

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname StemUp Model Solution

Forename(s) _____

Candidate signature _____

I declare this is my own work.

INTERNATIONAL AS CHEMISTRY (9620)

Unit 2: Organic 1 and Physical 1

Tuesday 9 January 2024 07:00 GMT Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- the Periodic Table/Data Sheet, provided as an insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do **not** write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
TOTAL	



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

0 1

Alkanes are used as fuels in internal combustion engines in cars.

0 1 . 1

Write an equation to show the incomplete combustion of heptane (C_7H_{16}) to form carbon monoxide and water only.

[1 mark]



0 1 . 2

Some of alkane **A** is found unburned in car exhaust fumes. Analysis shows that 0.0381 mol of **A** has a mass of 4.35 g

Determine the molecular formula of **A**.
Show your working.

[2 marks]

$$M_r = \text{mass} \div \text{moles} = 4.35 \div 0.0381 = 114.2$$

$$\text{alkane } C_nH_{2n+2}: 12.0n + 1.0(2n + 2) = 114$$

$$14n + 2 = 114, \text{ so } n = 8$$

$$C_8H_{18} \quad (M_r = 96.0 + 18.0 = 114.0)$$

Molecular formula C_8H_{18}

0 1 . 3

Give **one** environmental reason why unburned alkanes are pollutant gases.

[1 mark]

They are greenhouse gases, which contribute to global warming.

0 1 . 4

Combustion of alkane fuels can produce sulfur dioxide.

Give **one** environmental reason for removing sulfur dioxide from the gaseous products of fuel combustion.

[1 mark]

Sulfur dioxide causes acid rain.



Nitrogen monoxide and carbon monoxide are also produced during the combustion of alkane fuels. These pollutant gases can be removed using a catalytic converter.

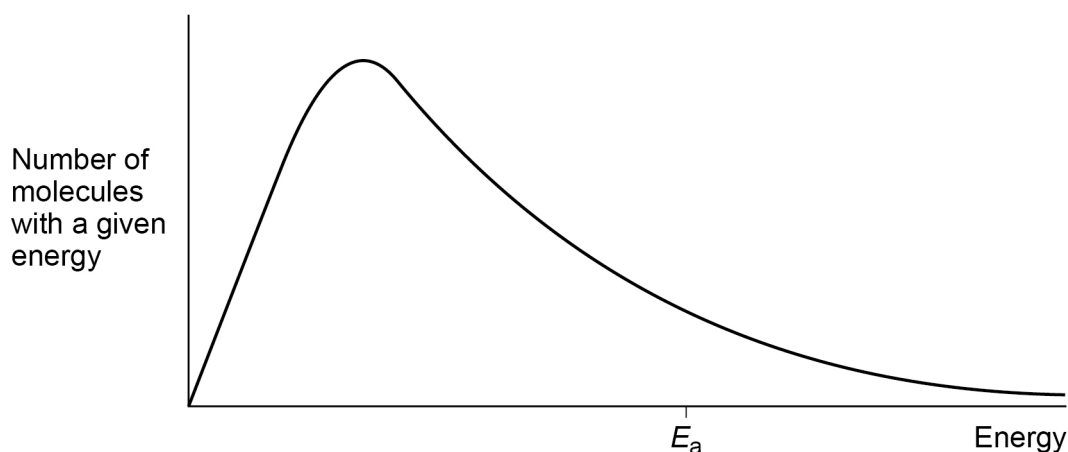
0 1 . 5 Suggest why the reaction is slow when a catalyst is **not** used.

[1 mark]

The reaction has a high activation energy (E_a).

Figure 1 shows a Maxwell–Boltzmann distribution for a gaseous mixture of nitrogen monoxide and carbon monoxide at a given temperature.

Figure 1



0 1 . 6 State the effect, if any, to the **area** under the curve when a catalyst is added to this gaseous mixture.

[1 mark]

No change (the area under the curve stays the same).

