OCR

SPECIMEN H

GENERAL CERTIFICATE OF SECONDARY EDUCATION

TWENTY FIRST CENTURY SCIENCE **A173/02**

CHEMISTRY A / FURTHER ADDITIONAL SCIENCE A

Unit A173/02: Module C7 (Higher Tier)

Candidates answer on the question paper
A calculator may be used for this paper

OCR Supplied Materials:
None

Other Materials Required:
- Pencil
- Ruler (cm/mm)

Duration: 1 hour

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES
- Write your name clearly in capital letters, your centre number and candidate number in the boxes above.
- 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
- Your quality of written communication is assessed in questions marked with a pencil (✎).
- The Periodic Table is printed on the back page.
- The number of marks for each question is given in brackets **[ ]** at the end of the question or part question.
- The total number of marks for this paper is **60**.
- This document consists of **20** pages. Any blank pages are indicated.

For Examiner's Use		
	Max	**Mark**
1	**11**	
2	**5**	
3	**8**	
4	**8**	
5	**8**	
6	**10**	
7	**10**	
TOTAL	**60**	

Answer **all** the questions.

1 Methanoic acid, HCOOH, is a carboxylic acid.

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

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

(b) Methanoic acid is used to remove the limescale in kettles.

Limescale is made of calcium carbonate.

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

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

..... + ... → $Ca(HCOO)_2$ + ... + ...

[2]

(ii) Calcium carbonate is insoluble so it stays inside the kettle.

When calcium carbonate in limescale reacts with methanoic acid, calcium methanoate forms.

The reaction with methanoic acid removes the calcium carbonate in limescale. Suggest a property of calcium methanoate that can explain why this happens.

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

(iii) Methanoic acid is a weak acid and hydrochloric acid is a strong acid.

Describe a reaction, other than with carbonates, that shows that methanoic acid is an acid.

Compare this with a similar reaction of hydrochloric acid to demonstrate why one is a weak acid and the other a strong acid.

Include relevant balanced equations in your answer.

The quality of written communication will be assessed in your answer.

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..... **[6]**

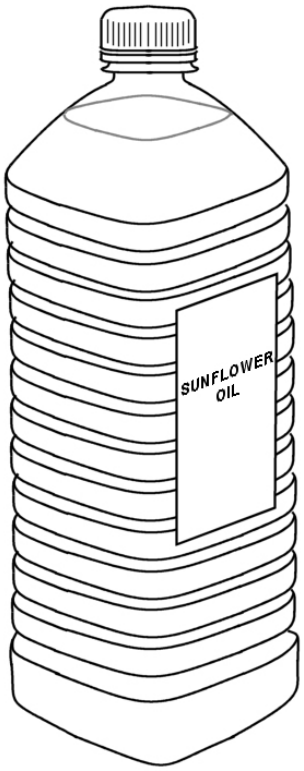
(c) Butanoic acid, $C_4H_8O_2$, is responsible for the unpleasant taste in rancid butter.

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

[1]

[Total: 11]

2 Sunflower oil is an example of a vegetable oil.



(a) The chemicals in sunflower oil are esters.

When an ester reacts with water it forms an alcohol and a type of carboxylic acid.

Complete the word equation for this reaction.

oil + water $\rightleftharpoons$ ..... + ... **[1]**

(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 in an upright position. Evaporated liquid is allowed to run back into the flask.
- In the **distillation** stage, the mixture is placed in a flask connected to a sloping condenser and heated. The product is collected at its boiling point.

Describe the stages of **purification** and **drying**.

