

Answer **all** the questions.

- 1 Crude oil is a complex mixture of hydrocarbons. Initial separation is achieved by fractional distillation. The separate fractions are then further refined to produce hydrocarbons such as decane.

(a) (i) State what is meant by the term *hydrocarbon*.

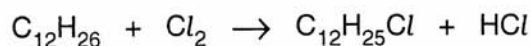
.....  
..... [1]

(ii) A molecule of decane contains ten carbon atoms. State the molecular formula of decane.

..... [1]

(iii) Deduce the empirical formula of decane. .... [1]

(b) Dodecane,  $C_{12}H_{26}$ , is a straight chain alkane that reacts with chlorine to produce a compound with molecular formula  $C_{12}H_{25}Cl$ .



The reaction is initiated by the formation of chlorine free radicals from chlorine.

(i) What is meant by the term *free radical*?

..... [1]

(ii) State the conditions necessary to bring about the formation of the chlorine free radicals from  $Cl_2$ .

..... [1]

(iii) State the type of bond fission involved in the formation of the chlorine free radicals.

..... [1]

- (iv) The chlorine free radicals react with dodecane to produce  $C_{12}H_{25}Cl$ . Write equations for the **two** propagation steps involved.

.....  
 ..... [2]

- (v) How many different structural isomers can be formed when chlorine reacts with dodecane to form  $C_{12}H_{25}Cl$ ?

answer ..... [1]

- (c) Dodecane,  $C_{12}H_{26}$ , can be cracked into ethene and a straight chain alkane such that the molar ratio ethene : straight chain alkane is 2 : 1.

- (i) Write a balanced equation for this reaction.

..... [2]

- (ii) Name the straight chain alkane formed.

..... [1]

- (d) Straight chain alkanes such as heptane,  $C_7H_{16}$ , can be isomerised into branched chain alkanes and reformed into cyclic compounds.

- (i) Using **skeletal** formulae, write an equation to show the isomerisation of heptane into 2,2,3-trimethylbutane.

[2]

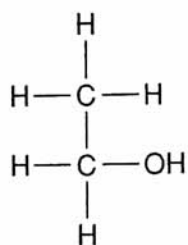
- (ii) Write a balanced equation to show the reforming of heptane into methylcyclohexane.

[2]

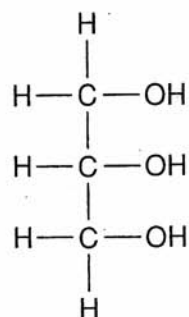
[Total: 16]

- 2 Ethanol and glycerol (propane-1,2,3-triol) are both produced industrially on a large scale.

Ethanol is manufactured by both fermentation and the hydration of ethene.  
Glycerol is produced as a by-product of soap manufacture.



ethanol



glycerol

- (a) The relatively low volatility of alcohols such as ethanol can be explained by the existence of intermolecular bonds.

- (i) Explain what is meant by the terms:

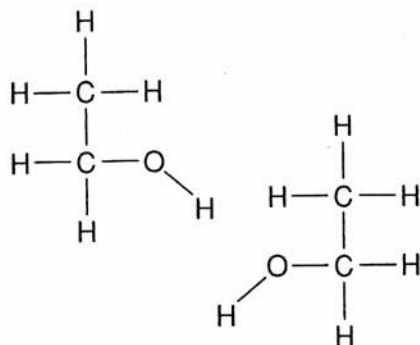
*low volatility*, .....

.....

*intermolecular bonds*. .....

..... [2]

- (ii) On the ethanol molecules below, label any relevant dipoles, show the intermolecular bond formed and state the type of intermolecular bond.



type of intermolecular bond .....

[3]

- (iii) Glycerol forms the same type of intermolecular bonds as ethanol. Predict, with a reason, whether the boiling point of glycerol will be higher or lower than that of ethanol.

The boiling point of glycerol will be ..... than that of ethanol because

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

- (b) Ethanol can react with sodium to produce an alkoxide and a gas.

