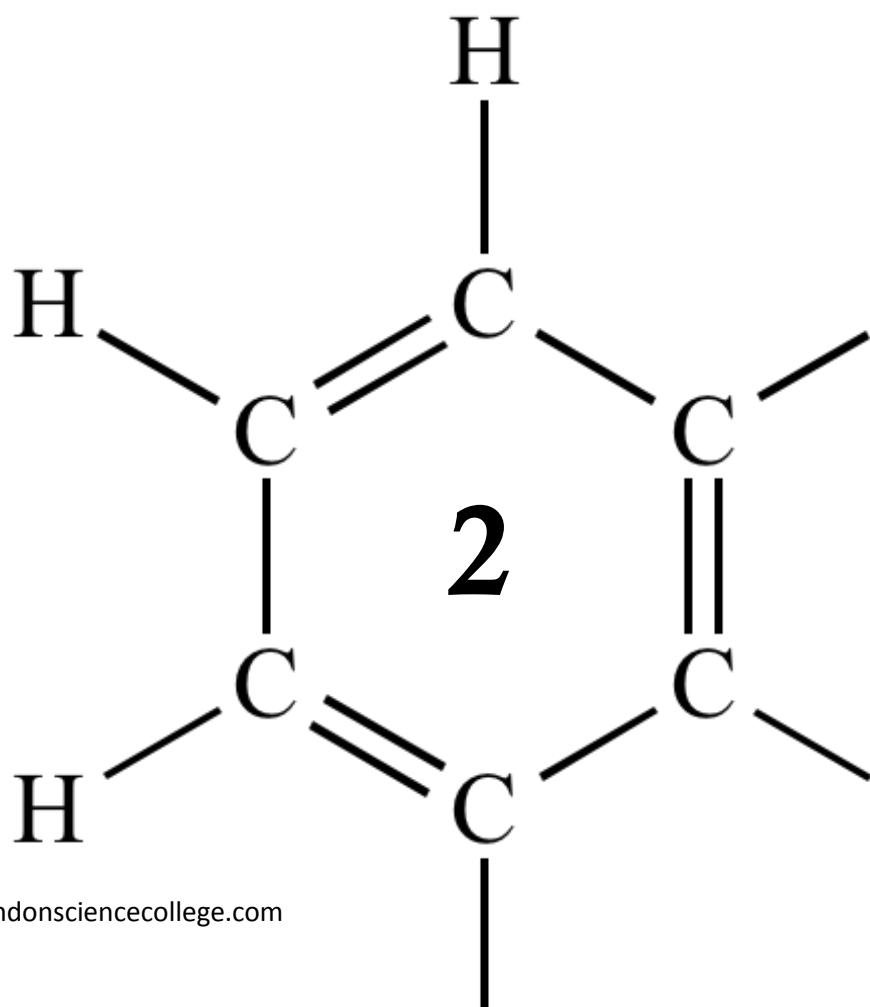


OCR AS CHEMISTRY

MODULE 4

ORGANIC
REACTION OF ALKANES / ALKENES



1

Alcohols can be prepared from alkenes in various ways.

- (a) On a laboratory scale, a mixture of propan-1-ol and propan-2-ol can be prepared from propene in two steps.

In step 1, propene reacts with cold, concentrated sulfuric acid to form intermediate compounds.

In step 2, the intermediate compounds react with water to form the mixture of alcohols.

Name and outline the mechanism for the reaction between propene and concentrated sulfuric acid to form the intermediate compound which gives propan-2-ol in step 2.

Explain why propan-2-ol is the major product of this preparation.

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(7)

- (b) On an industrial scale ethanol can be produced from ethene by direct hydration or from glucose by fermentation.

State the conditions for the direct hydration reaction.

State two advantages and two disadvantages of the fermentation method compared with the direct hydration method.

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(6)
(Total 13 marks)

2

Compound **J**, known as leaf alcohol, has the structural formula $\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_2\text{CH}_2\text{OH}$ and is produced in small quantities by many green plants. The *E* isomer of **J** is responsible for the smell of freshly cut grass.

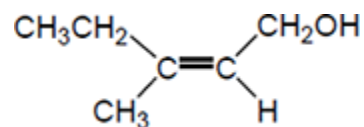
- (a) Give the structure of the *E* isomer of **J**.

(1)

- (b) Give the **skeletal formula** of the organic product formed when **J** is dehydrated using concentrated sulfuric acid.

(1)

- (c) 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.

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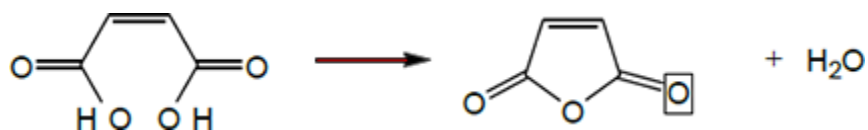
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(6)

(d) 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.

