10.2 Functional Group

Past Exam Questions (Paper 2)

1. *[3 marks]*

Both C_5H_{12} and $C_5H_{11}OH$ can be used as fuels. Predict which compound would release a greater amount of heat per gram when it undergoes complete combustion. Suggest **two** reasons to support your prediction.

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2a. *[1 mark]*

Halogenoalkanes can undergo substitution reactions with potassium hydroxide solution.

State an equation for the reaction of C_4H_9Cl with KOH.

2b. *[2 marks]*

On reaction with acidified potassium dichromate(VII), two of the isomers are oxidised in two steps to produce different products. Draw the structural formula of the **two** products formed from one of the isomers.

2c. *[1 mark]*

A third isomer is oxidized in one step. Draw the structural formula of the organic product formed.

2d. *[1 mark]*

State the colour change that takes place in these oxidation reactions.

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2e. *[1 mark]*

Identify the isomer which resists oxidation by acidified potassium dichromate(VI).

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3a. *[3 marks]*

Three compounds with similar relative molecular masses are butane, propanal and propan-1-ol.

When propan-1-ol is oxidized using a warm acidified solution of potassium dichromate(VI) two different organic products can be obtained. Deduce the name and structural formula for each of these two products.

3b. *[2 marks]*

Identify the class of alcohols that propan-2-ol belongs to and state the name of the organic product formed when it is oxidized by an acidified solution of potassium dichromate(VI).

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4a. *[4 marks]*

In some countries, ethanol is mixed with gasoline (petrol) to produce a fuel for cars called gasohol.

Ethanol can be oxidized using acidified potassium dichromate, $K_2Cr_2O_7$, to form two different organic products.

$CH_3CH_2OH \rightarrow^{Cr_2O_7^{2-}}_{H^+} \mathbf{A} \rightarrow^{Cr_2O_7^{2-}}_{H^+} \mathbf{B}$

State the structural formulas of the organic products **A** and **B** and describe the conditions required to obtain a high yield of each of them.

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4b. *[2 marks]*

Ethene can be converted into ethanol by direct hydration in the presence of a catalyst according to the following equation.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons CH_3CH_2OH(g)$$

For this reaction identify the catalyst used and state **one** use of the ethanol formed other than as a fuel.

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5a. *[3 marks]*

The alkenes are an example of a homologous series.

Bromine water, $Br_2(aq)$, can be used to distinguish between the alkanes and the alkenes.

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(i) Describe the colour change observed when the alkene shown in part (a) is added to bromine water.

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(ii) Draw the structural formula and state the name of the product formed.

5b. *[6 marks]*

The polymerization of the alkenes is one of the most significant reactions of the twentieth century.

(i) Outline **two** reasons why the polymers of the alkenes are of economic importance.

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(ii) State the type of polymerization reaction shown by the alkene in part (a).

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(iii) Deduce the structure of the resulting polymer showing **three** repeating units.

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(iv) Explain why monomers are often gases or volatile liquids, but polymers are solids.

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6. *[2 marks]*

Ethene, C_2H_4, and hydrazine, N_2H_4, are hydrides of adjacent elements in the periodic table.

State the name of the product and identify the type of reaction which occurs between ethene and hydrogen chloride.

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7a. *[2 marks]*

Consider the following sequence of reactions.

$$RCH_3 \rightarrow^{reaction1} RCH_2Br \rightarrow^{reaction2} RCH_2OH \rightarrow^{reaction3} RCOOH$$

RCH_3 is an unknown alkane in which R represents an alkyl group.

(i) State the reagent and conditions needed for *reaction 1*.

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(ii) State the reagent(s) and conditions needed for *reaction 3*.

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7b. *[4 marks]*

Reaction 1 involves a free-radical mechanism. Describe the stepwise mechanism, by giving equations to represent the initiation, propagation and termination steps.

8a. *[1 mark]*

Chloroethene, C_2H_3Cl, is an important organic compound used to manufacture the polymer poly(chloroethene).

Draw a section of poly(chloroethene) containing six carbon atoms.

8b. *[2 marks]*

Outline why the polymerization of alkenes is of economic importance and why the disposal of plastics is a problem.

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8c. *[2 marks]*

Chloroethene can be converted to ethanol in two steps. For each step deduce an overall equation for the reaction taking place.

Step 1:

Step 2:

8d. *[2 marks]*

State the reagents and conditions necessary to prepare ethanoic acid from ethanol in the laboratory.