Write a balanced equation for the reaction between sodium and ethanol.

..... [2]

- (c) Glycerol shows similar properties to ethanol and can also react with sodium.

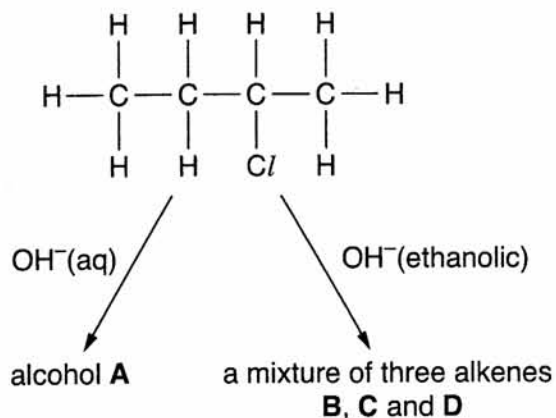
Draw the displayed formula of the alkoxide formed when glycerol reacts **completely** with sodium.

[2]

[Total: 10]

3 This question is about the halogenoalkane 2-chlorobutane.

2-Chlorobutane reacts with NaOH, but the products are dependent on the solvent used.



(a) 2-Chlorobutane reacts with  $\text{OH}^-$  in aqueous conditions to produce alcohol A.

(i) Identify alcohol A.

[1]

(ii) Describe, with the aid of curly arrows, the movement of the electrons in the mechanism. Show any relevant dipoles, lone pairs of electrons and the products.

[4]

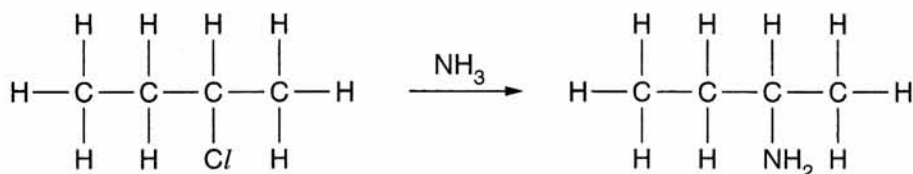
(b) 2-Chlorobutane reacts with  $\text{OH}^-$  in ethanolic conditions to produce a mixture of three alkenes **B**, **C** and **D**.

- (i) State the type of reaction. .... [1]  
 (ii) Identify the **three** alkenes formed.

<b>B</b>	<b>C</b>	<b>D</b>
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[3]

(c) Ammonia behaves as a nucleophile and reacts with 2-chlorobutane to produce 2-aminobutane.

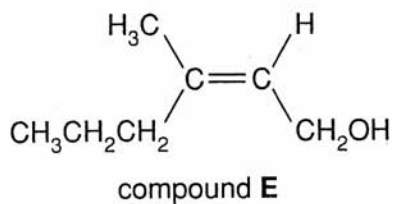


- (i) State a suitable solvent for this reaction.  
 ..... [1]
- (ii) What is the molecular formula of the organic product?  
 ..... [1]
- (iii) The reaction between 2-chlorobutane and ammonia also produces a small amount of the product  $\text{C}_8\text{H}_{19}\text{N}$ .  
 Suggest the structure of this product.

[1]

[Total: 12]

- 4 Body odour often begins with secretions from glands called apocrine glands, which are most numerous in the armpits. Bacteria, which live in the armpits, use these secretions to produce energy and many different waste products. Scientists have isolated one of these waste products, compound **E**, which is shown below.



- (a) Compound **E** contains two functional groups, one of which is a primary alcohol.

- (i) **Name** the other functional group and state how you could test for it.

name of the other functional group .....

test .....

observation ..... [3]

- (ii) Name compound **E**. ..... [1]

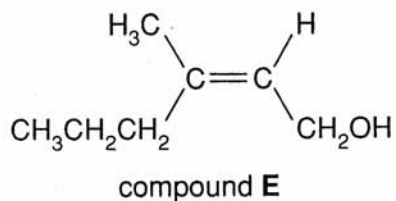
- (b) Compound **E** can be oxidised to form a carboxylic acid.