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(2)
(Total 10 marks)

3

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

(a) State the meaning of the term **structural isomers**.

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(1)

(b) Name and draw the mechanism for the formation of **one** of the isomers.

Name of mechanism

Mechanism

(5)
(Total 6 marks)

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.

(a) Deduce the empirical and molecular formulas of the carboxylic acid formed.

Empirical formula = Molecular formula =

(4)

(b) 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.

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(1)

(c) 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.

Advantage

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Disadvantage

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(2)

(d) The method used by the student in part (b) would result in the ethanol being contaminated by ethanoic acid.

How does this contamination occur?

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(1)

(e) 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.

Difference 1

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Difference 2

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(2)

(Total 10 marks)

5

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.

(a) 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.

Condition

Equation

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(2)

- (b) 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.

Equation 1

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Equation 2

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(2)

- (c) 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 = $6.02 \times 10^{23} \text{ mol}^{-1}$.

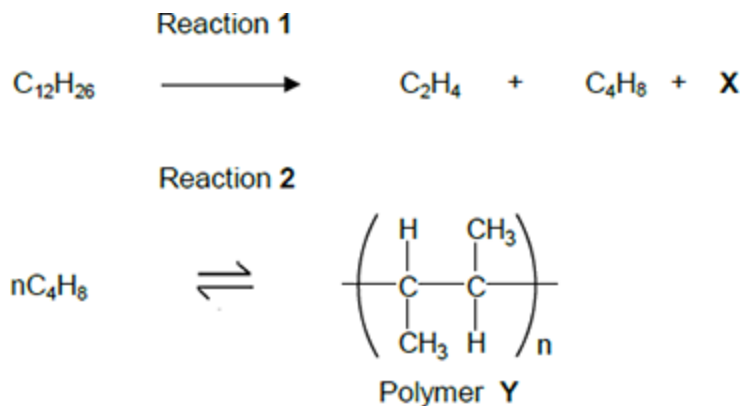
Number of molecules =

(3)

(Total 7 marks)

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 below shows how one such product, polymer **Y**, can be produced from dodecane.



- (a) 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.

Name

Functional group isomer

(2)

- (b) Identify compound **X**.

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(1)

- (c) Name polymer **Y**.

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(1)

- (d) Reaction **1** is an example of thermal cracking and is carried out at a temperature of $750\text{ }^\circ\text{C}$.

State **one other** reaction condition needed.

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(1)

- (e) 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.

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(6)
(Total 11 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 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 the table below.

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

- (a) 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.

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(2)

- (b) Other than incorrect use of the burette, suggest a reason for the inconsistency in the student's results.

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(1)

- (c) 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.

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(4)

- (d) The oil has a density of 0.92 g cm^{-3} and each of the 5 drops of oil has a volume of $5.0 \times 10^{-2} \text{ cm}^3$.
The approximate M_r of the oil is 885.
The concentration of bromine water used was $2.0 \times 10^{-2} \text{ mol dm}^{-3}$.

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

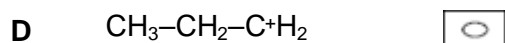
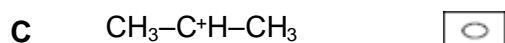
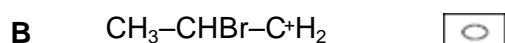
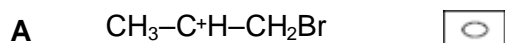
Show your working.

(5)
(Total 12 marks)

8

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

Which species is formed in the mechanism of this reaction?



(Total 1 mark)

9

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

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 $400\text{--}1500\text{ cm}^{-1}$.

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

(Total 1 mark)

10

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.

(Total 1 mark)

11 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 $C_nH_{2n+1}O$

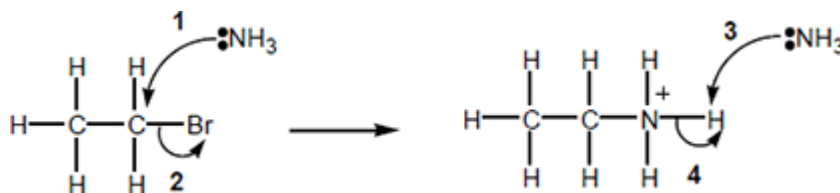
(Total 1 mark)

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

- A Unburned hydrocarbons.
- B Carbon dioxide.
- C Water vapour.
- D Nitrogen.

