SPECIMEN MATERIAL

AS
CHEMISTRY
(7404/2)

Paper 2: Organic and Physical Chemistry

Specimen 2015 Session Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- the Data Sheet, provided as an insert
- a ruler
- a calculator.

Instructions

- Answer **all** questions.
- Show **all** your working.

Information

- The maximum mark for this paper is 80.

Please write clearly, in block capitals, to allow character computer recognition.

Centre number ☐☐☐☐☐ Candidate number ☐☐☐☐

Surname ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Forename(s) ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Candidate signature _____

Section A

Answer **all** questions in this section.

1 Compound **J**, known as leaf alcohol, has the structural formula $CH_3CH_2CH{=}CHCH_2CH_2OH$ and is produced in small quantities by many green plants. The *E* isomer of **J** is responsible for the smell of freshly cut grass.

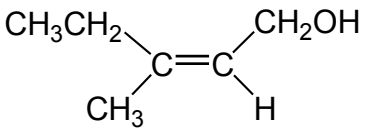
0 1 . 1 Give the structure of the *E* isomer of **J**.

[1 mark]

0 1 . 2 Give the **skeletal formula** of the organic product formed when **J** is dehydrated using concentrated sulfuric acid.

[1 mark]

0 1 . 3 Another structural isomer of **J** is shown below.

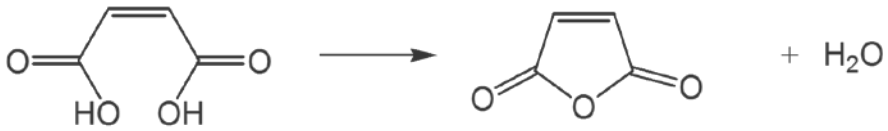


Explain how the Cahn-Ingold-Prelog (CIP) priority rules can be used to deduce the full IUPAC name of this compound.

[6 marks]

Question 1 continues on the next page

0 1 . 4 The effect of gentle heat on maleic acid is shown below.



A student predicted that the yield of this reaction would be greater than 80%.

In an experiment,10.0 g of maleic acid were heated and 6.53 g of organic product were obtained.

Is the student correct? Justify your answer with a calculation using these data.

[2 marks]

Turn over for the next question

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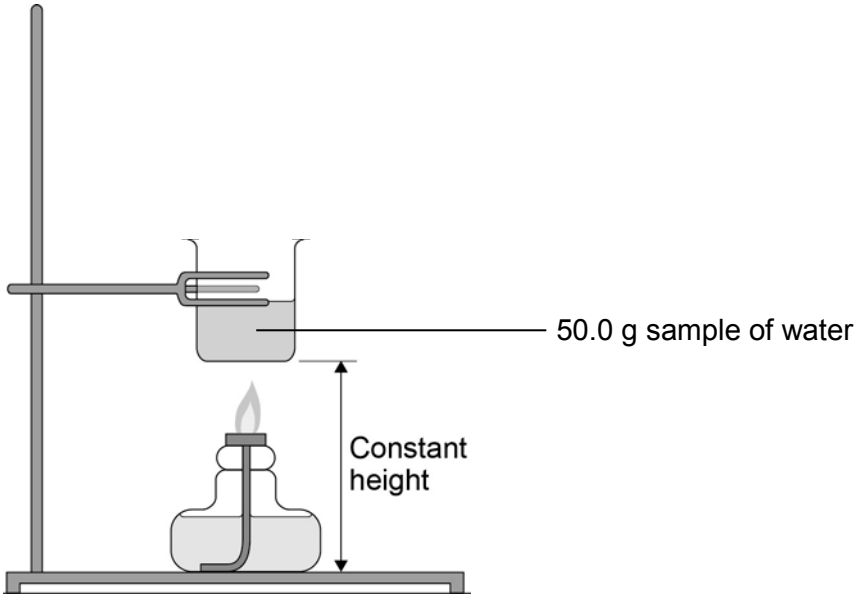
ANSWER IN THE SPACES PROVIDED

2 **Figure 1** shows apparatus used in an experiment to determine the enthalpy of combustion of leaf alcohol.