0 1 . 7 Explain how a catalyst increases the rate of a reaction.

[3 marks]

The catalyst provides an alternative reaction route (pathway) with a lower activation energy.

So a greater number of particles have energy $\geq E_a$.

So there is a greater frequency of successful collisions (with $E \geq E_a$).

0 1 . 8 Identify a catalyst used in the catalytic converter.

[1 mark]

Platinum (Pt)



0 2

The hydrocarbons in crude oil are separated into fractions by fractional distillation.

0 2 . 1

State the meaning of fractions.

[1 mark]

A mixture of hydrocarbons with similar boiling points.

There are three isomers with the molecular formula C_5H_{12}

0 2 . 2

Explain why dimethylpropane has the lowest boiling point.

[2 marks]

Dimethylpropane is the most branched isomer, so its molecules have fewer points of contact (a smaller surface area).

So there are weaker (fewer) van der Waals forces between the molecules, which need less energy to overcome.

0 2 . 3

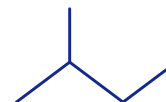
Draw skeletal formulas of the **two** other isomers with molecular formula C_5H_{12}

[2 marks]

Isomer 1



Isomer 2



0 2 . 4

Some of the hydrocarbons separated by fractional distillation are cracked. One molecule of a hydrocarbon **B** is cracked to produce two molecules of ethene, two molecules of propene and one molecule of butane.

Give the molecular formula of hydrocarbon **B**.

State the type of cracking involved.

Suggest why the percentage atom economy for this reaction is 100%

[3 marks]

Molecular formula of **B** *$C_{14}H_{30}$*

Type of cracking *Thermal cracking*

Atom economy reason *All the products are useful, so there are no waste products.*



0 3

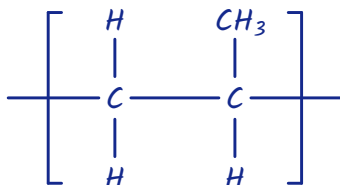
This question is about addition polymers.

0 3 . 1

The polymer poly(propene) is produced from propene.

Draw the repeating unit of poly(propene).

[1 mark]



0 3 . 2

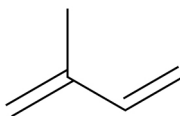
Give **one** reason why poly(propene) is unreactive.

[1 mark]

The C-C and C-H bonds are strong and non-polar.

0 3 . 3

An addition polymer is formed from isoprene.
The skeletal formula of isoprene is shown.



Use IUPAC rules to name isoprene.

[1 mark]

2-methylbuta-1,3-diene

3

Turn over ►

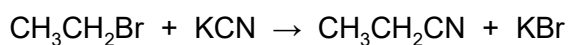


0 4

This question is about halogenoalkanes.

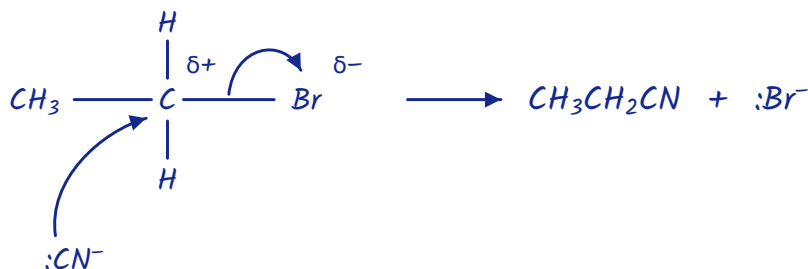
0 4 . 1

Bromoethane reacts with a warm aqueous ethanolic solution of potassium cyanide in a nucleophilic substitution reaction.



Outline a mechanism for the reaction.

[2 marks]



0 4 . 2

State why the reaction of potassium cyanide with iodoethane is faster than the reaction of potassium cyanide with bromoethane.

[1 mark]

The C-I bond is weaker than the C-Br bond (lower bond enthalpy), so less energy is needed to break it.

