Oxford Cambridge and RSA

AS Level Chemistry B (Salters)

H033/02 Chemistry in depth

Friday 10 June 2016 – Afternoon

Time allowed: 1 hour 30 minutes

You must have:
- the Data Sheet for Chemistry B (Salters) (sent with general stationery)

You may use:
- a scientific calculator

First name	
Last name	

Centre number						Candidate number					

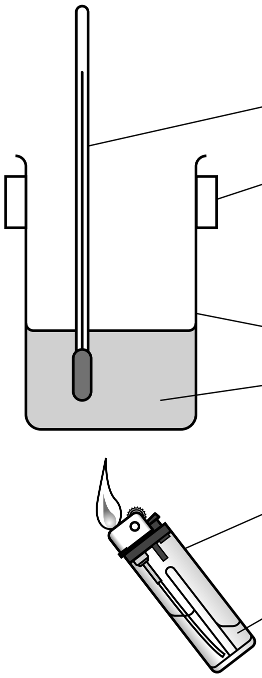
INSTRUCTIONS
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*****).
- This document consists of **20** pages.

Answer **all** the questions.

1 Disposable lighters use butane (C_4H_{10}). Heat energy is released when the butane is burned.

Some students wish to determine the enthalpy change of combustion ($\Delta_c H$) of butane. They use the apparatus below.



The mass of the lighter is measured before the butane is ignited and again after the butane has burned.
The water is stirred continuously using the thermometer and the temperature of the water in the metal can is measured before and after the combustion of the butane.

The results are shown below.

mass of lighter and butane before combustion	14.86 g
mass of lighter after combustion	14.39 g
temperature of water before heating	19 °C
temperature of water after heating	74 °C
mass of water	50.00 g

Table 1.1

(a) Write a chemical equation to represent the standard enthalpy change of combustion of butane ($\Delta_c H^{\ominus}$).

Show state symbols.

[2]

(b) Calculate a value for the enthalpy change of combustion (in kJ mol^{-1}) of butane ($\Delta_c H$) using the experimental results in **Table 1.1**.

enthalpy change of combustion of butane, $\Delta_c H$ = ... kJ mol^{-1} **[3]**

(c) The standard enthalpy changes of combustion of some alkanes are given in the table below.

Alkane	**$\Delta_c H^\ominus$/kJ mol^{-1}**
CH_4	–890
C_2H_6	–1560
C_3H_8	–2220
C_5H_{12}	–3509
C_6H_{14}	–4194

(i) Estimate the standard enthalpy change of combustion of butane.

$\Delta_c H^\ominus$ = ... kJ mol^{-1} **[1]**

(ii) Suggest **two** reasons, apart from 'heat losses', why the value calculated in the simple experiment in **(b)** is much less exothermic than the value estimated.

1 ....

....

2 ....

....

[2]

(iii) The students repeat the experiment using the same thermometer and balance.

State and explain **one** way in which they could modify the procedure in order to obtain a more accurate value for the enthalpy change of combustion of butane.

....

....

.... **[1]**

(d) The enthalpy change of **combustion** of butane can be measured directly using the method in **(b)**.
The standard enthalpy change of **formation** of butane is represented by the equation below.

$$4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)$$

Suggest why it is **not** possible to measure the enthalpy change of **formation** of butane directly.

....

.... **[1]**

(e) Butane has a structural isomer.

Draw the skeletal formula of this isomer and give its systematic name.

skeletal formula

systematic name .... **[1]**

(f) The enthalpy change of combustion of methanol and some bond enthalpies are shown below.

$$CH_3OH(g) + 1\tfrac{1}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(g) \qquad \Delta_c H = -726\,\text{kJ mol}^{-1}$$

Bond	**Bond enthalpy / kJ mol^{-1}**
C – C	+347
C – H	+413
C – O	+358
C = O	+805
O = O	+498

Use this information to calculate a value for the bond enthalpy of the O–H bond.

bond enthalpy of the O–H bond = ... kJ mol^{-1} **[3]**

2 In 1829, Sir James Murray used 'milk of magnesia' to treat the Marquis of Anglesey for stomach pain.

A student discovered an old, previously unopened, bottle of milk of magnesia. The label stated that the medicine contained magnesium hydroxide at 8% w/v as a suspension in water.

