

1(a). Three alcohols, **A**, **B** and **C**, are structural isomers with the molecular formula  $C_5H_{12}O$ .

**A**, **B** and **C** take part in combustion reactions.

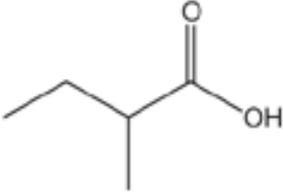
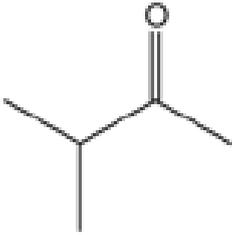
Complete the equation for the complete combustion of  $C_5H_{12}O$ .

$C_5H_{12}O + \dots\dots\dots$  [2]

(b). Alcohols **A**, **B** and **C** are each refluxed with acidified dichromate(VI),  $H^+/Cr_2O_7^{2-}$ .

The organic products are shown in the table below.

Complete the table to show the structures of alcohols **A**, **B** and **C**.

Alcohol	Structure of alcohol	Organic product after refluxing with $H^+/Cr_2O_7^{2-}$
<b>A</b>		
<b>B</b>		
<b>C</b>		No reaction

[3]

2. This question is about the analysis of organic compounds.

Compounds **F**, **G**, **H** and **I** are structural isomers.

A student carries out test-tube tests on the compounds.

The student records the observations after carrying out each test.

These are shown in **Table 5.1**.

In **Table 5.1**, 2,4-dinitrophenylhydrazine has been abbreviated to 2,4-DNP.



---

---

---

---

---

Extra answer space if required.

---

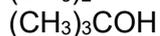
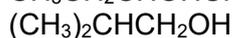
---

---

[6]

**3(a).** This question is about reactions of alcohols.

There are 4 structural isomers of  $C_4H_{10}O$  that are alcohols:



Alcohols take part in many different types of reaction, including

- elimination
- oxidation
- substitution
- esterification.

For each type of reaction, choose appropriate reagent(s) and/or catalyst, and show the organic product formed.

Elimination reaction of  $CH_3CH_2CH_2CH_2OH$

**Reagent(s) and/or catalyst**

---

---

<b>organic product</b>
------------------------

[2]

(b). Oxidation reaction of  $\text{CH}_3\text{CH}_2\text{CHOHCH}_3$

Reagent(s) and/or catalyst

-----

-----

organic product

[2]

(c). Substitution reaction of  $(\text{CH}_3)_2\text{CHCH}_2\text{OH}$

Reagent(s) and/or catalyst

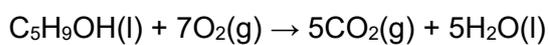
-----

-----

organic product

[2]

4. 4.30 g of the alcohol  $\text{C}_5\text{H}_9\text{OH}$ , ( $M_r = 86.0$ ), is burned in oxygen.



Which volume of oxygen gas is needed, in  $\text{dm}^3$ , for this complete combustion of  $\text{C}_5\text{H}_9\text{OH}$ , at RTP?

- A 1.2
- B 2.4
- C 5.8
- D 8.4

Your answer

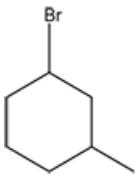
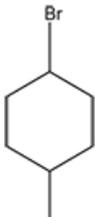
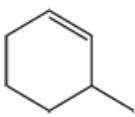
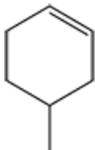
[1]





7. 3-Methylcyclohexanol is reacted with NaBr and H<sub>2</sub>SO<sub>4</sub>.

What is the organic product?

<b>A</b>	
<b>B</b>	
<b>C</b>	
<b>D</b>	

Your answer

[1]

8(a). This question is about alcohols.

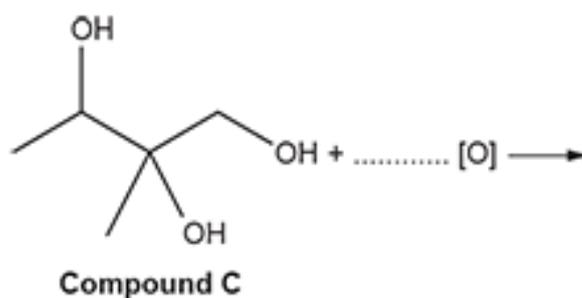
An **unsaturated** alcohol has 6 carbon atoms and contains **one** C=C bond.

Construct an equation for the complete combustion of this alcohol.

[2]

(b). Compound **C**, shown below, is refluxed with excess acidified potassium dichromate(VI) to form a single organic product and one other product.

Complete the equation for this reaction.



[3]

(c). Compound **D**, shown below, is refluxed with  $\text{H}_2\text{SO}_4$ , as an acid catalyst, to form a mixture of three isomers with the molecular formula  $\text{C}_7\text{H}_{10}$ .