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..... **[4]**

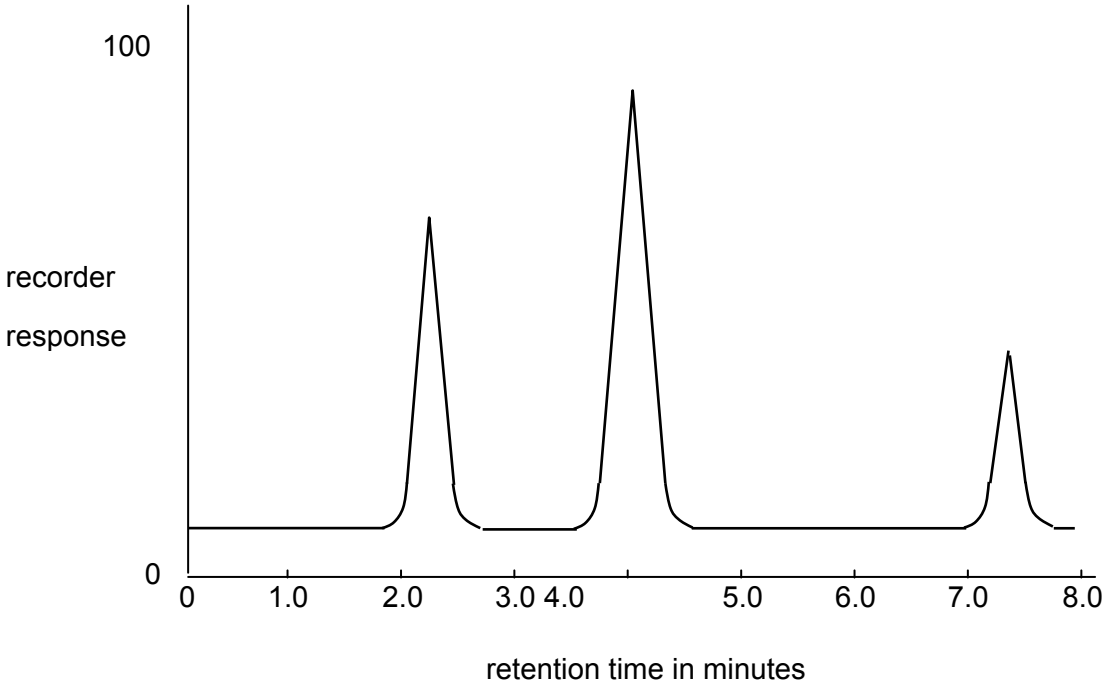
[Total: 5]

3 A technician wants to analyse a mixture of hydrocarbons using gas chromatography.

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

standard hydrocarbon	formula	retention time in minutes
methane	CH_4	1.7
ethane	C_2H_6	2.2
propane	C_3H_8	3.5
butane	C_4H_{10}	4.0
pentane	C_5H_{12}	7.4

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



(a) (i) How does the recorder print out show that butane has the highest concentration?

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

(ii) Use data in the table to write a conclusion relating the formula of each standard hydrocarbon to its retention time.

.....

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

(b) During gas chromatography, each component of a mixture is involved in a dynamic equilibrium.

Explain how this separates the components in a mixture.

The quality of written communication will be assessed in your answer.

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..... **[6]**

[Total: 8]

4 A company makes tablets that contain the active ingredient magnesium hydroxide.

The tablets also contain starch.

A chemist uses quantitative analysis to find the mass of magnesium hydroxide in five tablets.

- He makes a suspension of each of the five tablets.
- He titrates each suspension with a solution containing hydrochloric acid. The concentration of this acid is 40.0 g/dm^3.

Here are his results.

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

Relative atomic masses are given in the Periodic Table on the back page.

relative formula mass (RFM) = ... **[1]**

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

mass = ... g **[1]**

(iii) Use the equation below to work out the mass of magnesium hydroxide that reacts with this mass of hydrochloric acid. This is the average mass of magnesium hydroxide in each tablet.

The relative formula mass of hydrochloric acid, HC*l*, is 36.5.

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

Show your working.

average mass of magnesium hydroxide in each tablet = ... g **[2]**

(iv) The company makes batches of 100 000 tablets. The chemist samples and tests some tablets from each batch to obtain data about the mass of magnesium hydroxide in the tablets.

Look at his results.

	batch 1	**batch 2**	**batch 3**
number of tablets sampled	2	8 6	
average mass of magnesium hydroxide in one tablet, in grams	0.64	0.77 0.72	

Suggest what changes the chemist should make to the testing procedure.

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..... **[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.

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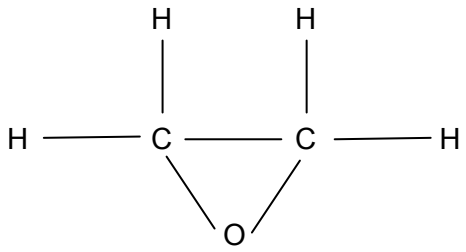
..... **[2]**

[Total: 8]

5 Epoxyethane is an intermediate in the production of car anti-freeze.



epoxyethane

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.

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

The **new** method involves only one step. Ethene and oxygen are passed over a silver catalyst at 250–350 ^{o}C.

ethene + oxygen → epoxyethane

(a) The sustainability of the two processes can be compared.