0 4 . 3

2-Bromopropane reacts with a hot ethanolic solution of potassium hydroxide to form propene.

State the role of the hydroxide ion in this reaction.

Write an overall equation for the reaction.

[2 marks]

Role of the hydroxide ion *Acts as a base (proton acceptor)*

Overall equation

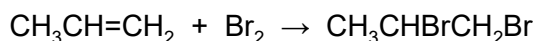


0 5

This question is about the formation of halogenoalkanes.

0 5 . 1

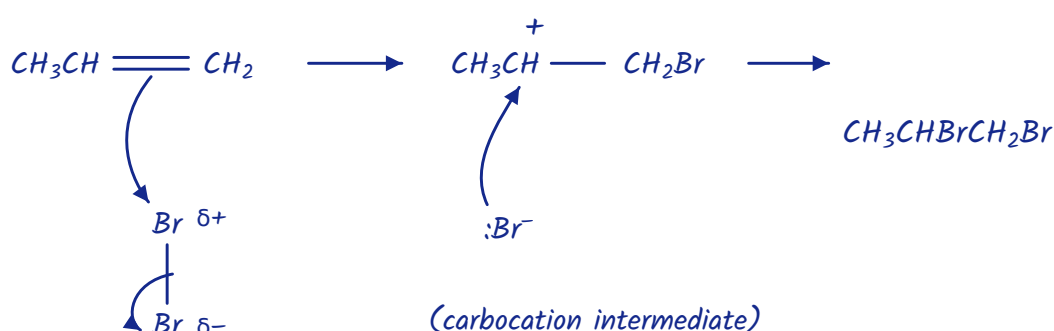
Propene reacts with bromine.



Name and outline the mechanism of this reaction.

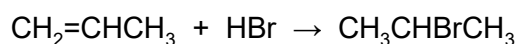
[4 marks]Name of mechanism Electrophilic addition

Mechanism



0 5 . 2

Propene reacts with HBr to form two possible products. The equation shows the formation of the major product.



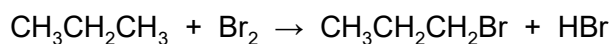
State the type of intermediate in the formation of the major product.

Explain why this intermediate is more stable than the intermediate that forms the minor product.

[3 marks]Type of intermediate Secondary carbocationExplanation The secondary carbocation has two alkyl groups attached to the C⁺, compared with only one in the primary carbocation.Alkyl groups are electron releasing (positive inductive effect), so the positive charge is more spread out and the ion is more stable.**Turn over ►**

0 5 . 3

Propane can react with bromine in ultraviolet light to form $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$



State the role of ultraviolet light in this reaction.

Outline **two** propagation steps from the mechanism.

[3 marks]

Role of ultraviolet light Provides energy to break the Br-Br bond

Propagation step 1 $\text{CH}_3\text{CH}_2\text{CH}_3 + \text{Br}\cdot \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\cdot + \text{HBr}$

Propagation step 2 $\text{CH}_3\text{CH}_2\text{CH}_2\cdot + \text{Br}_2 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{Br} + \text{Br}\cdot$

10



Turn over for the next question

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0 6

This question is about alcohols.

0 6 . 1

Alcohol **S** contains 60.0% C, 13.3% H and 26.7% ODetermine the empirical formula of **S**.

[2 marks]

$$C: 60.0 \div 12.0 = 5.00 \quad H: 13.3 \div 1.0 = 13.3 \quad O: 26.7 \div 16.0 = 1.67$$

$$\div 1.67: \quad C = 3.00 \quad H = 7.97 \approx 8 \quad O = 1.00$$

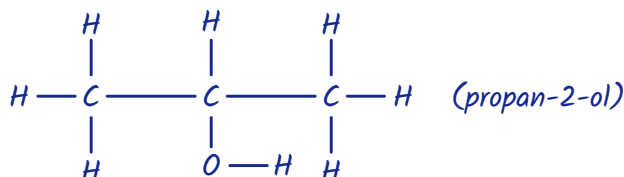
$$\text{ratio } C : H : O = 3 : 8 : 1$$

Empirical formula C_3H_8O

0 6 . 2

Alcohol **S** has $M_r = 60.0$ Alcohol **S** can be oxidised to form a compound that gives a signal at 1715 cm^{-1} in its infrared spectrum. The compound does **not** react with Tollens' reagent.Draw the displayed formula of alcohol **S**.