- (i) State a suitable oxidising mixture for this reaction.

..... [2]

- (ii) Write a balanced equation for this oxidation of compound **E**.

Use [O] to represent the oxidising mixture.



- (iii) Explain how compound **E** and the carboxylic acid could be distinguished by infra-red spectroscopy.

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

- (c) Compound **E** reacts with an excess of HBr to produce a mixture of **two** organic compounds, each with the molecular formula  $C_7H_{14}Br_2$ .

Identify both organic compounds in the mixture.

[2]

[Total: 12]





..... [9]

Quality of Written Communication [1]

[Total: 10]

- 1(a)  
 (i) compound/molecule containing hydrogen and carbon **only** ✓  
 (ii)  $C_{10}H_{22}$  ✓  
 (iii)  $C_5H_{11}$  {ecf from (ii)} ✓  
 (b)(i) (a particle that) contains/has a single/unpaired electron ✓  
 (ii) UV (light) /sunlight/high temp ✓

- (iii) homolytic (fission)/ homolysis ✓  
 (iv)  $C_{12}H_{26} + Cl\bullet \longrightarrow \bullet C_{12}H_{25} + HCl$  ✓  
 (the dot for the free radical does not have to be on the C) ✓  
 $\bullet C_{12}H_{25} + Cl_2 \longrightarrow C_{12}H_{25}Cl + Cl\bullet$  ✓  
 (v) six ✓

- (c)(i)  $C_{12}H_{26} \longrightarrow 2C_2H_4 + 1C_8H_{18}$  ✓✓  
 (1 mark for correct formula of octane or ethene)

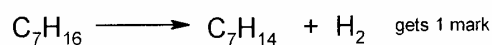
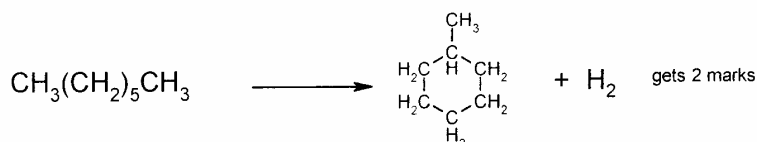
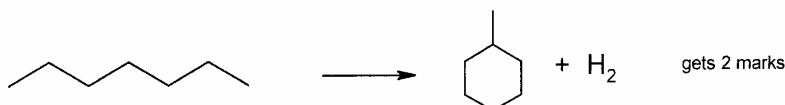
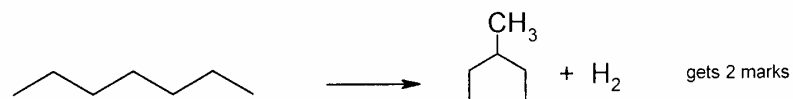
- (ii) octane/ ecf from (c) (i) ✓

- (d)(i)  ✓✓

1 mark for correct reagent and 1 mark for correct product.

- (ii) 1 mark for any unambiguous formula of cyclohexane ✓

1 mark for  $1H_2$  but check that formula of heptane is correct/equation balanced. ✓

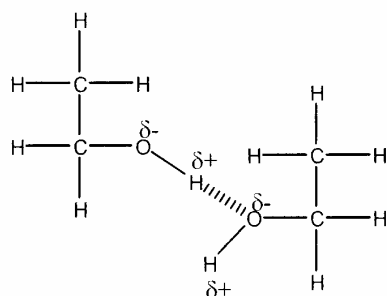


[Total : 16]

2(a)

- (i) *low volatility*, = **high** boiling point/ not easy to vapourise/owtte ✓  
*intermolecular bonds*, = bonds/forces/attractions **between** molecules ✓