'w/v' means 'weight/volume' such that a 10% w/v mixture contains 10 g of named substance per 100 cm^3.

(a) The student tests a small sample of the medicine with universal indicator.

Suggest a pH value that would be obtained by the student.

.... **[1]**

(b) Calculate the amount (in mol) of $Mg(OH)_2$ in a bottle containing 250 cm^3 at 8.0% w/v.

Give your answer to **two** significant figures.

amount of $Mg(OH)_2$ = ... mol **[3]**

(c) The student investigates whether the amount of $Mg(OH)_2$ in the bottle has changed over time. The student has a standard solution of sulfuric(VI) acid but realises that a direct titration of the mixture with acid is difficult to use in this situation.

(i) Explain the significance of the (VI) in the systematic name, sulfuric(VI) acid.

.... **[1]**

(ii) Suggest why it is not easy to use a direct titration in this situation.

.... **[1]**

(d) The student uses an indirect titration method to determine the mass of $Mg(OH)_2$ in a 250 cm^3 bottle of milk of magnesia.

25.0 cm^3 of the milk of magnesia are reacted with 25.0 cm^3 of 2.00 mol dm^{-3} sulfuric(VI) acid (an excess).

The unreacted excess of this acid is titrated against 1.99 mol dm^{-3} sodium hydroxide solution. The student repeats the procedure until concordant titres are obtained.
The titres of 1.99 mol dm^{-3} sodium hydroxide are as follows:

	Trial	**Repeat 1**	**Repeat 2**	**Repeat 3**
Titre / cm^3	16.90	16.60	16.95	16.70

(i) Explain why the student should use 16.65 cm^3 as the mean titre.

....

....

.... **[1]**

(ii) The equation for the titration is shown below.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

Calculate the amount (in mol) of the H_2SO_4 in excess.

amount of H_2SO_4 in excess = ... mol **[2]**

(iii) Calculate the mass of $Mg(OH)_2$ in 250 cm^3 of milk of magnesia.

The equation for the reaction of sulfuric acid with magnesium hydroxide is shown below.

$$Mg(OH)_2 + H_2SO_4 \rightarrow MgSO_4 + 2H_2O$$

mass of $Mg(OH)_2$ = ... g **[3]**

(iv) The uncertainty associated with the use of a class B pipette is 0.06 cm^3.

Calculate the percentage uncertainty associated with using this pipette to measure the 25.0 cm^3 of milk of magnesia.

Give your answer to an **appropriate** number of significant figures.

percentage uncertainty = ... % **[1]**

(e) The student attempts to make magnesium hydroxide. First an excess of magnesium is reacted with hydrochloric acid.

The equation for the reaction is shown below.

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ **Equation 2.1**

(i) Write a half-equation to represent the oxidation that is occurring in this reaction.

[1]

(ii) Explain why the half-equation in **(e)(i)** represents oxidation.

.... **[1]**

(iii) Identify the oxidising agent in the reaction in **equation 2.1**.

.... **[1]**

(f) The student then filters the reaction mixture from **(e)** to remove the excess magnesium to leave the solution of magnesium chloride.

The student adds sodium hydroxide solution to form a precipitate of magnesium hydroxide.

(i) Write an ionic equation, with state symbols, to represent this precipitation reaction.

[2]

(ii) Suggest why this would be a less effective method for preparing $Ba(OH)_2$ from $BaCl_2$.

.... **[1]**

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

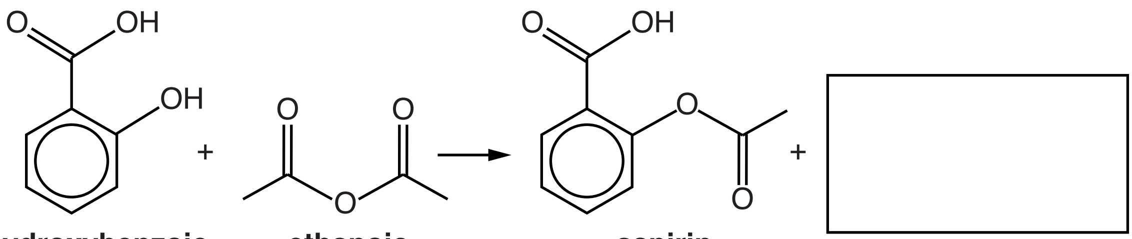
Turn over for the next question

3 Aspirin is a painkiller.

Student **A** attempts to prepare, purify and analyse aspirin in the laboratory.

