

CHEMISTRY 3.5 Paper 1

Describe the structure and reactions of organic compounds
containing selected organic groups

Credits: Five

INSTRUCTIONS

Answer **ALL** questions

You are advised to spend about 50 minutes answering these questions.

Question One (Bursary 2003 Question 3: modified)

The following data are extracted from the 'Properties of Organic Compounds' in a Data Book. Use these data to answer the questions that follow.

Name	Formula	$M / \text{g mol}^{-1}$	Density / g mL^{-1}	Melting Point / $^{\circ}\text{C}$	Boiling Point / $^{\circ}\text{C}$	$\Delta_f H^{\circ} / \text{kJ mol}^{-1}$	$\Delta_c H^{\circ} / \text{kJ mol}^{-1}$
Alkanes							
methane	CH_4	16.0	0.423	-182.5	-161.5	-74.0	-890
ethane	CH_3CH_3	30.1	0.545	-182.8	-88.6	-84.0	-1560
propane	$\text{CH}_3\text{CH}_2\text{CH}_3$	44.1	0.585	-187.7	-42.1	-105.0	-2220
butane	$\text{CH}_3(\text{CH}_2)_2\text{CH}_3$	58.1	0.601	-138.3	-0.5	-126.0	-2877
pentane	$\text{CH}_3(\text{CH}_2)_3\text{CH}_3$	72.1	0.621	-129.7	36.1	-147.0	-3509
hexane	$\text{CH}_3(\text{CH}_2)_4\text{CH}_3$	86.1	0.655	-95.3	68.7	-167.0	-4163
heptane	$\text{CH}_3(\text{CH}_2)_5\text{CH}_3$	100.2	0.680	-90.6	98.4	-188.0	-4817
octane	$\text{CH}_3(\text{CH}_2)_6\text{CH}_3$	114.2	0.698	-56.8	125.7	-209.0	-5470
Alkenes							
ethene	$\text{CH}_2=\text{CH}_2$	28.1	0.568	-169.1	-103.7	52.0	-1411
propene	$\text{CH}_3\text{CH}=\text{CH}_2$	42.1	0.610	-185.2	-47.7	20.0	-2058
but-1-ene	$\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2$	56.1	0.579	-185.3	-6.3	0.1	-2718
but-2-ene (<i>cis</i>)	$\text{CH}_3\text{CH}=\text{CHCH}_3$	56.1	0.595	-138.9	2.7	-7.0	-2710
but-2-ene (<i>trans</i>)	$\text{CH}_3\text{CH}=\text{CHCH}_3$	56.1	0.578	-105.6	0.88	-11.0	-2706
pent-1-ene	$\text{CH}_3(\text{CH}_2)_2\text{CH}=\text{CH}_2$	70.1	0.635	-165.2	30.0	-21.0	-3350
pent-2-ene (<i>cis</i>)	$\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_3$	70.1	0.650	-151.4	36.9	-28.0	-3343
pent-2-ene (<i>trans</i>)	$\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_3$	70.1	0.643	-140.2	36.4	-32.0	-3338
Alcohols							
methanol	CH_3OH	32.0	0.787	-97.7	64.7	-201.0	-726
ethanol	$\text{CH}_3\text{CH}_2\text{OH}$	46.1	0.785	-114.1	78.3	-235.0	-1267
propan-1-ol	$\text{CH}_3(\text{CH}_2)_2\text{OH}$	60.1	0.800	-126.2	97.2	-255.0	-2021
propan-2-ol	$\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$	60.1	0.781	-89.5	82.3	-273.0	-2006
butan-1-ol	$\text{CH}_3(\text{CH}_2)_3\text{OH}$	74.1	0.806	-89.8	117.7	-275.0	-2676
butan-2-ol	$\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$	74.1	0.802	-114.7	99.5	-293.0	-2661
2-methyl propan-1-ol	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$	74.1	0.798	-108.0	107.9	-283.0	-2668
2-methyl propan-2-ol	$\text{CH}_3\text{C}(\text{CH}_3)(\text{OH})\text{CH}_3$	74.1	0.781	25.7	82.6	-313.0	-2644
pentan-1-ol	$\text{CH}_3(\text{CH}_2)_4\text{OH}$	88.2	0.816	-78.9	138.0	-295.0	-3331
pentan-2-ol	$\text{CH}_3(\text{CH}_2)_2\text{CH}(\text{OH})\text{CH}_3$	88.2	0.805	-73.0	119.0	-313.0	-3317

- a Give the formula of a secondary alcohol listed in the table above. A
-

b Write the names of TWO compounds from the table that are structural isomers. **A**

_____ and _____

c But-2-ene has two geometrical isomers.

