ibuprofen but **not** by paracetamol using the data booklet.

..... [1]

(iii) Identify **two** of the infra-red absorption ranges that will be shown by paracetamol but **not** by aspirin or ibuprofen using the data booklet.

..... [1]

(iv) Identify a type of reaction that will occur with both paracetamol and aspirin but **not** with ibuprofen.

..... [1]

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(d) Write an equation for the reaction of propene with hydrogen. State the conditions required and the type of reaction occurring.

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.....

.....

..... [3]

[Total: 20]

8 **(a)** State the type of bonding and describe the lattice structure of the crystalline solids sodium chloride, iodine and copper. You may include labelled diagrams in your answer.

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..... [6]

(b) **(i)** Define the term lattice energy.

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..... [2]

(ii) Explain why the lattice energy of magnesium oxide is much more exothermic than that of sodium chloride.

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..... [4]

(c) A common battery consists of nickel-cadmium components. One component is a rod of cadmium, Cd, metal and the other component is made of nickel(III) hydroxide, $Ni(OH)_3$. The two components are connected by potassium hydroxide.

The half-equations at each component are shown.

$$Cd(OH)_2 + 2e^- \rightleftharpoons Cd + 2OH^-$$

$$Ni(OH)_3 + e^- \rightleftharpoons Ni(OH)_2 + OH^-$$

(i) Combine these two half-equations to show the overall reaction in the battery.

.....

.....

..... [2]

(ii) Show which species in your equation is reduced and which is oxidised using oxidation numbers.

.....

.....

.....

..... [3]

(d) **(i)** Propanal and propanone can both be reduced using lithium aluminum hydride, $LiAlH_4$.

Draw the displayed formulae of the organic product formed in each reaction.

[2]

(ii) Propanal and propanone were heated with acidified potassium dichromate(VI). Write an equation for any reaction that occurs.
Use [O] to represent the oxidising agent.

.....

..... [1]

[Total: 20]

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