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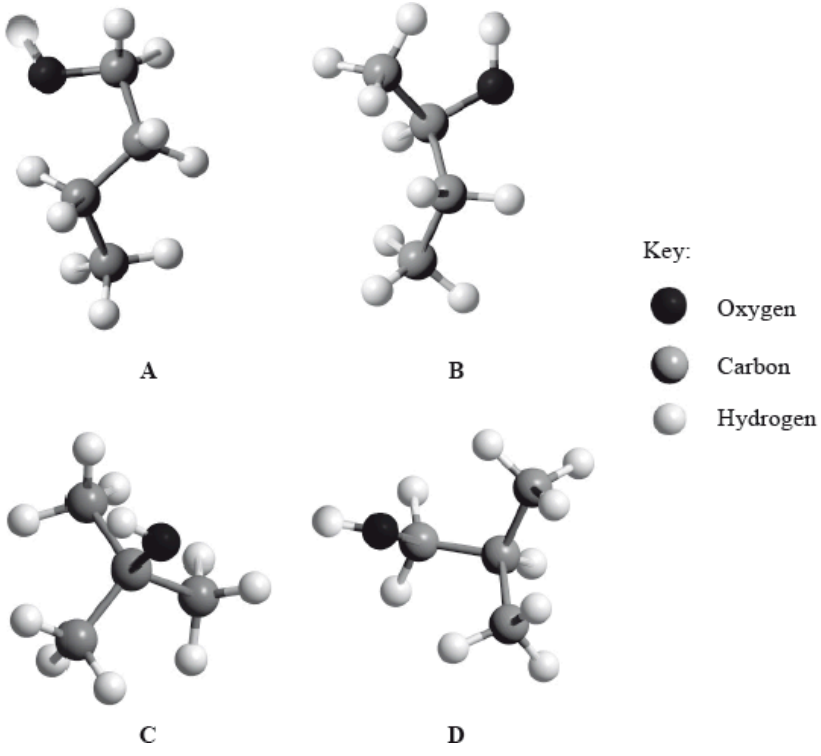
9. *[8 marks]*

(i) Below are **four structural** isomers of alcohols with molecular formula $C_4H_{10}O$. State the name of each of the isomers **a**, **b**, **c** and **D**.



(ii) Determine the isomer that cannot be oxidized by acidifi ed potassium dichromate(VI), $K_2Cr_2O_7$.

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(iii) Determine the isomer which can be oxidized to butanal.

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(iv) Determine the isomer which can be oxidized to butanone.

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(v) Suggest the structural formula of another isomer of $C_4H_{10}O$.

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10. *[1 mark]*

Alkenes are an economically and chemically important family of organic compounds.

The reaction of alkenes with bromine water provides a test for unsaturation in the laboratory. Describe the colour change when bromine water is added to chloroethene.

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11. *[1 mark]*

Deduce the balanced chemical equation for the complete combustion of butan-1-ol.

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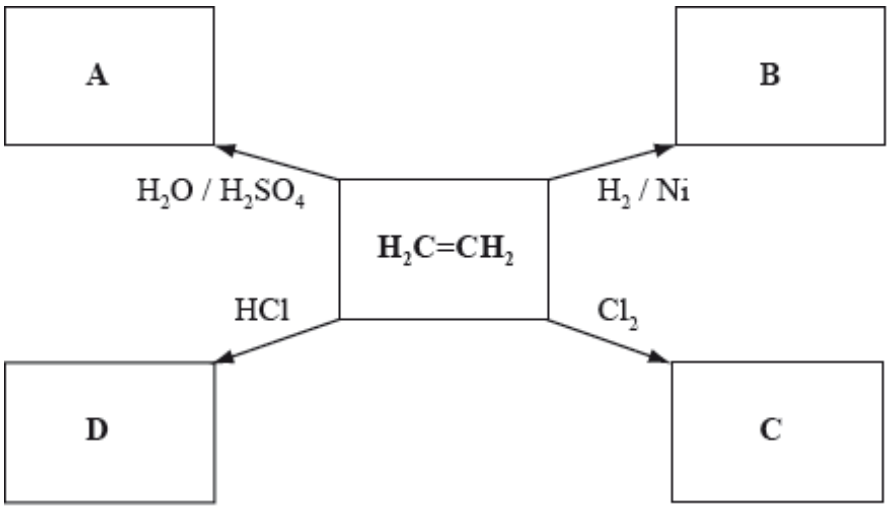
12a.

Alkenes are important starting materials for a variety of products.

Below is a schematic diagram representing some reactions of ethene. The letters **A**–**D** represent the organic compounds formed from the reactants and catalysts shown.



Deduce the structural formulas of compounds **A**, **B**, **C**, and **D** and state the IUPAC name of compound **C**.