Figure 1



The alcohol is placed in a spirit burner and weighed. The burner is lit and the alcohol allowed to burn for a few minutes. The flame is extinguished and the burner is re-weighed. The temperature of the water is recorded before and after heating.

Table 1 shows the results obtained.

Table 1

Initial mass of spirit burner and alcohol / g	56.38
Final mass of spirit burner and alcohol / g	55.84
Initial temperature of water / °C	20.7
Final temperature of water / °C	40.8

0 2 . 1 Write an equation for the complete combustion of leaf alcohol ($CH_3CH_2CH{=}CHCH_2CH_2OH$).

[1 mark]

0 2 . 2 Use the results from **Table 1** to calculate a value for the enthalpy of combustion of leaf alcohol. Give units in your answer.
(The specific heat capacity of water is 4.18 J K^{-1} g^{-1})

[4 marks]

Enthalpy of combustion = _____ Units = _____

0 2 . 3 State how your answer to Question **2.2** is likely to differ from the value quoted in reference sources.
Give **one** reason for your answer.

[2 marks]

_____

_____

_____

_____

_____

Question 2 continues on the next page

0 2 . 4 A 50.0 g sample of water was used in this experiment.

Explain how you could measure out this mass of water without using a balance.

[2 marks]

3 2-bromo-2-methylpentane is heated with potassium hydroxide dissolved in ethanol. Two structural isomers are formed.

0 3 . 1 State the meaning of the term **structural isomers**.

[1 mark]

0 3 . 2 Name and draw the mechanism for the formation of **one** of the isomers.

[5 marks]

Name of mechanism _____

Mechanism

Turn over for the next question

4 Glucose can decompose in the presence of microorganisms to form a range of products. One of these is a carboxylic acid (M_r = 88.0) containing 40.9% carbon and 4.5% hydrogen by mass.

0 4 . 1 Deduce the empirical and molecular formulas of the carboxylic acid formed.

[4 marks]

Empirical formula = _____ Molecular formula = _____

0 4 . 2 Ethanol is formed by the fermentation of glucose.
A student carried out this fermentation reaction in a beaker using an aqueous solution of glucose at a temperature of 25 °C in the presence of yeast.

Write an equation for the reaction occurring during fermentation.

[1 mark]

_____

0 4 . 3 In industry, this fermentation reaction is carried out at 35 °C rather than 25 °C.

Suggest **one** advantage and **one** disadvantage for industry of carrying out the fermentation at this higher temperature.

[2 marks]

Advantage _____

_____

Disadvantage _____

_____

0 4 . 4 The method used by the student in Question **4.2** would result in the ethanol being contaminated by ethanoic acid.

How does this contamination occur?

[1 mark]

0 4 . 5 Give **two** differences between the infrared spectrum of a carboxylic acid and that of an alcohol other than in their fingerprint regions.
Use **Table A** on the Data Sheet.

[2 marks]

Difference 1 _____

Difference 2 _____

Turn over for the next question

5 CCl_4 is an effective fire extinguisher but it is no longer used because of its toxicity and its role in the depletion of the ozone layer. In the upper atmosphere, a bond in CCl_4 breaks and reactive species are formed.

0 5 . 1 Identify the condition that causes a bond in CCl_4 to break in the upper atmosphere. Deduce an equation for the formation of the reactive species.

[2 marks]

Condition _____

Equation

_____

0 5 . 2 One of the reactive species formed from CCl_4 acts as a catalyst in the decomposition of ozone.

Write **two** equations to show how this species acts as a catalyst.

[2 marks]

Equation 1

_____

Equation 2

_____

0 5 . 3 A small amount of the freon CF_3Cl with a mass of 1.78×10^{-4} kg escaped from a refrigerator, into a room of volume 100 m^3. Assuming that the freon is evenly distributed throughout the air in the room, calculate the number of freon molecules in a volume of 500 cm^3.
Give your answer to the appropriate number of significant figures.

The Avogadro constant = 6.02×10^{23} mol^{-1}.

[3 marks]

Number of molecules = _____

Turn over for the next question

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6 Dodecane ($C_{12}H_{26}$) is a hydrocarbon found in the naphtha fraction of crude oil. Dodecane can be used as a starting material to produce a wide variety of useful products. The scheme in **Figure 2** shows how one such product, polymer **Y**, can be produced from dodecane.

