Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
GENERAL CERTIFICATE OF SECONDARY EDUCATION

A323/02

TWENTY FIRST CENTURY SCIENCE

CHEMISTRY A

Unit 3 Ideas in Context plus C7
(Higher Tier)

THURSDAY 4 JUNE 2009: Morning
DURATION: 60 minutes

SUITABLE FOR VISUALLY IMPAIRED CANDIDATES

Candidates answer on the question paper

OCR SUPPLIED MATERIALS:

Insert (inserted)

OTHER MATERIALS REQUIRED:

Pencil
Ruler (cm/mm)

READ INSTRUCTIONS OVERLEAF

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INSTRUCTIONS TO CANDIDATES

- **Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes on the first page.**
- **Use black ink. Pencil may be used for graphs and diagrams only.**
- **Read each question carefully and make sure that you know what you have to do before starting your answer.**
- **Answer ALL the questions.**
- **Write your answer to each question in the space provided, however additional paper may be used if necessary.**

INFORMATION FOR CANDIDATES

- **The number of marks is given in brackets [ ] at the end of each question or part question.**
- **The total number of marks for this paper is 55.**
-  **Where you see this icon you will be awarded a mark for the quality of written communication in your answer.**
- **The Periodic Table is printed on the back page.**

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Answer ALL the questions.

1 THIS QUESTION IS BASED ON THE ARTICLE 'THE BIOETHANOL DILEMMA'.

(a) Burning bioethanol gives a 70% carbon dioxide reduction compared to petrol.

However, some scientists think that the overall effect of using bioethanol instead of petrol would reduce total carbon dioxide emissions by only about 13%.

Use information from the article to explain why a figure of 13% for overall reduction in carbon dioxide emissions may be more realistic than 70%.

_____

_____

_____

_____ **[2]**

(b) It is technically feasible to produce enough bioethanol from crops grown in the UK to satisfy all of our transport needs.

Suggest TWO disadvantages of this.

_____

_____

_____ **[2]**

(c) In the UK it is reasonable to suggest that enough bioethanol can be made from crops to use as a 5% blend with petrol.

It is less reasonable to suggest that developing countries in Africa should do the same.

Explain why.

_____

_____

_____ **[2]**

(d) The combustion of bioethanol can be represented by this equation.

$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

Octane, C_8H_{18}, is one of the hydrocarbons in petrol. The combustion of octane can be represented by this equation.

$C_8H_{18} + 12½O_2 \rightarrow 8CO_2 + 9H_2O$

Burning 1.0 g of bioethanol produces 1.9 g of carbon dioxide.

Burning octane produces about 60% more carbon dioxide than the same mass of bioethanol.

Show that this is true by calculating the mass of carbon dioxide produced when 1.0 g of octane burns, and the percentage increase in carbon dioxide produced compared to bioethanol.

(relative atomic masses: C = 12, H = 1, O = 16)

mass of carbon dioxide = _____ g

percentage increase = _____ [3]

(e) (i) List <u>TWO</u> factors mentioned in the article that are involved in the Life Cycle Assessment for bioethanol that do not apply to petrol.

1 _____

_____

2 _____

_____ **[2]**

(ii) Explain how bioethanol may be a more sustainable fuel than petrol.

_____

_____

_____

_____ **[2]**

[Total: 13]

2 Methanoic acid, HCOOH, is a carboxylic acid that is released in bee stings.

(a) What is the formula of the functional group that is responsible for the characteristic properties of carboxylic acids?

_____ **[1]**

(b) Methanoic acid is used to remove the limescale that can build up in kettles.
Limescale is made of calcium carbonate, which is insoluble in water.

Carboxylic acids react with carbonates in a similar way to other acids, such as hydrochloric acid.

calcium carbonate + hydrochloric acid → calcium chloride + carbon dioxide + water

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

(i) Complete and balance this symbol equation for the reaction between calcium carbonate and methanoic acid.

_____ + _____ → $Ca(HCOO)_2$ + _____ + _____ **[2]**

(ii) Suggest a property of $Ca(HCOO)_2$ (calcium methanoate) that explains how this reaction removes limescale.

_____

_____ **[1]**

(iii) Hydrochloric acid is not used to remove limescale from kettles because it is a strong acid.