**Compound D**

i. Draw the structures of the **three** isomers of  $\text{C}_7\text{H}_{10}$  formed from compound **D**.

--	--	--

[3]

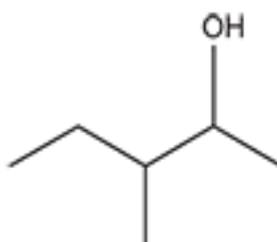
ii. A student converts compound **D** into a diiodoalkane.

Suggest suitable reagents for this reaction.

[1]

**9(a)**. This question is about alkenes.

A mixture of alkenes is produced when water is eliminated from alcohol **A**.



**Alcohol A**

i. What is the systematic name of alcohol **A**?

[1]

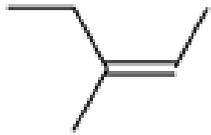
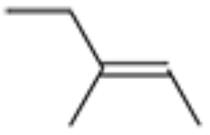
ii. Alcohol **A** is refluxed with an acid catalyst.

- A mixture of alkene isomers **B**, **C** and **D** is formed.
- Alkenes **B** and **C** show *E/Z* isomerism but alkene **D** does not.

Construct the equation for the formation of alkene **D** from alcohol **A**.  
Show the structure of the organic product.

[2]

iii. The skeletal formulae of alkenes **B** and **C** are shown below.

	Alkene B	Alkene C
Skeletal formula		
Isomer	<i>Z</i>	<i>E</i>

Use the Cahn-Ingold-Prelog priority rules to explain why alkene **B** is the *Z* isomer.

---



---

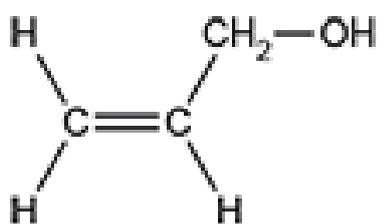


---

[2]

(b). A chemistry company is developing water-soluble polymers.

The chemists decide to use compound **E**, shown below, as the monomer.



Compound **E**

i.

- ii. Draw a section of the polymer formed, showing **two** repeat units, and suggest why this polymer is likely to be soluble in water.

Section of polymer (**two** repeat units)

Reason for solubility in water \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

----- [2]

- ii. Outline **two** ways that waste hydrocarbon polymers can be processed usefully, rather than being disposed of in landfill sites.

1 \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

2 \_\_\_\_\_

\_\_\_\_\_

----- [2]

10. Information about 1-bromobutane and butan-1-ol is shown in the table.

Compound	Melting point / °C	Boiling point / °C	Density / g cm <sup>-3</sup>
1-bromobutane	-113	102	1.268
butan-1-ol	-90	118	0.810

A student prepares a sample of 1-bromobutane by refluxing 9.25 g of butan-1-ol with sodium bromide and sulfuric acid.

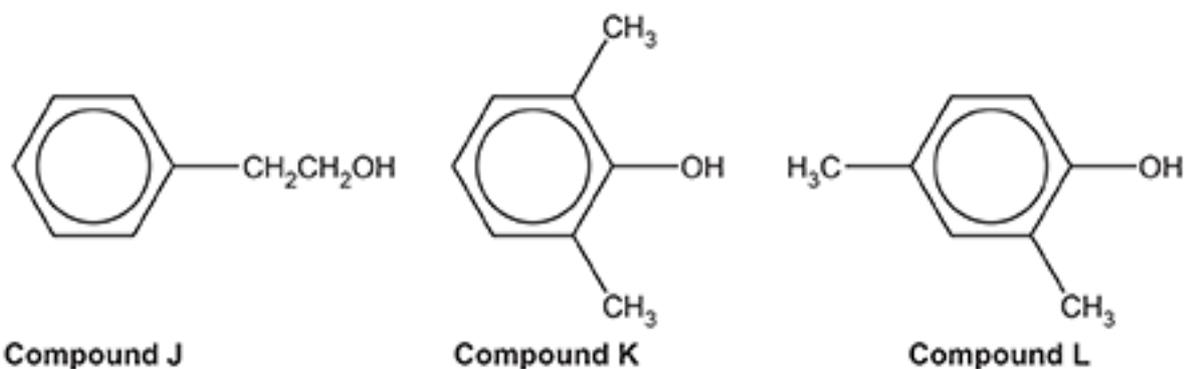
After reflux, the reaction mixture is purified.

The student obtains 6.10 cm<sup>3</sup> of pure 1-bromobutane.



**11(a).** This question is about the chemistry of aromatic compounds.

Compounds **J**, **K** and **L**, shown below, are structural isomers.



Compound **J**,  $\text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{OH}$ , is reacted with acidified potassium dichromate(VI) under reflux to form organic product **M**.

Write an equation for this reaction.

Use [O] to represent the oxidising agent and show the structure of **M**.