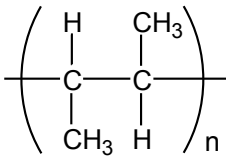
Figure 2

Reaction **1**

$$C_{12}H_{26} \longrightarrow C_2H_4 + C_4H_8 + \mathbf{X}$$

Reaction **2**

$$nC_4H_8 \rightleftharpoons$$



Polymer **Y**

0 6 . 1 Name the homologous series that both C_2H_4 and C_4H_8 belong to.
Draw a functional group isomer of C_4H_8 that does **not** belong to this homologous series.

[2 marks]

Name _____

Functional group isomer

0 6 . 2 Identify compound **X**.

[1 mark]

_____

0 6 . 3 Name polymer **Y**.

[1 mark]

_____

0 6 . 4 Reaction **1** is an example of thermal cracking and is carried out at a temperature of 750 °C.

State **one other** reaction condition needed.

[1 mark]

0 6 . 5 Reaction **2** is exothermic. A typical compromise temperature of 200 °C is used industrially for this reaction.

Explain the effect of a change of temperature on both the position of equilibrium and the rate of reaction, and justify why a compromise temperature is used industrially.

[6 marks]

7 A student carried out an experiment to determine the number of C=C double bonds in a molecule of a cooking oil by measuring the volume of bromine water decolourised.

The student followed these instructions:

- Use a dropping pipette to add 5 drops of oil to 5.0 cm^3 of inert organic solvent in a conical flask.
- Use a funnel to fill a burette with bromine water.
- Add bromine water from a burette to the solution in the conical flask and swirl the flask after each addition to measure the volume of bromine water that is decolourised.

The student's results are shown in **Table 2**.

Table 2

Experiment	Volume of bromine water / cm^3
1	39.40
2	43.50
3	41.20

0 7 . 1 In a trial experiment, the student failed to fill the burette correctly so that the gap between the tap and the tip of the burette still contained air.

Suggest what effect this would have on the measured volume of bromine water in this trial. Explain your answer.

[2 marks]

0 7 . 2 Other than incorrect use of the burette, suggest a reason for the inconsistency in the student's results.

[1 mark]

0 7 . 3 Outline how the student could improve this practical procedure to determine the number of C=C double bonds in a molecule of the oil so that more consistent results are obtained.

[4 marks]

0 7 . 4 The oil has a density of 0.92 g cm^{-3} and each of the 5 drops of oil has a volume of 5.0×10^{-2} cm^3.
The approximate M_r of the oil is 885
The concentration of bromine water used was 2.0×10^{-2} mol dm^{-3}.

Use these data and the results from experiment **1** to deduce the number of C=C double bonds in a molecule of the oil.
Show your working.

[5 marks]

Number of C=C double bonds = _____

Section B

Answer **all** questions in this section.

Only **one** answer per question is allowed.

For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD  WRONG METHODS 

If you want to change your answer you must cross out your original answer as shown. 

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. 

0 8 Which of these samples of gas contains the largest number of molecules?
The gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$.

[1 mark]

A $5.0 \times 10^{-4}\ m^3$ at 1.0×10^{6} Pa and 300 K ⬭

B $4.0 \times 10^{-3}\ m^3$ at 2.0×10^{5} Pa and 400 K ⬭

C $3.0 \times 10^{1}\ dm^3$ at 3.0×10^{4} Pa and 500 K ⬭

D $2.0 \times 10^{2}\ dm^3$ at 4.0×10^{3} Pa and 600 K ⬭

0 9 Which of these substances has permanent dipole-dipole attractions between molecules?

[1 mark]

A CCl_4 ⬭

B C_2F_4 ⬭

C $(CH_3)_2CO$ ⬭

D CO_2 ⬭

1 0 What is the total volume of gas remaining after 20 cm^3 ethane are burned completely in 100 cm^3 oxygen? All volumes are measured at the same pressure and the same temperature, which is above 100 °C.