Methanoic acid is used to remove limescale from kettles because it is a weak acid.

Explain the difference between a strong acid and a weak acid in terms of dynamic equilibrium.

One mark is for correct spelling.

_____

_____

_____

_____

_____ **[3+1]**

(c) Butanoic acid, $C_4H_8O_2$, is responsible for the unpleasant taste in rancid butter.

Draw a diagram to show the structural formula for butanoic acid.

[1]

[Total: 9]

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3 Vegetable oils are commonly used in cooking. Examples are rape seed oil and sunflower seed oil.

(a) (i) When an ester is hydrolysed it forms an alcohol and a carboxylic acid. This reaction is the reverse of that used to make the ester.

Oils and fats are esters. Write the <u>NAME</u> of the alcohol and of the <u>TYPE</u> of carboxylic acid to complete this word equation for the hydrolysis of an oil.

oil + water $\rightleftharpoons$ _____ + _____ [2]

(ii) What <u>TWO</u> things does the $\rightleftharpoons$ sign tell you about this reaction?

_____

_____

_____ **[2]**

(b) An ester can be made by reacting an alcohol with a carboxylic acid. The technique used involves four stages: REFLUX, DISTILLATION, PURIFICATION and DRYING.

In the REFLUX stage the alcohol and ester are heated with a little concentrated sulfuric acid in a flask with a condenser attached. The condenser prevents evaporation of the mixture.

In the DISTILLATION stage the mixture is heated, and the product collected at its boiling point. This separates the product from most of the impurities.

Describe and explain the other two stages.

PURIFICATION _____

_____

DRYING _____

_____ **[4]**

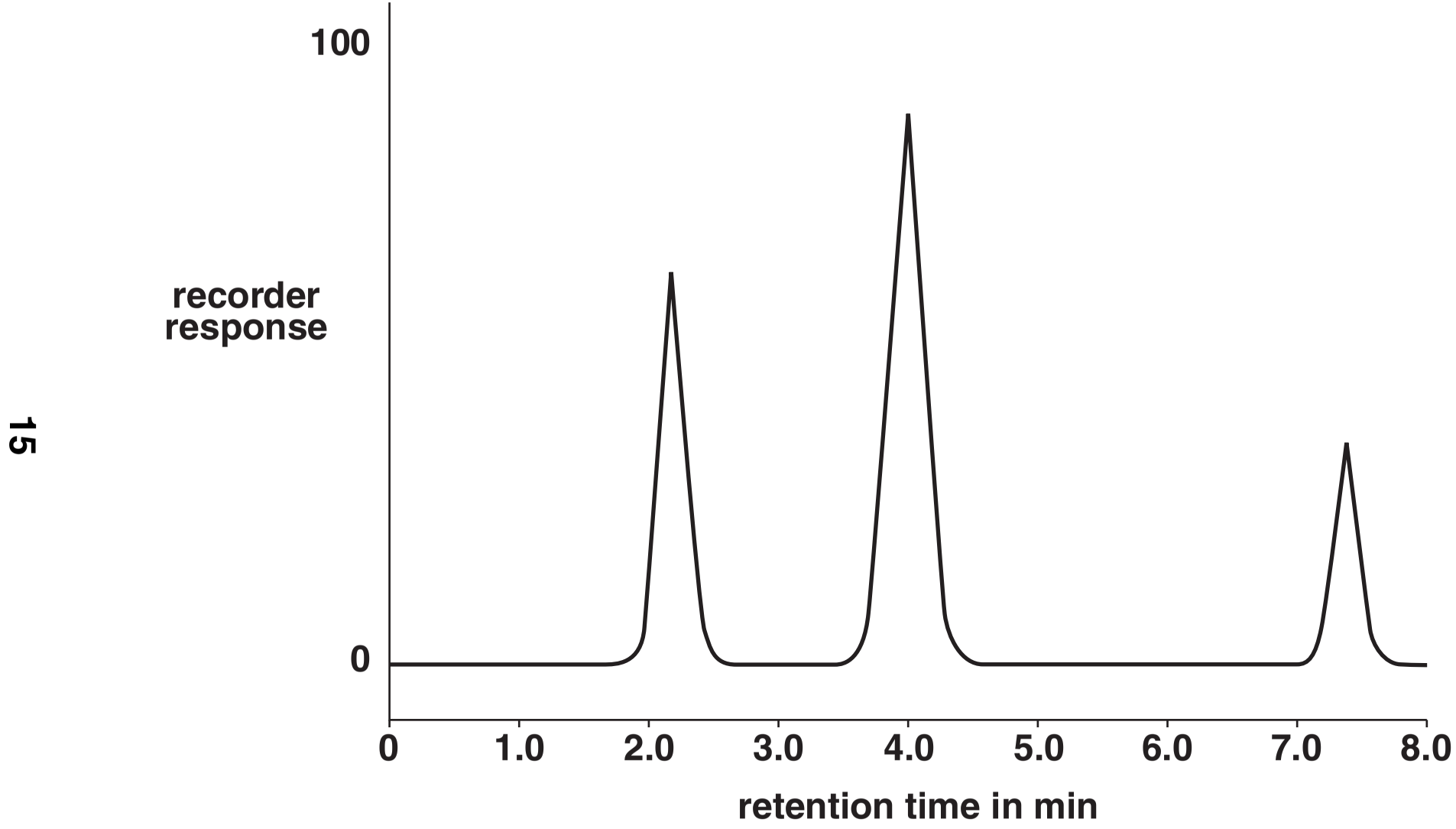
[Total: 8]