- (ii) type of intermolecular bond = hydrogen bond ✓



dipoles on both O-H bonds ✓

H-bond shown as a 'dashed bond' ✓

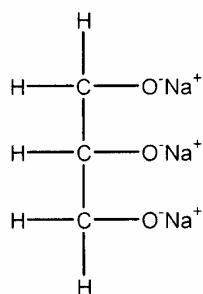
- (iii) (The boiling point of glycerol will be *higher* than ethanol because there are) ✓  
 more OH groups ∴ more H-bonds ✓

- (b)  $\text{C}_2\text{H}_5\text{OH} + \text{Na} \longrightarrow \text{C}_2\text{H}_5\text{O}^-\text{Na}^+ + \frac{1}{2} \text{H}_2$  (or multiple of this) ✓✓

charges are not essential

1 mark for correct formula of sodium ethoxide & 1 mark for correct balancing

(c)



charges are not essential for both marks

✓✓

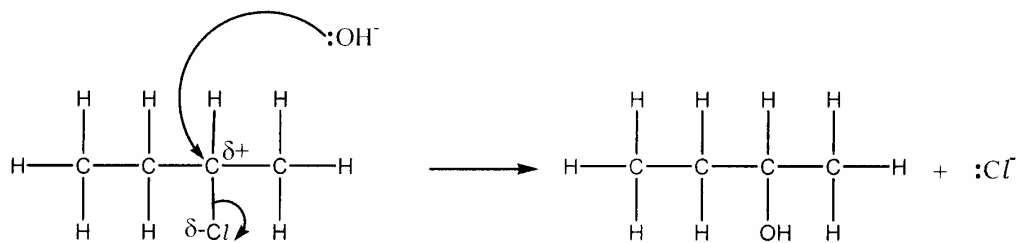
1 mark for partial reaction. 1 mark if all 3 "ONa" are shown as covalent "O-Na"

[Total : 10]

3.

(a)(i) butan-2-ol by name or by formula ✓

(ii)

curly arrow from the O of the  $\text{OH}^-$  to  $\text{C}^{(\delta+)}$  ✓curly arrow from C-Cl bond to Cl **and** correct dipoles ✓

correct products/ allow NaCl ✓

curly arrow from lone pair on  $\text{:OH}^-$  ✓

[4]

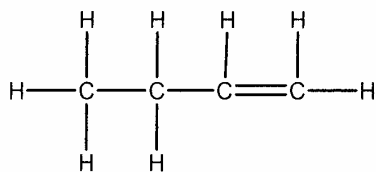
 $\text{S}_{\text{N}}1$  route can still score all 4 marks:curly arrow from C-Cl bond to Cl **and** correct dipoles ✓curly arrow from the O of the  $\text{OH}^-$  to  $\text{C}^+$  ion ✓

correct products/ allow NaCl ✓

curly arrow from lone pair on  $\text{:OH}^-$  ✓

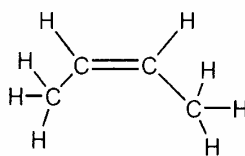
(b) (i) elimination ✓

(ii)



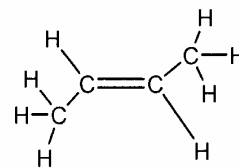
but-1-ene

✓



cis-but-2-ene

✓



trans-but-2-ene

✓

2812

Mark Scheme

Jan 2006

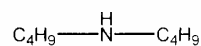
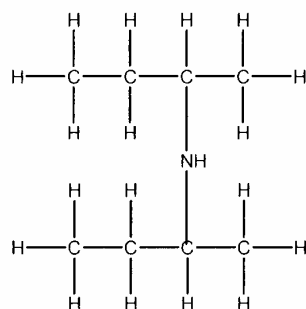
(c) (i) ethanol

✓

(ii) C<sub>4</sub>H<sub>11</sub>N

✓

(iii)



any unambiguous structure or formula for the secondary amine

✓

[Total : 12]

