OXFORD CAMBRIDGE AND RSA EXAMINATIONS
AS LEVEL

H033/02

CHEMISTRY B (SALTERS)

Chemistry in depth

FRIDAY 10 JUNE 2016: Afternoon
TIME ALLOWED: 1 hour 30 minutes
plus your additional time allowance

MODIFIED ENLARGED

First name		Last name	
Centre number					**Candidate number**				

YOU MUST HAVE:

the Data Sheet for Chemistry B (Salters)
(sent with general stationery)

YOU MAY USE:

a scientific calculator

READ INSTRUCTIONS OVERLEAF

653131 7104

INSTRUCTIONS

Use black ink. HB pencil may be used for graphs and diagrams only.

Complete the boxes on the first page 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.

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 (*).

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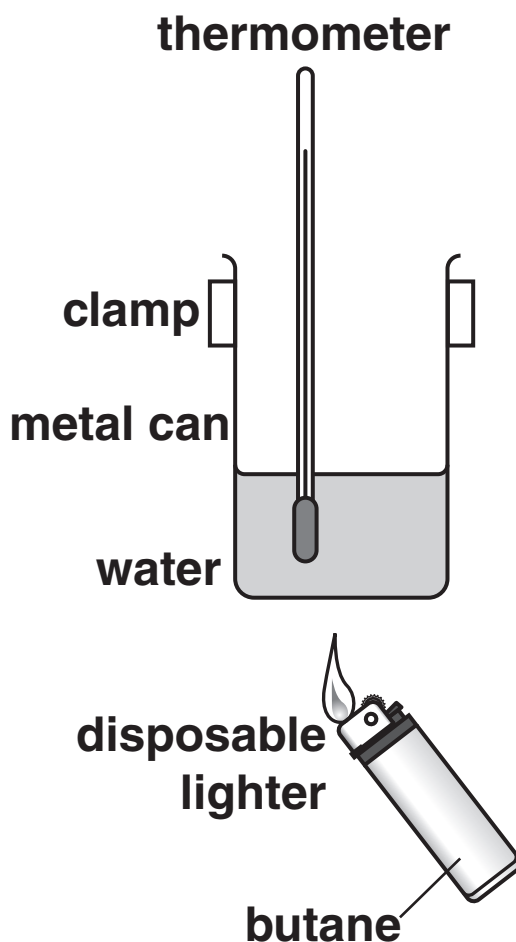
The mass of the lighter is measured before the butane is ignited and again after the butane has burned. The water is stirred continuously using the thermometer and the temperature of the water in the metal can is measured before and after the combustion of the butane.

The results are shown below.

Table 1.1

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

(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]**

5

(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.

$$4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)$$
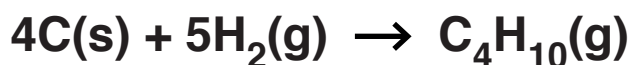
Suggest why it is **NOT** possible to measure the enthalpy change of **FORMATION** of butane directly.
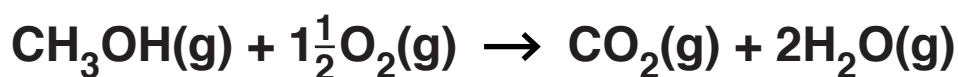
_____

_____ **[1]**

(e) **Butane has a structural isomer.**

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

skeletal formula

systematic name _____ **[1]**

8

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

$$CH_3OH(g) + 1\tfrac{1}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

$$\Delta_c H = -726\,kJ\,mol^{-1}$$

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.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$
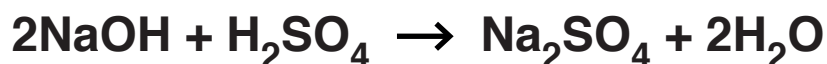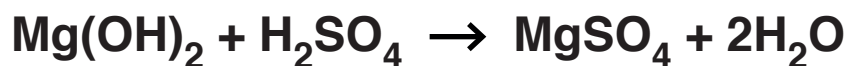
Calculate the amount (in mol) of the H_2SO_4 in excess.

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.

EQUATION 2.1

$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$
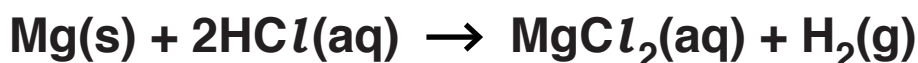
(i) Write a half-equation to represent the oxidation that is occurring in this reaction.

[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]

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 opposite.