[1 mark]



0 6 . 3

A position isomer of alcohol **S** is oxidised to give compound **T**.
T reacts with NaHCO_3 Identify **T**.State what is observed when **T** reacts with NaHCO_3

[2 marks]

Identity of **T** Propanoic acid, $\text{CH}_3\text{CH}_2\text{COOH}$ Observation Effervescence (bubbles of CO_2 gas)

0 6 . 4

Identify a test-tube reagent, or combination of reagents, that can be used to oxidise primary and secondary alcohols but not tertiary alcohols.

State the colour change that is observed.

[2 marks]

Reagent(s) Potassium dichromate(VI) and sulfuric acid

Colour change Orange to green

0 6 . 5

A different alcohol $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{OH}$ is oxidised to form compound **X**.
X reacts with Fehling's solution.

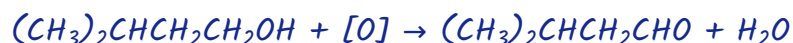
Write an equation for this oxidation of $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{OH}$
Use [O] to represent the oxidising agent.

Use IUPAC rules to name **X**.

State what is observed when **X** reacts with Fehling's solution.

[3 marks]

Equation



Name of **X** 3-methylbutanal

Observation Blue solution gives a brick-red precipitate

0 6 . 6

Ethanol reacts with epoxyethane to form compound **Z** ($\text{C}_4\text{H}_{10}\text{O}_2$)

State the C–O–C bond angle in epoxyethane.

Give the structure of **Z**.

[2 marks]

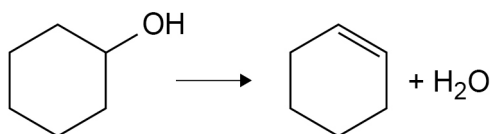
C–O–C bond angle in epoxyethane 60°

Structure of **Z** $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_2\text{OH}$



07

Cyclohexene can be made by adding an excess of concentrated sulfuric acid to hot cyclohexanol.



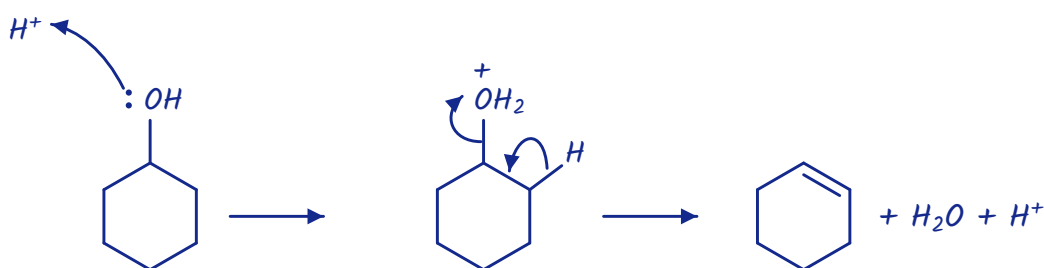
07.1

Name and outline the mechanism for this reaction.

[4 marks]

Name of mechanism Elimination

Mechanism



07.2

Identify a reagent, or combination of reagents, that can be used to confirm that an alkene is formed.

State what is observed.

[2 marks]

Reagent Bromine water

Observation Orange to colourless

(the bromine water is decolourised)

Table 1 contains data about cyclohexene and cyclohexanol.

Use the information in **Table 1** to help answer Questions **07.3–07.5**.