[1 mark]

$$C_2H_6 + 3\tfrac{1}{2}O_2 \longrightarrow 2CO_2 + 3H_2O$$

A 40 cm^3 ⬭

B 100 cm^3 ⬭

C 120 cm^3 ⬭

D 130 cm^3 ⬭

1 1 Consider the reaction between propene and hydrogen bromide to form the major product.

Which species is formed in the mechanism of this reaction?

[1 mark]

A $CH_3–C^+H–CH_2Br$ ⬭

B $CH_3–CHBr–C^+H_2$ ⬭

C $CH_3–C^+H–CH_3$ ⬭

D $CH_3–CH_2–C^+H_2$ ⬭

1 2 Which of these substances reacts most rapidly to produce a silver halide precipitate with acidified silver nitrate?

[1 mark]

A CH_3Br ⬭

B CH_3Cl ⬭

C CH_3F ⬭

D CH_3I ⬭

1 3 Which statement about *E*-1,2-dichloroethene is correct?

[1 mark]

A It has the same boiling point as *Z*-1,2-dichloroethene. ⬭

B It forms a polymer with the same repeating unit as *Z*-1,2-dichloroethene. ⬭

C It has the same IR spectrum as *Z*-1,2-dichloroethene in the range 400–1500 cm^{-1}. ⬭

D It has a molecular ion peak different from that of *Z*-1,2-dichloroethene in its mass spectrum. ⬭

1 4 Which statement about ethene is correct?

[1 mark]

A It has no geometric isomers because there is free rotation around the C=C bond. ⬭

B It reacts with HBr in a nucleophilic addition reaction. ⬭

C It burns in excess oxygen to produce carbon dioxide and water. ⬭

D The C=C bond is twice as strong as the C–C bond in ethane. ⬭

1 5 Which statement about ethanal is correct?

[1 mark]

A It reacts with Tollens' reagent to form silver. ⬭

B It has a higher boiling point than ethanol. ⬭

C Its empirical and molecular formulas are different. ⬭

D It belongs to a homologous series with general formula $C_nH_{2n+1}O$ ⬭

1 6 Which of these substances does **not** contribute to the greenhouse effect?

[1 mark]

A Unburned hydrocarbons. ⬭

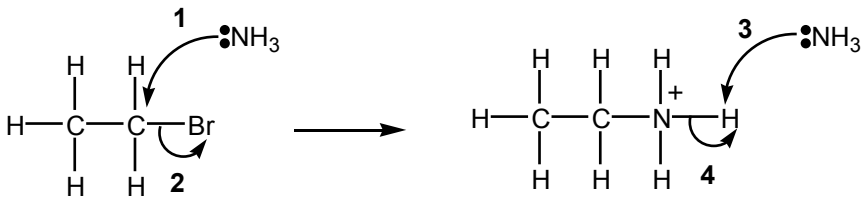
B Carbon dioxide. ⬭

C Water vapour. ⬭

D Nitrogen. ⬭

Questions **17** and **18** are about a method that can be used to prepare ethylamine.

$$CH_3CH_2Br + 2NH_3 \longrightarrow CH_3CH_2NH_2 + NH_4Br$$



1 7 Which of the curly arrows in the mechanism is **not** correct?

[1 mark]

A 1 ⬭

B 2 ⬭

C 3 ⬭

D 4 ⬭

1 8 Which statement about the reaction is **not** correct?

[1 mark]