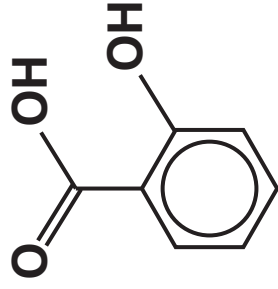   (i) Complete the equation opposite by drawing the other product in the box. [1]

   (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]

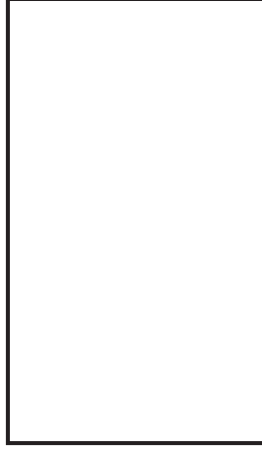**2-HYDROXYBENZOIC ACID** + **ETHANOIC ANHYDRIDE** → **ASPIRIN** + ☐

Mr 138
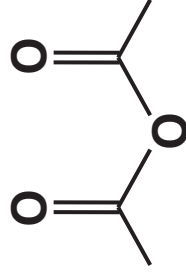
Mr 102
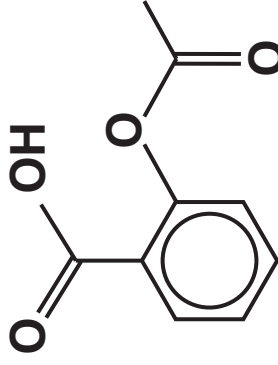
(b) The crude aspirin is filtered off. It is then washed, dried and weighed.

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

solvent front

baseline

1   2   CP   RP
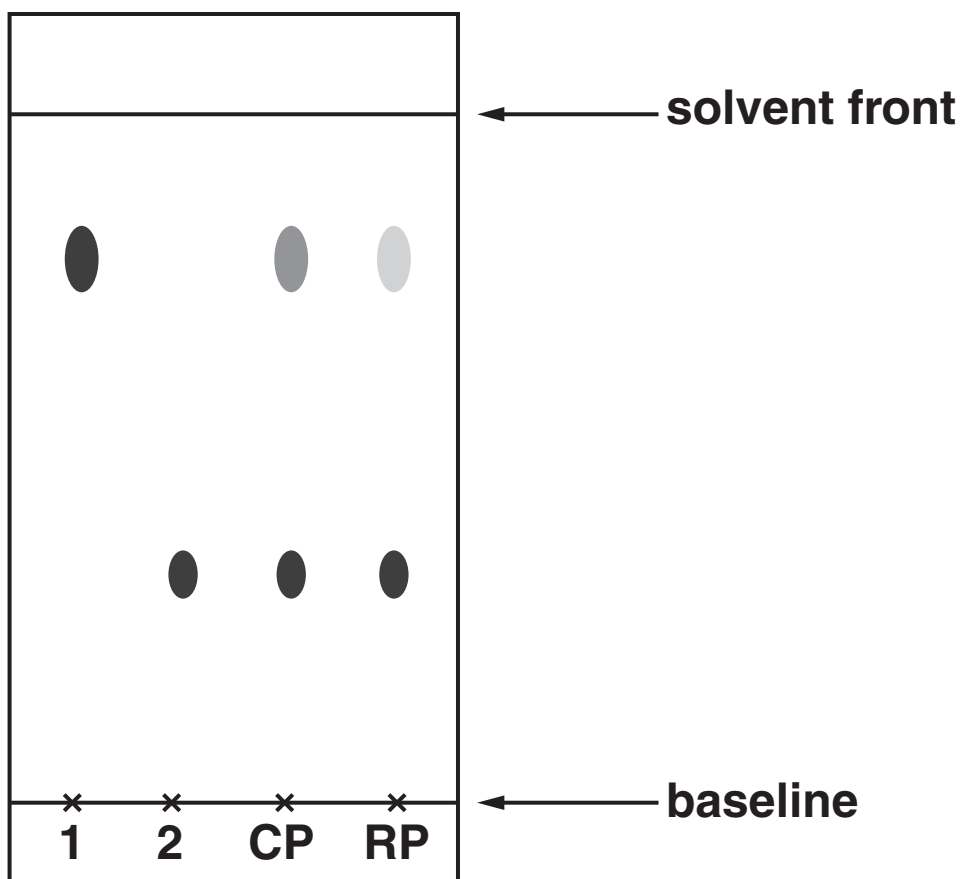
Describe how the student would run the chromatography and analyse the chromatogram (you do not need to describe how the chromatogram is developed). Suggest any further action required to make pure aspirin.
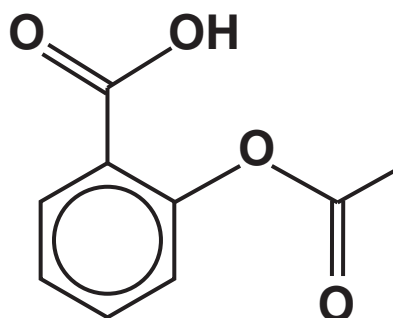
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_____ **[6]**