The student reacts together 2-hydroxybenzoic acid and ethanoic anhydride.

(a) An incomplete equation for the reaction is shown below.



2-hydroxybenzoic acid *Mr* 138 | **ethanoic anhydride** *Mr* 102 | **aspirin**

(i) Complete the equation above by drawing the other product in the box. **[1]**

(ii) Which functional group does aspirin contain that is **not** in either of the two reactants?

.... **[1]**

(iii) Calculate the atom economy for the production of aspirin.

atom economy = ... % **[2]**

(b) The crude aspirin is filtered off. It is then washed, dried and weighed.

Student **A** tests a small amount of the crude aspirin with neutral iron(III) chloride solution. A purple coloration is produced.

Name the impurity in the crude aspirin that is suggested by this result.

.... **[1]**

(c) Describe the essential steps that the student would carry out in order to purify the aspirin by recrystallisation from ethanol as solvent.

....

....

....

....

....

....

.... **[4]**

(d) The melting point of aspirin is 138–140 °C.

How would the melting point of the crude aspirin product compare with that of the recrystallised (purer) aspirin?

.... **[1]**

(e) Student **B** prepares 0.68 g pure aspirin starting with 1.15 g of 2-hydroxybenzoic acid.

Calculate student **B**'s percentage yield of pure aspirin.

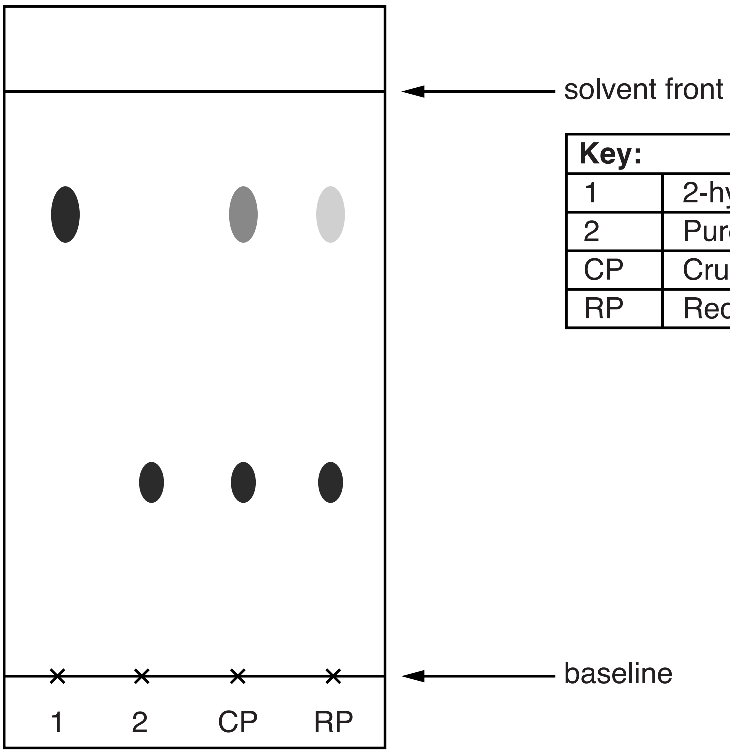
percentage yield of pure aspirin = ... % **[2]**

(f) * Student **A** investigates the composition of both the crude and recrystallised products using thin-layer chromatography.

The student applies separate samples of 2-hydroxybenzoic acid, pure aspirin, the crude product and the recrystallised product to a chromatography plate.

The chromatography is then run.

The developed chromatogram is shown below.



Key:	
1	2-hydroxybenzoic acid
2	Pure aspirin
CP	Crude product
RP	Recrystallised product

Describe how the student would run the chromatography and analyse the chromatogram (you do not need to describe how the chromatogram is developed). Suggest any further action required to make pure aspirin.

....

....

....

....

....

....

....

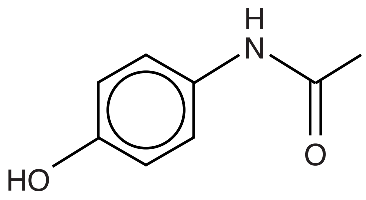
....

....