A Ethylamine is a primary amine. ⬭

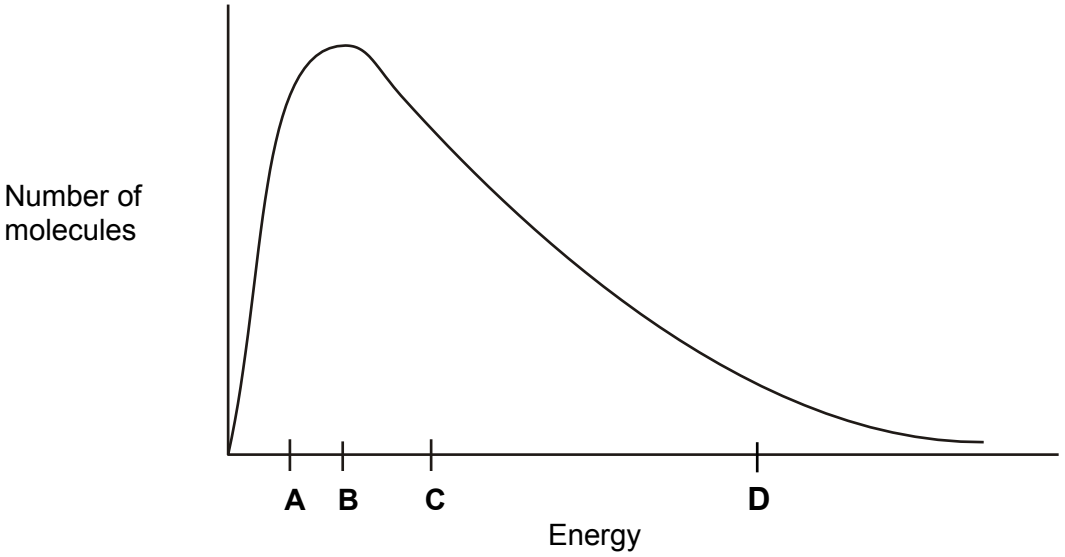
B The mechanism is a nucleophilic substitution. ⬭

C Using an excess of bromoethane will prevent further reaction to form a mixture of amine products. ⬭

D Ammonium bromide is an ionic compound. ⬭

Questions **19** and **20** are about the Maxwell–Boltzmann distribution of molecular energies in a sample of a gas shown in **Figure 3**.

Figure 3



1 9 Which letter best represents the mean energy of the molecules?

[1 mark]

A ⬭

B ⬭

C ⬭

D ⬭

2 0 What does the area under the curve represent?

[1 mark]

A The total energy of the particles. ⬭

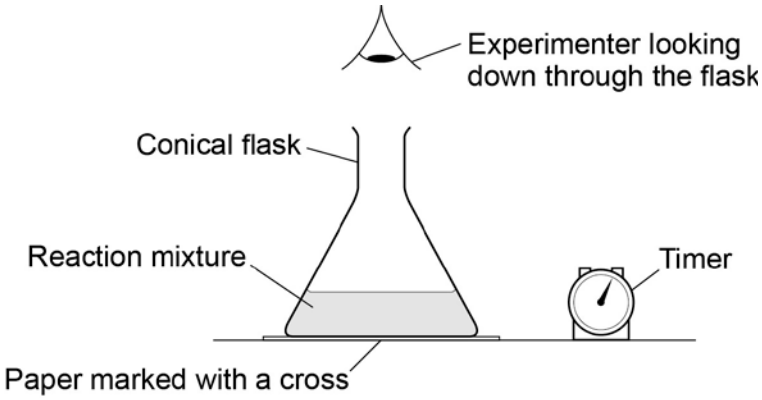
B The total number of particles. ⬭

C The number of particles that can react with each other. ⬭

D The total number of particles that have activation energy. ⬭

The apparatus in **Figure 4** was set up to measure the time taken for 20.0 cm^3 of sodium thiosulfate solution to react with 5.0 cm^3 of hydrochloric acid in a 100 cm^3 conical flask at 20 °C. The timer was started when the sodium thiosulfate solution was added to the acid in the flask. The timer was stopped when it was no longer possible to see the cross on the paper.

Figure 4



2 1 What is likely to decrease the accuracy of the experiment?

[1 mark]

A Rinsing the flask with acid before each new experiment. ⬭

B Stirring the solution throughout each experiment. ⬭

C Using the same piece of paper for each experiment. ⬭

D Using different measuring cylinders to measure the volumes of acid and sodium thiosulfate. ⬭

2 2 The experiment was repeated at 20 °C using a 250 cm^3 conical flask.

Which statement is correct about the time taken for the cross to disappear when using the larger conical flask?

[1 mark]

A The time taken will **not** be affected by using the larger conical flask. ⬭

B The time taken will be decreased by using the larger conical flask. ⬭

C The time taken will be increased by using the larger conical flask. ⬭

D It is impossible to predict how the time taken will be affected by using the larger conical flask. ⬭

END OF QUESTIONS

There are no questions printed on this page

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