AS Chemistry (7404/2)
Paper 2: Organic and Physical Chemistry

Specimen 2015 v0.5 Session 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 [Redacted] Candidate number [Redacted]
Surname [Redacted]
Forename(s) [Redacted]
Candidate signature [Redacted]
Section A

Answer all questions in this section.

1 Compound J, known as leaf alcohol, has the structural formula CH₃CH₂CH=CHCH₂CH₂OH and is produced in small quantities by many green plants. The E isomer of J is responsible for the smell of freshly cut grass.

Give the structure of the E isomer of J. [1 mark]

Give the skeletal formula of the organic product formed when J is dehydrated using concentrated sulfuric acid. [1 mark]
Another structural isomer of J is shown below.

\[
\begin{align*}
\text{CH}_3\text{CH}_2 & \quad \text{C} = \text{C} \quad \text{CH}_3\text{OH} \\
\text{CH}_3 & \quad \text{H} 
\end{align*}
\]

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
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

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED
Figure 1 shows apparatus used in an experiment to determine the enthalpy of combustion of leaf alcohol.

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.

| 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  |

Write an equation for the complete combustion of leaf alcohol (CH₃CH₂CH=CHCH₂CH₂OH).

[1 mark]
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]

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]

Enthalpy of combustion = ____________________ Units = ____________________

Question 2 continues on the next page
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]

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

03.1 State the meaning of the term structural isomers. [1 mark]

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
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.

Deduce the empirical and molecular formulas of the carboxylic acid formed. [4 marks]

Empirical formula = ________________  Molecular formula = ________________

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]

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 ___________________________________________________________________
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]

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
CCl₄ 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 CCl₄ breaks and reactive species are formed.

Identify the condition that causes a bond in CCl₄ to break in the upper atmosphere. Deduce an equation for the formation of the reactive species. [2 marks]

Condition ____________________________

Equation ____________________________

One of the reactive species formed from CCl₄ 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

A small amount of the freon CF₃Cl with a mass of 1.78 × 10⁻⁴ kg escaped from a refrigerator, into a room of volume 100 m³. Assuming that the freon is evenly distributed throughout the air in the room, calculate the number of freon molecules in a volume of 500 cm³.

Give your answer to the appropriate number of significant figures.

The Avogadro constant = 6.02 × 10²³ mol⁻¹. [3 marks]

Number of molecules = ____________________________
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**

\[ \text{C}_{12}\text{H}_{26} \rightarrow \text{C}_2\text{H}_4 + \text{C}_4\text{H}_8 + X \]

**Reaction 2**

\[ n\text{C}_4\text{H}_8 \xrightarrow{\text{C}} \bigg( \begin{array}{c} \text{H} \\ \text{CH}_3 \end{array} \bigg) \bigg( \begin{array}{c} \text{C} \\ \text{C} \end{array} \bigg)_n \bigg( \begin{array}{c} \text{CH}_3 \\ \text{H} \end{array} \bigg) \]

**Polymer Y**

06.1 Name the homologous series that both C\textsubscript{2}H\textsubscript{4} and C\textsubscript{4}H\textsubscript{8} belong to. Draw a functional group isomer of C\textsubscript{4}H\textsubscript{8} that does not belong to this homologous series.

[2 marks]

Name ____________________________________________

Functional group isomer

06.2 Identify compound X.

[1 mark]

________________________________________________

06.3 Name polymer Y.

[1 mark]

________________________________________________
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]

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]
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 cm³ 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>
<thead>
<tr>
<th>Experiment</th>
<th>Volume of bromine water / cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39.40</td>
</tr>
<tr>
<td>2</td>
<td>43.50</td>
</tr>
<tr>
<td>3</td>
<td>41.20</td>
</tr>
</tbody>
</table>

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]

Other than incorrect use of the burette, suggest a reason for the inconsistency in the student’s results.