(i) Both methods use ethene.

Explain why this makes **both** methods unsustainable.

.....

.....

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

(ii) Which two statements explain why the **original** method is less sustainable in terms of by-products?

Put ticks (✓) in the boxes next to the **two** correct answers.

Chlorine is a poisonous gas.	☐
Hydrochloric acid is corrosive and its disposal can cause environmental problems.	☐
There is little use for calcium chloride.	☐
The original method produces water as a by-product.	☐
Calcium hydroxide is an alkaline solid.	☐
The new process has no by-products.	☐

[2]

(b) Complete the sentence to explain what the silver catalyst does in the reaction of the **new** method.

The catalyst provides an alternative …… for the reaction with a lower …… .

[2]

(c) Complete and balance this symbol equation for the **new** method.

……..C_2H_4 + ……..O_2 → .....

[2]

[Total: 8]

6 Natural gas is used as a fuel. It contains the hydrocarbon methane.

(a) Methane burns in air according to this equation.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Energy changes are involved in the breaking and making of bonds when methane burns.

Use ideas about the energy involved to explain why this reaction of methane with oxygen is exothermic.

The quality of written communication will be assessed in your answer.

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..... **[6]**

(b) The table shows the energy involved in the making or breaking of some bonds.

bond	energy in kJ/mol
C – H	435
O = O	498
C = O	805
H – O	464

The energy change involved in the **breaking** of bonds in this reaction can be calculated as follows.

4 x C – H = 4 x 435 = 1740 kJ/mol

2 x O = O = 2 x 498 = 996 kJ/mol

energy involved = 1740 + 996 = 2736 kJ/mol

(i) Calculate the energy change involved in **making** bonds in this reaction.

Show your working.

energy involved = ... kJ/mol **[3]**

(ii) Calculate the overall energy change for the reaction.

overall energy change = ... kJ/mol **[1]**

[Total: 10]

7 Gemma works for a company making vinegar.

Each day she measures the amount of ethanoic acid in 25.0 cm^3 samples of the vinegar made.

She does a titration using a standard solution of sodium hydroxide and an indicator.

(a) Gemma makes her standard solution of sodium hydroxide to use for her titration.

The statements describe how she makes up this solution, but they are in the wrong order.

A Rinse all of the solution from the beaker using more distilled water.

B Place a stopper in the graduated flask and shake it.

C Dissolve the sodium hydroxide in a small volume of distilled water in a beaker.

D Accurately weigh 1.0 g of sodium hydroxide.

E Transfer the solution to a 250 cm^3 graduated flask.

F Add more distilled water up to the 250 cm^3 volume mark on the graduated flask.

(i) Write the letters of these statements in the boxes to show the correct order.

The first and last have been done for you.

D					**B**

[3]

(ii) Calculate the concentration of her sodium hydroxide solution in g/dm^3.

concentration of sodium hydroxide solution = ... g/dm^3 **[1]**

(b) Gemma does two sets of six titrations.

All of the samples she tests are from the same vinegar.

Here are her results.

	volume of sodium hydroxide solution in cm^3					
set 1 morning	12.9	12.2	12.5	12.8	12.9	12.1
set 2 afternoon	12.4	12.6	12.5	12.5	12.4	12.6

(i) Gemma uses **set 2** to get a best estimate for the concentration of ethanoic acid in the vinegar.

Explain why she uses **set 2**.

.....

.....

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

(ii) There is not a significant difference between the sets of results.

How do the data show this?

.....

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

(iii) Gemma works out the average (mean) value for her afternoon results and finds that 12.5 cm^3 of the sodium hydroxide solution neutralises 25 cm^3 of the vinegar.

Vinegar contains ethanoic acid that reacts with sodium hydroxide in this equation.

$$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$$

Calculate the best estimate for the concentration of ethanoic acid in the vinegar.

Relative atomic masses are given in the Periodic Table on the back page.

You will also need to use your answer to part **(a) (ii)**.

Show your working.

concentration of ethanoic acid = ... g/dm^3 **[2]**

(iv) Quality control requires the ethanoic acid in the vinegar to be of concentration 2.8 g/dm^3 plus or minus 10%.

Explain whether the sample of vinegar that Gemma tested would have passed the quality test.

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

[Total: 10]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE

Periodic Table

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.***