Table 1

Compound	Boiling point / °C	Density / g cm ⁻³	<i>M_r</i>
Cyclohexene	82.8	0.811	82.0
Cyclohexanol	161.8	0.948	100.0



0 7 . 3

Name a technique that can be used to separate cyclohexene from unreacted cyclohexanol.

[1 mark]

Fractional distillation

0 7 . 4

Explain, using the information in **Table 1**, how the purity of the separated cyclohexene can be determined.

[1 mark]

Measure the boiling point: pure cyclohexene boils sharply (narrow range) at 82.8 °C.

0 7 . 5

In an experiment 15.0 cm³ of cyclohexanol forms 9.62 g of cyclohexene.

Calculate the maximum mass of cyclohexene that can be made from 15.0 cm³ of cyclohexanol.

Calculate the percentage yield of cyclohexene in this experiment.

Use data from **Table 1** to answer this question.

[4 marks]

$$\text{mass of cyclohexanol} = 15.0 \times 0.948 = 14.22 \text{ g}$$

$$n(\text{cyclohexanol}) = 14.22 \div 100.0 = 0.1422 \text{ mol}$$

$$1 : 1 \text{ ratio, so } n(\text{cyclohexene}) = 0.1422 \text{ mol}$$

$$\text{maximum mass} = 0.1422 \times 82.0 = 11.66 \text{ g}$$

Maximum mass of cyclohexene 11.66 g

$$\% \text{ yield} = (9.62 \div 11.66) \times 100 = 82.5\%$$

Percentage yield of cyclohexene 82.5 %

12

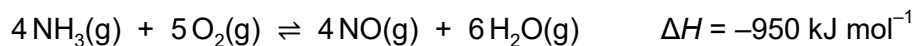
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0 8

This question is about chemical equilibria.

The equation for the reaction between ammonia and oxygen is



0 8

1

Write an expression for K_c for this reaction.Give the units of K_c

$$K_c = \frac{[\text{NO}]^4 [\text{H}_2\text{O}]^6}{[\text{NH}_3]^4 [\text{O}_2]^5}$$

[2 marks]

Units mol dm^{-3}

0 8

2

In an experiment 0.650 mol of NH_3 and 0.743 mol of O_2 are mixed and left to reach equilibrium.The equilibrium mixture contains 0.144 mol of NO and 0.216 mol of H_2O Calculate the amount, in mol, of NH_3 and O_2 in the equilibrium mixture.

[2 marks]

$$\text{NO formed} = 0.144 \text{ mol}; \text{NH}_3 : \text{NO} = 4 : 4$$

$$\text{NH}_3 \text{ reacted} = 0.144 \text{ mol, so } \text{NH}_3 = 0.650 - 0.144 = 0.506 \text{ mol}$$

$$\text{O}_2 \text{ reacted} = 0.144 \times 5/4 = 0.180 \text{ mol}$$

$$\text{O}_2 = 0.743 - 0.180 = 0.563 \text{ mol}$$

Mol NH_3 0.506Mol O_2 0.563

0 8 . 3

Explain why the K_c value for this reaction decreases as the temperature increases.

[3 marks]

The forward reaction is exothermic (ΔH is negative).

Increasing the temperature shifts the equilibrium to the left, in the endothermic direction, to oppose the increase in temperature.

So the amounts of reactants increase and the amounts of products decrease, so K_c decreases.

0 8 . 4

Explain why using a catalyst does **not** affect the equilibrium yield of NO

[1 mark]

A catalyst increases the rates of the forward and reverse reactions equally, so the position of equilibrium does not change.

0 8 . 5

The table shows three different gaseous equilibria reactions all at the same temperature.

Tick (✓) **one** box to select the reaction where an increase in overall pressure increases the equilibrium yield of **C**.

[1 mark]

Reaction
$A + 2B \rightleftharpoons 4C$
$A + B \rightleftharpoons 2C$
$2A + B \rightleftharpoons C$

☐
☐
☒

9

END OF QUESTIONS



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2 0



2 4 1 X C H O 2