Draw and label the two geometric isomers of but-2-ene. **A**

Explain why there are no geometric isomers of but-1-ene. **A M**

Question Two (Bursary 2003 Question 5: modified)

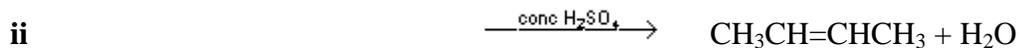
a Draw the structural formula of the organic compound with THREE carbon atoms that matches each of the descriptions given below. **A M**

i a hydrocarbon that rapidly **decolourises** acidified potassium permanganate solution

ii a compound that is **oxidised** to a **ketone**

iii an **ester**

b Write formulae for the missing reactants or products for each of the following reactions. **A M**



iii Circle the word below that best describes the type of reaction occurring in the reaction in **ii** above.

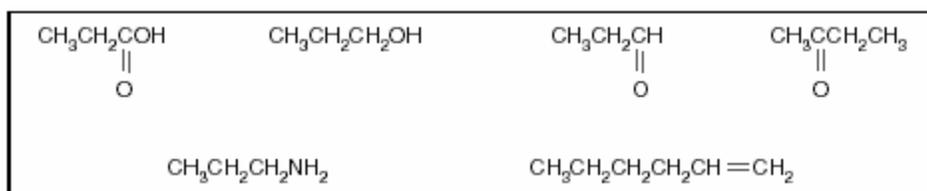
Addition

Elimination

Oxidation

Substitution

c An unlabelled bottle is known to contain only one of the following compounds:



In order to identify the unknown compound, small samples from the bottle were treated in the following ways:

- A** added to water and then tested with litmus
- B** added to a solution of bromine
- C** added to a solution of ammoniacal silver nitrate (Tollens' reagent) and warmed
- D** warmed with an acidic solution of potassium dichromate.

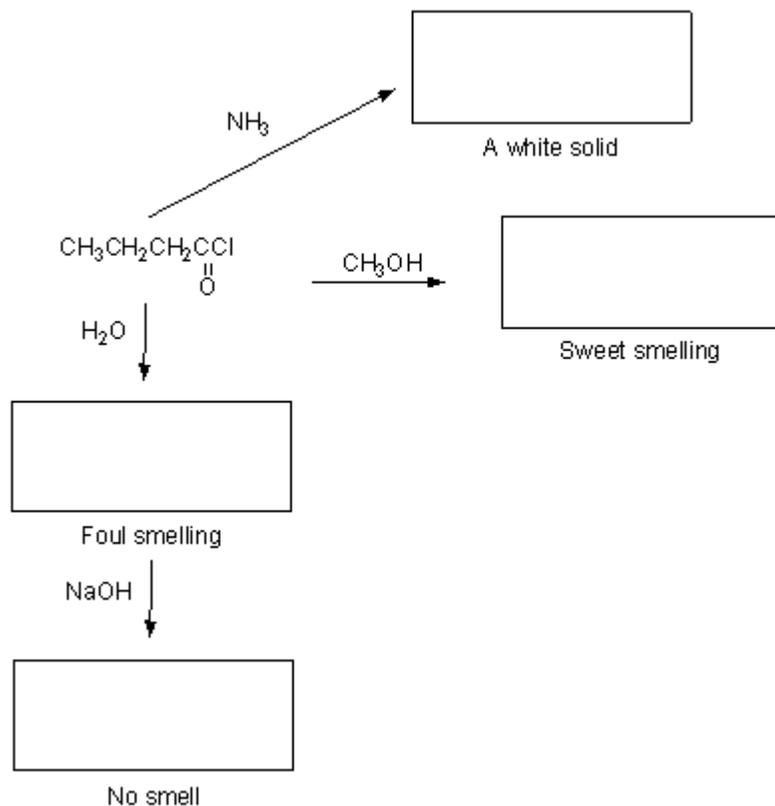
i Complete the table below by writing the formula for the compound(s) that will be identified by each step **A** to **D** and the expected observations that will be made if these compounds are present.

Reaction	Compounds identified	Expected observations
A		
B		
C		
D		

- ii Write the formula of the compound that does not react with any of the reagents in **A–D** above and name the functional group that it contains. **A**

Formula: _____ Functional group: _____

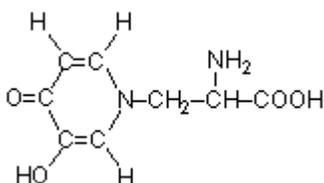
- d Study the reaction flow diagram below.