[2]

**(b).** 1-phenylethanol is a naturally occurring compound found in many vegetables and flowers.

1-phenylethanol can be synthesised from 2-phenylethanol in two stages.



Suggest reagents, conditions and equations for each stage in the synthesis.

Show structures for organic compounds.

**Stage 1**

reagents and conditions .....

equation:

**Stage 2**

reagents and conditions .....

equation:

**[4]**

**12.** 2-Bromobutane,  $\text{CH}_3\text{CH}_2\text{CHBrCH}_3$ , can be prepared by several different methods.

The relative molecular mass,  $M_r$ , of 2-bromobutane is 136.9.

2-Bromobutane can be prepared by reacting butan-2-ol,  $\text{CH}_3\text{CH}_2\text{CHOHCH}_3$ , with sodium bromide and sulfuric acid (**Reaction 5.3**).

**Reaction 5.3**

2-Bromobutane is a liquid with a boiling point of 91 °C and does not mix with water.

- i. A student plans to prepare 10.0 g of 2-bromobutane using **Reaction 5.3**.

The percentage yield is 67.0%.

Calculate the mass of  $\text{CH}_3\text{CH}_2\text{CHOHCH}_3$  needed for this preparation.

Give your answer to **3** significant figures.

mass = ..... g **[3]**

- ii. The student mixes butan-2-ol, sodium bromide and sulfuric acid in a pear-shaped flask, and refluxes the mixture.

After 1 hour, the mixture in the flask has separated into two layers: an aqueous layer and an organic layer.

Describe the procedures the student would need to carry out to obtain a pure, dry sample of 2-bromobutane from this mixture.

---

---

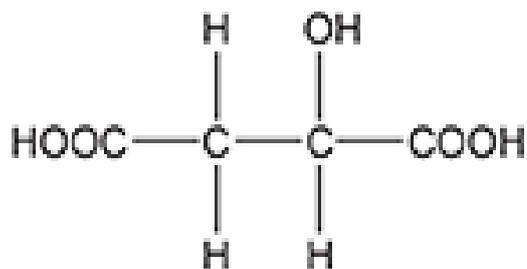
---

---

---

----- **[3]**

13. Apple juice contains malic acid which has the following structure.



Malic acid can be oxidised by heating with acidified potassium dichromate(VI).

Write a balanced equation for the reaction, showing the structure of the organic product.

Use [O] to represent the oxidising agent.

[2]

14. Internal combustion engines have historically used fuels obtained from crude oil as a source of power.

The environmental effects of fossil fuel use can be reduced by blending petrol with biofuels such as ethanol.

A fuel is being developed using a 1:1 molar ratio of octane and ethanol.

- i. Write the equation for the complete combustion of this fuel.

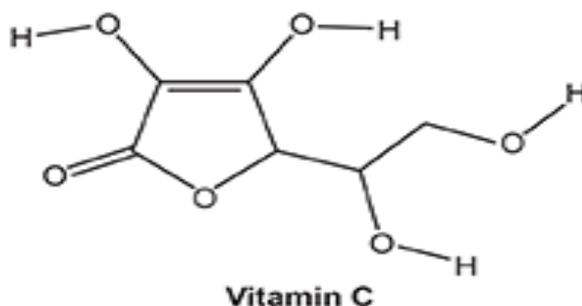
[1]

- ii. Calculate the energy released, in kJ, by the complete combustion of 8.00 kg of this fuel.  
 $\Delta_c H(\text{C}_8\text{H}_{18}) = -5470 \text{ kJ mol}^{-1}$  ;  $\Delta_c H(\text{C}_2\text{H}_5\text{OH}) = -1367 \text{ kJ mol}^{-1}$ .

energy released = ..... kJ [3]

**15(a).** A student carries out an investigation on vitamin C,  $C_6H_8O_6$ .

The structure of vitamin C is shown below. Vitamin C is an optical isomer.



What is the total number of optical isomers with the structure of vitamin C?

total number of optical isomers = ..... **[1]**

**(b).** Vitamin C is extremely soluble in water. This means that vitamin C is removed rapidly from the body. 'Vitamin C ester' is available in tablet form as a less soluble source of vitamin C which stays in the body for longer.

i. Suggest why vitamin C is extremely soluble in water.

---



---

..... **[1]**

ii. A 'vitamin C ester' tablet contains an ester with the molecular formula  $C_{22}H_{38}O_7$ .

This ester can be prepared by reacting vitamin C with a long chain carboxylic acid,  $C_xH_yCOOH$ , in the presence of an acid catalyst.

Vitamin C and the long chain carboxylic acid react in a 1:1 molar ratio.

Determine  $x$  and  $y$  in the formula of this carboxylic acid.

$x = \dots\dots\dots y = \dots\dots\dots$  **[2]**

**END OF QUESTION PAPER**