4 A technician carries out an analysis of a mixture of hydrocarbons using gas chromatography.

She first calibrates the equipment using standard hydrocarbons. The retention times for these hydrocarbons are shown in the table.

HYDROCARBON	RETENTION TIME IN MIN
methane	1.7
ethane	2.2
propane	3.5
propene	4.0
butane	7.4

The technician then analyses the mixture of hydrocarbons. The recorder print-out from this analysis is shown opposite.


100
recorder
response
0
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
retention time in min

15

(a) The mixture contained ethane, propene and butane

(i) Name the hydrocarbon that has the highest concentration in the mixture.

_____ **[1]**

(ii) Explain how the recorder print-out shows that this gas has the highest concentration.

_____

_____ **[1]**

(b) Explain how this gas chromatography separated the components of the mixture.

Use ideas about the following in your answer:

- **stationary phase**
- **mobile phase**
- **dynamic equilibrium.**

_____

_____

_____

_____

_____

_____ **[4]**

(c) Two of the hydrocarbons in the mixture are alkanes.

Alkanes burn but they do not react with solutions of other chemicals, for example bromine water.

(i) Explain why alkanes do not react with bromine water.

Use ideas about the bonds in alkanes in your answer.

_____

_____

_____ **[2]**

(ii) The burning of alkanes gives out energy.

Use ideas about bond making and breaking to explain why.

_____

_____

_____ **[2]**

[Total: 10]

5 Some indigestion tablets contain the active ingredient, magnesium hydroxide. This neutralises excess stomach acid to relieve the symptoms of acid indigestion. The tablets also contain starch.

A chemist uses quantitative analysis to find the mass of active ingredient in each tablet. He makes a suspension of each of five tablets and titrates these with a solution containing hydrochloric acid. The concentration of this acid is 40.0 g/dm^3.

His results are shown in the table.

tablet number	1	2	3	4	5	average
volume of hydrochloric acid in cm^3	23.6	23.5	23.4	23.5	23.5	23.5

(a) Use the average of his results to work out the average mass of magnesium hydroxide in each tablet in the following way.

(i) The relative formula mass of hydrochloric acid is 36.5.

Work out the relative formula mass (RFM) of magnesium hydroxide, $Mg(OH)_2$.

You should show your working.

(relative atomic masses: H = 1, Mg = 24, O = 16)

relative formula mass (RFM) of magnesium hydroxide = _____ [2]

(ii) Work out the mass of hydrochloric acid in 23.5 cm^3 of the hydrochloric acid solution used in the titrations.

mass of hydrochloric acid = _____ g [1]

(iii) Use the neutralization equation below to work out the mass of magnesium hydroxide that reacts with this mass of hydrochloric acid.

$$Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$$

This is the average mass of magnesium hydroxide in each tablet.

mass of magnesium
hydroxide in each tablet = _____ g [2]

(b) Use the table of titration results to assess the degree of uncertainty in your calculated value of the mass of magnesium hydroxide in each tablet.