- i Name the starting reagent. **A**
- ii Complete the flow diagram by writing the structural formula for the organic product of each reaction and naming it. **A M E**

Question Three (Bursary 2002 Question 2: modified)

The compound mimosine, shown below, is a natural product found in large quantities in the seeds and foliage of some plants.



a Mark with a * the carbon responsible for the optically isomeric properties of this compound. A

b Name THREE different functional groups found in the above structure. A

1 _____

2 _____

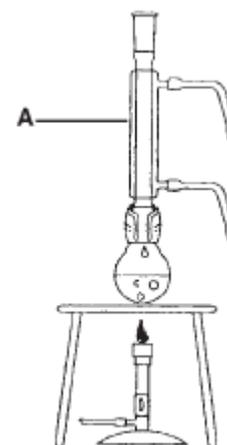
3 _____

Question Four (Bursary 2002 Question 4: modified)

a When a bromoalkane is mixed with aqueous sodium hydroxide and boiled at 71°C for 40 minutes, a hydrolysis reaction occurs. The hydrolysis reaction is carried out using the apparatus in the diagram shown below.

i Name the process that uses this apparatus. A

ii Name the piece of equipment marked A in the diagram above. A



iii Explain why it is necessary to use **this apparatus** for the hydrolysis reaction. A M

Question Five (Bursary 2002 Question 5: modified)

a Perspex and Nylon 6,6 are synthetic polymers.

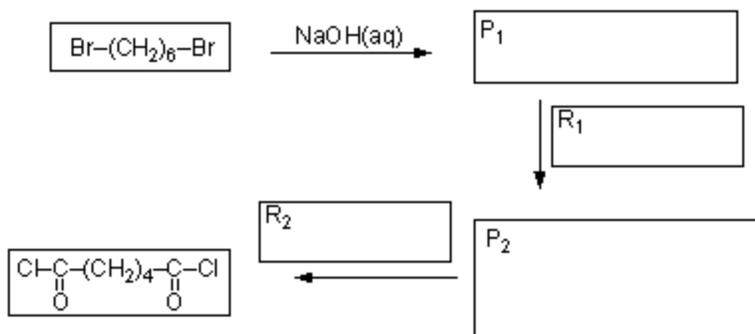
i Complete the table below by drawing the repeating unit of these polymers. **A M**

Polymer	Monomers	Repeating Unit of the Polymer
Perspex	$\text{H}_2\text{C}=\text{C} \begin{array}{l} \diagup \text{CH}_3 \\ \diagdown \text{COOCH}_3 \end{array}$	
Nylon 6,6	$\begin{array}{c} \text{Cl}-\text{C}(=\text{O})-(\text{CH}_2)_4-\text{C}(=\text{O})-\text{Cl} \\ \text{O} \qquad \qquad \qquad \text{O} \\ \text{and} \\ \text{H}_2\text{N}-(\text{CH}_2)_6-\text{NH}_2 \end{array}$	

The diacyl chloride monomer for the synthesis of nylon 6,6 can be made in the laboratory using 1,6-dibromohexane.

ii Complete the flow diagram below to show how this could be done.

Write the reagents in the boxes marked **R** and the compounds formed in the boxes marked **P**.

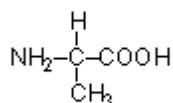


A M E

b Amino acids are linked together to form proteins. Protein and starch are examples of naturally occurring polymers.

i Name the monomer from which starch is made. **A**

Alanine is a simple amino acid. It has the structure:



ii Draw a **box** around the group of atoms that causes the amino acid to behave as a base. **A**

The table below lists some common fatty acids that react to make fats and oils.

Number of Carbon Atoms	Systematic Name	Trivial Name	Structural Formula
12	dodecanoic acid	lauric	$\text{CH}_3(\text{CH}_2)_{10}\text{COOH}$
14	tetradecanoic acid	myristic	$\text{CH}_3(\text{CH}_2)_{12}\text{COOH}$
16	hexadecanoic acid	palmitic	$\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$
	<i>cis</i> -hexadec-9-enoic acid	palmitoleic	$\text{CH}_3(\text{CH}_2)_5\text{CH}=\text{CHCH}_2(\text{CH}_2)_6\text{COOH}$
18	octadecanoic acid	stearic	$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$
	<i>cis</i> -octadec-9-enoic acid	oleic	$\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CHCH}_2(\text{CH}_2)_6\text{COOH}$
	<i>cis,cis</i> -octadec-9,12-dienoic acid	linoleic	$\text{CH}_3(\text{CH}_2)_4(\text{CH}=\text{CHCH}_2)_2(\text{CH}_2)_6\text{COOH}$
	<i>cis,cis,cis</i> -octadec-9,12,15-trienoic acid	linolenic	$\text{CH}_3\text{CH}_2(\text{CH}=\text{CHCH}_2)_3(\text{CH}_2)_6\text{COOH}$

b Give an example from the table of an acid that is:

i saturated: **A**

ii monounsaturated: **A**

Most of the naturally occurring acids are of the *cis* variety, but during hydrogenation some of the *cis* double bonds are changed into *trans* double bonds. It is now believed that *trans* fatty acids may be responsible for certain heart diseases.

c What must happen to the double bond for the *cis* isomer to be changed into the *trans* isomer? **A M**