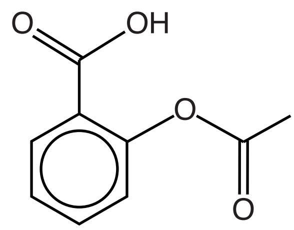
....

.... **[6]**

(g) Paracetamol is another widely used painkiller.
The structures of paracetamol and aspirin are shown below.



paracetamol



aspirin

A student adds small amounts of powdered paracetamol and powdered aspirin separately to sodium carbonate solution.

Describe what the student will observe in each case and explain the difference in the observations.

....

....

....

.... **[3]**

4 Ethanoic acid is an important chemical intermediate in the manufacture of a wide range of products. It was originally made by oxidising ethanol.

(a) **(i)** Give the reagents and the conditions for the laboratory oxidation of ethanol to ethanoic acid.

Reagents ....

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

(ii) Write a balanced equation for the oxidation of ethanol to ethanoic acid.

Use structural formulae for the organic compounds and use [O] to represent the oxidising agent.

[1]

(b) One safety precaution when carrying out this reaction is to keep the flammable ethanol away from naked flames.

Write an equation for the **incomplete** combustion of ethanol.

[1]

(c) Ethanal (CH_3CHO) is formed as an intermediate compound during the oxidation of ethanol to ethanoic acid. The boiling points of these three compounds are shown in the table below.

Compound	Boiling point / °C
ethanal	21
ethanol	78
ethanoic acid	118

Explain how the differences in intermolecular bonding in the three compounds account for the differences in their boiling points. Intermolecular bonds should be named.

....

....

....

....

....

....

....

....

.... **[4]**

(d) When ethanal burns completely, the equation for the reaction that occurs at the temperature of the combustion is shown below.

$$CH_3CHO(l) + 2\tfrac{1}{2}O_2(g) \rightarrow 2CO_2(g) + 2H_2O(g)$$

0.55 g of ethanal is burned completely.

(i) Calculate the minimum volume of oxygen (measured in cm^3 at RTP) required.

minimum volume of oxygen at RTP = ... cm^3 **[2]**

(ii) The gaseous products of the reaction are cooled to room temperature.

Calculate the percentage of the products (by mass) that remain gaseous.