A:

B:

C:

IUPAC name: . . . . . .

D:

12b. *[2 marks]*

Describe a chemical test that could be used to distinguish between pent-1-ene and pentane.

12c. *[4 marks]*

Explain, using equations, the following steps in the free-radical mechanism of the reaction of methane with chlorine.

- Initiation
- Propagation
- Termination

13a. *[2 marks]*

Propane can be formed by the hydrogenation of propene.

$$CH_3CH = CH_2(g) + H_2(g) \rightarrow CH_3CH_2CH_3(g)$$

State the conditions necessary for the hydrogenation reaction to occur.

13b. *[1 mark]*

Explain why the enthalpy of hydrogenation of propene is an exothermic process.

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13c. *[2 marks]*

Describe a chemical test that could be used to distinguish between propane and propene. In **each** case state the result of the test.

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13d. *[2 marks]*

Under certain conditions propene can polymerize to form poly(propene). State the type of polymerization taking place and draw a section of the polymer to represent the repeating unit.

13e. *[1 mark]*

Other than polymerization, state **one** reaction of alkenes which is of economic importance.

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14a. *[2 marks]*

Propan-1-ol and propan-2-ol are two structural isomers of C_3H_8O.

State the equation for the complete combustion of C_3H_8O.

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14b. *[3 marks]*

Both propan-1-ol and propan-2-ol can be oxidized in aqueous solution by potassium dichromate(VI). State any necessary conditions for the oxidation to occur and describe the colour change during the oxidation process.

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14c. *[5 marks]*

State the name(s) and structure(s) of the organic product(s) that can be formed when each of the alcohols is oxidized and suggest why one of the alcohols gives two organic products and the other only gives one organic product.

15a. *[1 mark]*

Alkenes, alcohols and esters are three families of organic compounds with many commercial uses.

State the balanced chemical equation for the reaction of **X** with HBr to form **Y**.

15b. *[1 mark]*

Y reacts with aqueous sodium hydroxide, NaOH(aq), to form an alcohol, **Z**. Identify whether **Z** is a primary, secondary or tertiary alcohol.

15c. *[2 marks]*

Deduce the structural formula of the organic product formed when **Z** is oxidized by heating under reflux with acidified potassium dichromate(VI) **and** state the name of the functional group of this organic product.

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16a. *[10 marks]*

Halogenoalkanes can be classified as primary, secondary or tertiary.

Alkanes undergo few reactions other than combustion and halogenation.

(i) Explain why alkanes have low reactivity.

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(ii) Outline the meaning of the term *homolytic fission*.

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(iii) Describe the meaning of the symbol $Br\bullet$.

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(iv) State an equation for the reaction of ethane with bromine.

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(v) Explain the reaction of ethane with bromine using equations for the initiation step, two propagation steps and one termination step.

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16b. *[5 marks]*

Under certain conditions but-2-ene can react with water to form butan-2-ol.

(i) Identify a suitable catalyst for this reaction.

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(ii) But-2-ene can be converted to 2-bromobutane and then to butan-2-ol as follows:

$CH_3CH{=}CHCH_3 \rightarrow^{I} CH_3CH(Br)CH_2CH_3 \rightarrow^{II} CH_3CH(OH)CH_2CH_3$

Identify the reagent(s) and conditions necessary for each of the steps **I** and **II**.

Step **I**:

Step **II**:

17a. *[1 mark]*

Ethane reacts with chlorine in the presence of sunlight.

Complete the overall equation for this reaction by stating the products.

$C_2H_6 + Cl_2 \rightarrow$

17b. *[1 mark]*

State the type of mechanism by which this reaction occurs.

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17c. *[2 marks]*

Traces of butane, C_4H_{10}, are also found amongst the products of this reaction. Explain how this product arises.

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18a. *[2 marks]*

2-methylbutan-2-ol, $(CH_3)_2C(OH)CH_2CH_3$, is a liquid with a smell of camphor that was formerly used as a sedative. One way of producing it starts with 2-methylbut-2-ene.

State the other substances required to convert 2-methylbut-2-ene to 2-methylbutan-2-ol.

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18b. *[2 marks]*

Explain whether you would expect 2-methylbutan-2-ol to react with acidified potassium dichromate(VI).