(Total 1 mark)

13 This question is about a method that can be used to prepare ethylamine.



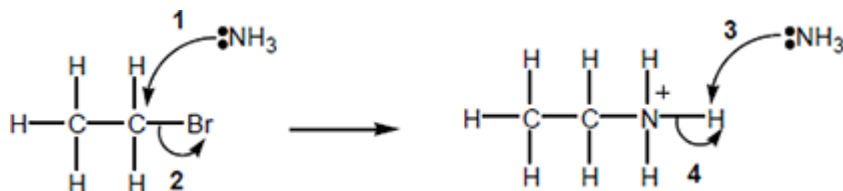
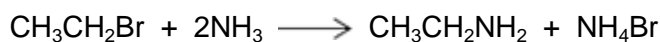
Which of the curly arrows in the mechanism is **not** correct?

- A 1
- B 2
- C 3
- D 4

(Total 1 mark)

14

This question is about a method that can be used to prepare ethylamine.



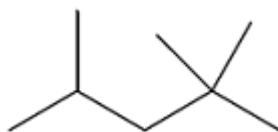
Which statement about the reaction is **not** correct?

- 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.

(Total 1 mark)

15

Isooctane (C_8H_{18}) is the common name for the branched-chain hydrocarbon that burns smoothly in car engines. The skeletal formula of isooctane is shown below.



(a) Give the IUPAC name for isooctane.

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(1)

(b) Deduce the number of peaks in the ^{13}C NMR spectrum of isooctane.

5

6

7

8

(1)

- (c) Isooctane can be formed, together with propene and ethene, in a reaction in which one molecule of an alkane that contains 20 carbon atoms is cracked.

Using molecular formulas, write an equation for this reaction.

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(1)

- (d) How do the products of the reaction in part (c) show that the reaction is an example of thermal cracking?

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(1)

- (e) Deduce the number of monochloro isomers formed by isooctane.
Draw the structure of the monochloro isomer that exists as a pair of optical isomers.

Number of monochloro isomers

Structure

(2)

- (f) An isomer of isooctane reacts with chlorine to form only one monochloro compound.

Draw the **skeletal formula** of this monochloro compound.

(1)

- (g) A sample of a monochlorooctane is obtained from a comet. The chlorine in the monochlorooctane contains the isotopes ^{35}Cl and ^{37}Cl in the ratio 1.5 : 1.0. Calculate the M_r of this monochlorooctane.

$M_r = \dots\dots\dots$

(2)

- (h) Isooctane reacts with an excess of chlorine to form a mixture of chlorinated compounds. One of these compounds contains 24.6% carbon and 2.56% hydrogen by mass. Calculate the molecular formula of this compound.

Molecular formula =

(3)

(Total 12 marks)

16

Alcohol **A** $(\text{CH}_3)_2\text{CHCH}(\text{OH})\text{CH}_3$ undergoes reactions separately with acidified potassium dichromate(VI) and with concentrated sulfuric acid.

- (a) Deduce the IUPAC name for alcohol **A**.

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(1)

- (b) Draw the structure of the organic product, **B**, formed when **A** is oxidised in the reaction with acidified potassium dichromate(VI).

(1)

- (c) Two isomeric alkenes, **C** and **D**, are formed when **A** is dehydrated in the reaction with concentrated sulfuric acid.

Name the mechanism for this dehydration reaction.

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(1)

- (d) Draw the structure of each isomer.

Isomer **C**

Isomer **D**

(2)

- (e) Name the type of structural isomerism shown by **C** and **D**.

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(1)

- (f) List alcohol **A**, product **B** and isomer **C** in order of increasing boiling point.

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(1)

- (g) Draw the structure of the isomer of **A** that is **not** oxidised by acidified potassium dichromate(VI).

(1)

- (h) Draw the structure of the isomer of **A** that **cannot** be dehydrated to form an alkene by reaction with concentrated sulfuric acid.

(1)

(Total 9 marks)

17

But-1-ene reacts with a reagent of the form HY to form a saturated compound.

- (a) Suggest a reagent of the form HY which reacts with but-1-ene.

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(1)

- (b) Name and draw a mechanism for the reaction in part (a).

Name of mechanism

Mechanism

(5)

(c) Explain how three isomeric products are formed when HY reacts with but-1-ene.

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(3)
(Total 9 marks)

18 How many isomers have the molecular formula C_5H_{12} ?

- A 2
- B 3
- C 4
- D 5

(Total 1 mark)

19 Which molecule is **not** produced when ethane reacts with bromine in the presence of ultraviolet light?

- A $C_2H_4Br_2$
- B HBr
- C H_2
- D C_4H_{10}

(Total 1 mark)

20How many structural isomers have the molecular formula C_4H_9Br ?

- A 2
- B 3
- C 4
- D 5

(Total 1 mark)**21**What is the major product of the reaction between but-1-ene and DBr ?
(D is deuterium and represents 2H)

- A $CH_2DCH_2CH_2CH_2Br$
- B $CH_2DCH_2CHBrCH_3$
- C $CH_3CH_2CHBrCH_2D$
- C $CH_3CH_2CHDCH_2Br$

(Total 1 mark)