% by mass of products that are gaseous at room temperature = ... % **[1]**

BLANK PAGE

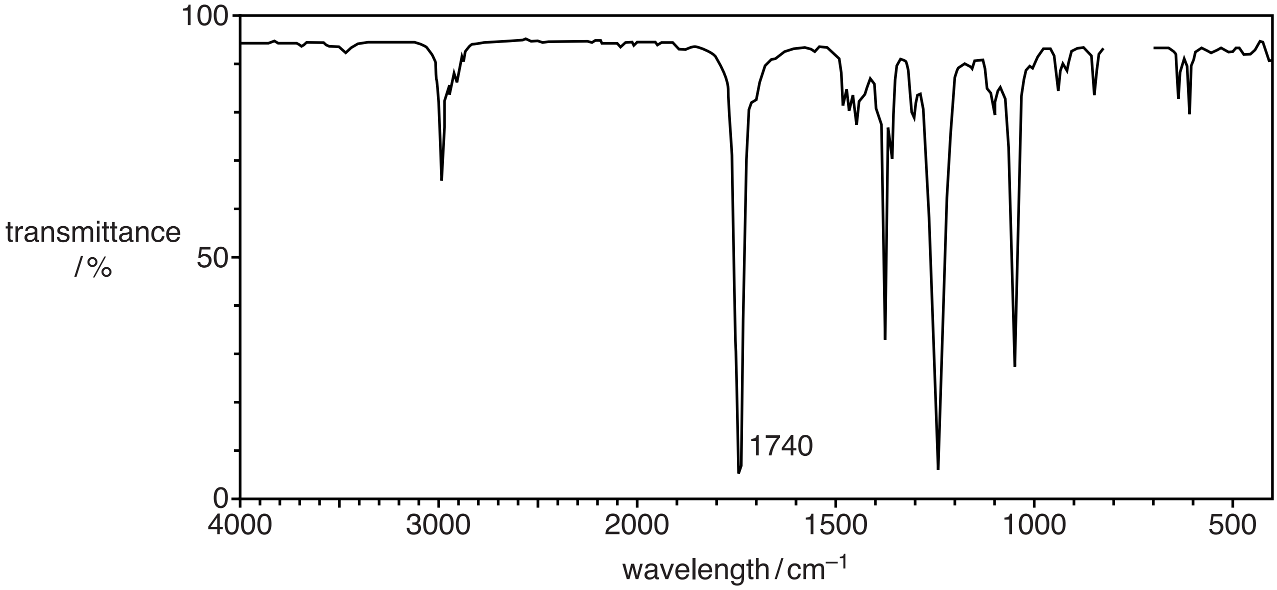
PLEASE DO NOT WRITE ON THIS PAGE

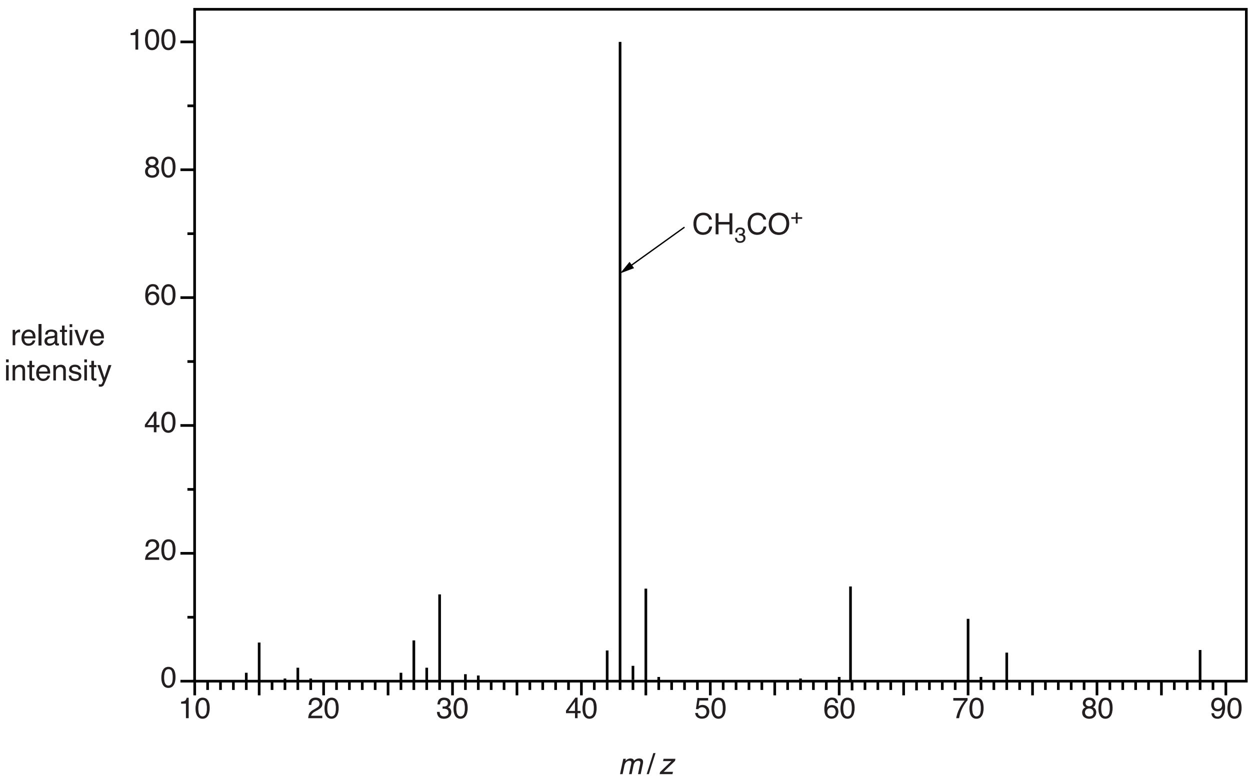
Turn over for the next question

(e)* An alcohol can be converted into compound **A**.

Compound **A** has the percentage composition by mass:
C 54.5%; H 9.1%; O 36.4%

The infrared and mass spectra of compound **A** are shown below.





You may do rough working on this page but your answer should be written on page 19.

Use the information on page 18 to identify compound **A**.

In your answer you should make clear how your identification is linked to all of the evidence.

....

....

....

....

....

....

....

....

....

....

....

....

....

.... **[6]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).