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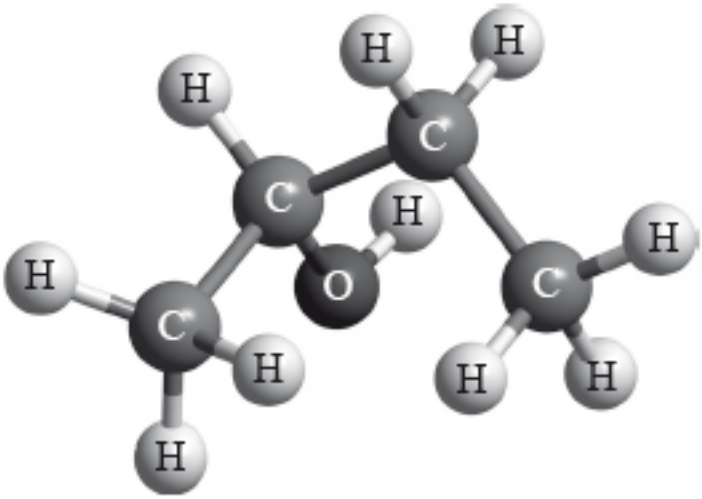
19. *[1 mark]*

The following diagram shows the three-dimensional structure of a molecule.



Describe, using an equation, the oxidation by acidified potassium dichromate(VI) of the substance shown in the diagram. Use the symbol [O] to represent the oxidizing agent.

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20a. *[2 marks]*

Ethene belongs to the homologous series of the alkenes.

Describe a test to distinguish ethene from ethane, including what is observed in **each** case.

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20b. *[2 marks]*

Bromoethane can be produced either from ethene or from ethane. State an equation for **each** reaction.

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20c. *[1 mark]*

A bromoalkane, C_4H_9Br, reacts with a warm, aqueous sodium hydroxide solution, NaOH.

State the equation for the reaction of C_4H_9Br with NaOH.

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20d. *[1 mark]*

Suggest what would happen to the pH of the solution as the reaction proceeds.

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20e. *[1 mark]*

The time taken to produce a certain amount of product using different initial concentrations of C_4H_9Br and NaOH is measured. The results are shown in the following table.

Reaction	$[C_4H_9Br]$ / 10^{-2} mol dm^{-3}	[NaOH] / 10^{-3} mol dm^{-3}	t / s
A	1.0	2.0	46
B	2.0	2.0	23
C	2.0	4.0	23

Describe, using an equation, how C_4H_9Br can be converted into $C_4H_8Br_2$.

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21a. *[1 mark]*

Chlorine occurs in Group 7, the halogens.

Chloroethene, $H_2C{=}CHCl$, the monomer used in the polymerization reaction in the manufacture of the polymer poly(chloroethene), PVC, can be synthesized in the following two-stage reaction pathway.

$$Stage\ 1{:}\ C_2H_4(g) + Cl_2(g) \rightarrow ClCH_2CH_2Cl(g)\ Stage\ 2{:}\ ClCH_2CH_2Cl(g) + HC = CHCl(g) + HCl(g)$$

Draw the structure of poly(chloroethene) showing **two** repeating units.

21b. *[2 marks]*

Suggest why monomers are often gases or volatile liquids whereas polymers are solids.

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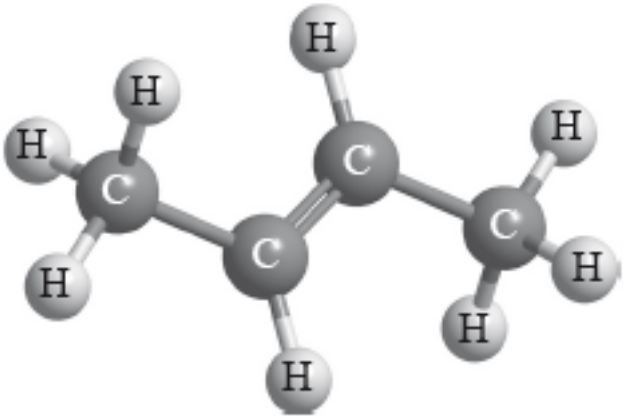
22a. *[2 marks]*



P

$$CH_3CH{=}CHCH_3 \xrightarrow[(2)\ H_2O(l)]{(1)\ \text{concentrated } H_2SO_4(aq)} \mathbf{Q}$$

Q:

$$CH_3CH{=}CHCH_3 + H_2(g) \xrightarrow{\text{catalyst}} \mathbf{R}$$

R:

22b. *[1 mark]*

Identify a suitable catalyst used in the reaction to form **R**.

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22c. *[1 mark]*

State the structural formula of the organic product formed, **S**, when **Q** is heated under reflux with acidified potassium dichromate(VI).

22d. *[1 mark]*

Apply IUPAC rules to state the name of this product, **S**.

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22e. *[1 mark]*

P can undergo a polymerization reaction. Draw **two** repeating units of the resulting polymer.