[1 mark]
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]

The oil has a density of 0.92 g cm\(^{-3}\) and each of the 5 drops of oil has a volume of \(5.0 \times 10^{-2}\) cm\(^3\).

The approximate \(M_r\) of the oil is 885

The concentration of bromine water used was \(2.0 \times 10^{-2}\) 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 \( R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1} \).

[1 mark]

A 5.0 \times 10^{-4} \text{ m}^3 \text{ at } 1.0 \times 10^6 \text{ Pa and } 300 \text{ K} ✗

B 4.0 \times 10^{-3} \text{ m}^3 \text{ at } 2.0 \times 10^5 \text{ Pa and } 400 \text{ K} ✗

C 3.0 \times 10^1 \text{ dm}^3 \text{ at } 3.0 \times 10^4 \text{ Pa and } 500 \text{ K} ✗

D 2.0 \times 10^2 \text{ dm}^3 \text{ at } 4.0 \times 10^3 \text{ Pa and } 600 \text{ K} ✗

0 9

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

[1 mark]

A CCl\(_4\) ✗

B C\(_2\)F\(_4\) ✗

C (CH\(_3\))\(_2\)CO ✗

D CO\(_2\) ✗
10 What is the total volume of gas remaining after 20 cm³ ethane are burned completely in 100 cm³ oxygen? All volumes are measured at the same pressure and the same temperature, which is above 100 °C.

\[
\begin{align*}
\text{C}_2\text{H}_6 + \frac{3}{2}\text{O}_2 & \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O} \\
\end{align*}
\]

<table>
<thead>
<tr>
<th>Option</th>
<th>Volume (cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>40</td>
</tr>
<tr>
<td>B</td>
<td>100</td>
</tr>
<tr>
<td>C</td>
<td>120</td>
</tr>
<tr>
<td>D</td>
<td>130</td>
</tr>
</tbody>
</table>

[1 mark]

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

Which species is formed in the mechanism of this reaction?

<table>
<thead>
<tr>
<th>Option</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>CH₃–C’H–CH₂Br</td>
</tr>
<tr>
<td>B</td>
<td>CH₃–CHBr–C’H₂</td>
</tr>
<tr>
<td>C</td>
<td>CH₃–C’H–CH₃</td>
</tr>
<tr>
<td>D</td>
<td>CH₃–CH₂–C’H₂</td>
</tr>
</tbody>
</table>

[1 mark]

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

<table>
<thead>
<tr>
<th>Option</th>
<th>Substance</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>CH₃Br</td>
</tr>
<tr>
<td>B</td>
<td>CH₃Cl</td>
</tr>
<tr>
<td>C</td>
<td>CH₃F</td>
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<tr>
<td>D</td>
<td>CH₃I</td>
</tr>
</tbody>
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[1 mark]
Which statement about \(\text{E}-1,2\)-dichloroethene is correct?

A) It has the same boiling point as \(\text{Z}-1,2\)-dichloroethene.

B) It forms a polymer with the same repeating unit as \(\text{Z}-1,2\)-dichloroethene.

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

D) It has a molecular ion peak different from that of \(\text{Z}-1,2\)-dichloroethene in its mass spectrum.

---

Which statement about ethene is correct?

A) It has no geometric isomers because there is free rotation around the \(\text{C}=\text{C}\) 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 \(\text{C}=\text{C}\) bond is twice as strong as the \(\text{C}–\text{C}\) bond in ethane.

---

Which statement about ethanal is correct?

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 \(\text{C}_n\text{H}_{2n+1}\text{O}\).
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.

\[
\text{CH}_3\text{CH}_2\text{Br} + 2\text{NH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{NH}_2 + \text{NH}_4\text{Br}
\]

Which of the curly arrows in the mechanism is not correct? [1 mark]

A 1  
B 2  
C 3  
D 4

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.

Which letter best represents the mean energy of the molecules?

A  
B  
C  
D  

What does the area under the curve represent?

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**

What is likely to decrease the accuracy of the experiment?

- **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.

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?

- **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