Explain your answer.

_____

_____

_____ [2]

[Total: 7]

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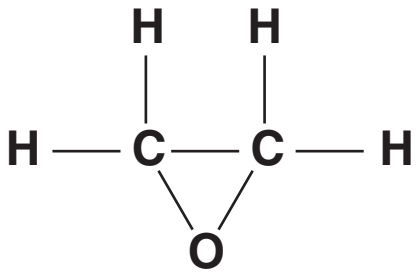
6 Epoxyethane, $(CH_2)_2O$, is an intermediate in the production of car anti-freeze, and is used to sterilize medical supplies.



epoxyethane

Epoxyethane is poisonous, carcinogenic and highly flammable.

The raw material used to make epoxyethane is ethene. This is obtained by the cracking of hydrocarbons from petroleum.

Two different methods have been used to make epoxyethane.

In the original method epoxyethane was manufactured in a two stage process.

1 Ethene was passed into an aqueous solution of chlorine.

$$C_2H_4 + Cl_2 + H_2O \rightarrow CH_2ClCH_2OH + HCl$$

2 The reaction mixture was treated with calcium hydroxide.

$$CH_2ClCH_2OH + HCl + Ca(OH)_2 \rightarrow (CH_2)_2O + CaCl_2 + 2H_2O$$

The modern method involves only one step. Ethene and oxygen are passed over a silver catalyst at 250-350 °C.

ethene + oxygen → epoxyethane

(a) Compare the sustainability of the two methods in terms of the following:

(i) obtaining the hydrocarbon feedstock used for manufacture,

_____

_____

_____ **[2]**

(ii) disposing of the by-products of manufacture.

_____

_____

_____ **[2]**

(b) The catalyst speeds up the reaction.

Explain how a catalyst carries out this function.

_____

_____

_____ **[2]**

(c) Write a balanced symbol equation for the reaction that produces epoxyethane in the modern method.

_____ **[2]**

[Total: 8]

END OF QUESTION PAPER

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The Periodic Table of the Elements

1	2											3	4	5	6	7	0
							1 **H** hydrogen 1										4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4											11 **B** boron 5	12 **C** carbon 6	14 **N** nitrogen 7	16 **O** oxygen 8	19 **F** fluorine 9	20 **Ne** neon 10
23 **Na** sodium 11	24 **Mg** magnesium 12											27 **Al** aluminium 13	28 **Si** silicon 14	31 **P** phosphorus 15	32 **S** sulfur 16	35.5 **Cl** chlorine 17	40 **Ar** argon 18
39 **K** potassium 19	40 **Ca** calcium 20	45 **Sc** scandium 21	48 **Ti** titanium 22	51 **V** vanadium 23	52 **Cr** chromium 24	55 **Mn** manganese 25	56 **Fe** iron 26	59 **Co** cobalt 27	59 **Ni** nickel 28	63.5 **Cu** copper 29	65 **Zn** zinc 30	70 **Ga** gallium 31	73 **Ge** germanium 32	75 **As** arsenic 33	79 **Se** selenium 34	80 **Br** bromine 35	84 **Kr** krypton 36
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[98] **Tc** technetium 43	101 **Ru** ruthenium 44	103 **Rh** rhodium 45	106 **Pd** palladium 46	108 **Ag** silver 47	112 **Cd** cadmium 48	115 **In** indium 49	119 **Sn** tin 50	122 **Sb** antimony 51	128 **Te** tellurium 52	127 **I** iodine 53	131 **Xe** xenon 54
133 **Cs** caesium 55	137 **Ba** barium 56	139 **La*** lanthanum 57	178 **Hf** hafnium 72	181 **Ta** tantalum 73	184 **W** tungsten 74	186 **Re** rhenium 75	190 **Os** osmium 76	192 **Ir** iridium 77	195 **Pt** platinum 78	197 **Au** gold 79	201 **Hg** mercury 80	204 **Tl** thallium 81	207 **Pb** lead 82	209 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

**** The lanthanoids (atomic numbers 58-71) and the actinoids (atomic numbers 90-103) have been omitted.***

The relative atomic masses of copper and chlorine have not been rounded to the nearest whole number.