2812

Mark Scheme

Jan 2006

4 (a)(i) alkene ✓

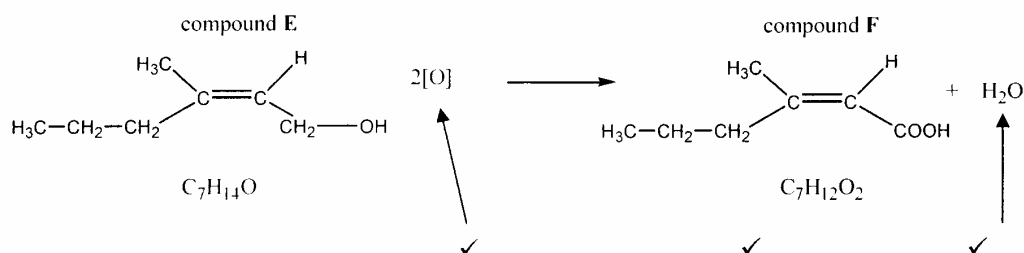
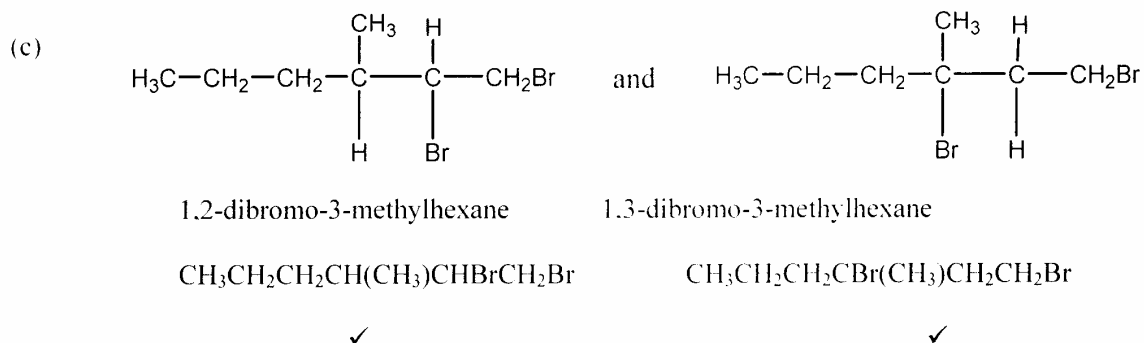
bromine ✓

decolourises ✓

(ii) 3-methylhex-2-en-1-ol/ 1-hydroxy-3-methylhex-2-ene ✓

(b) (i)  $\text{H}^+$  ✓  $\text{Cr}_2\text{O}_7^{2-}$  ✓

(ii)

(iii) carboxylic acid would have an absorption between  $1680 - 1750 \text{ cm}^{-1}$  /  $1700 \text{ cm}^{-1}$  or  $2500 - 3300 \text{ cm}^{-1}$ . ✓

[Total :12]

**margarine**

Ni catalyst

✓

hydrogen/ hydrogenated

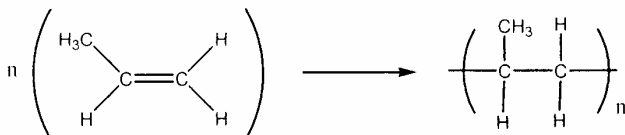
✓

unsaturated vegetable oil/fat

✓

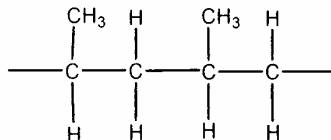
**poly(propene)**

equation



✓

two repeat units



✓

(Ziegler) catalyst / high temp/heat/use of an initiator

✓

**Problems with disposal**

non-biodegradable/don't decompose/not broken down by bacteria etc

✓

when burnt produces toxic fumes

✓

**Future methods of disposal**

recycling (to produce new polymers)

✓

incineration for energy (production)

✓

cracking/owtte (to produce useful organic molecules)

use gas scrubbers to reduce toxic fumes

any two

**max = 9**

QWC

Answer is well organised/structure and using at least three of:

catalyst, hydrogenation, addition polymerisation, Ziegler, incineration, feedstock, recycling, non-biodegradable, initiator, monomer, unsaturated.

in the correct context.

✓

[Total : 10]