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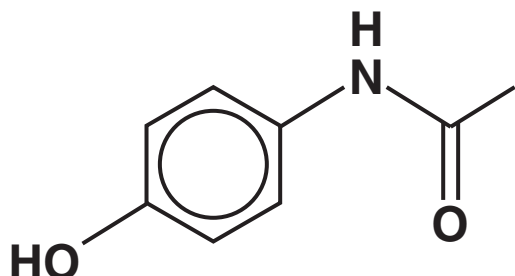
PARACETAMOL   **ASPIRIN**

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]**

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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.

$$CH_3CHO(l) + 2\tfrac{1}{2}O_2(g) \rightarrow 2CO_2(g) + 2H_2O(g)$$
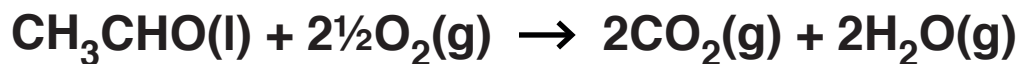
0.55 g of ethanal is burned completely.

(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]

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(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 on the next page.

transmittance /%

1740

wavelength / cm⁻¹

relative intensity

CH₃CO+

m / z
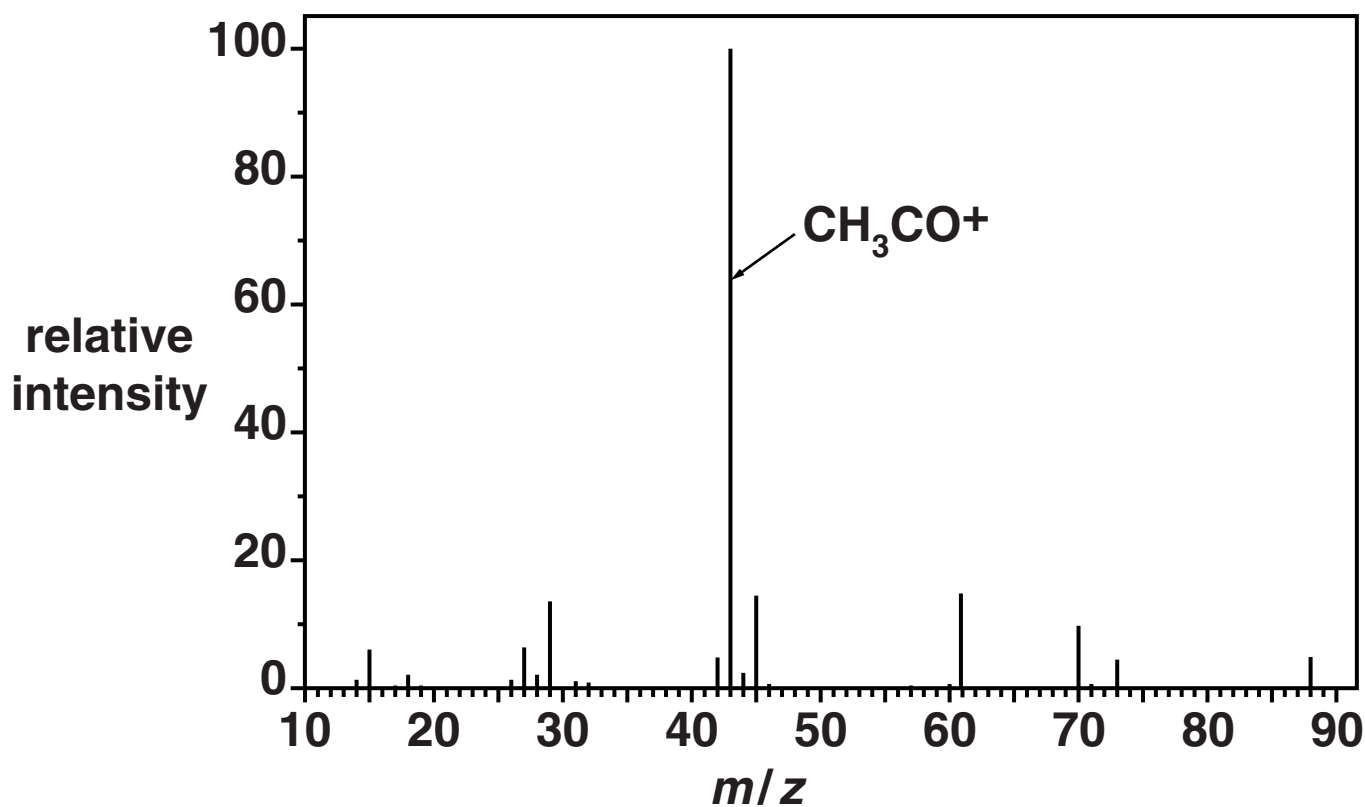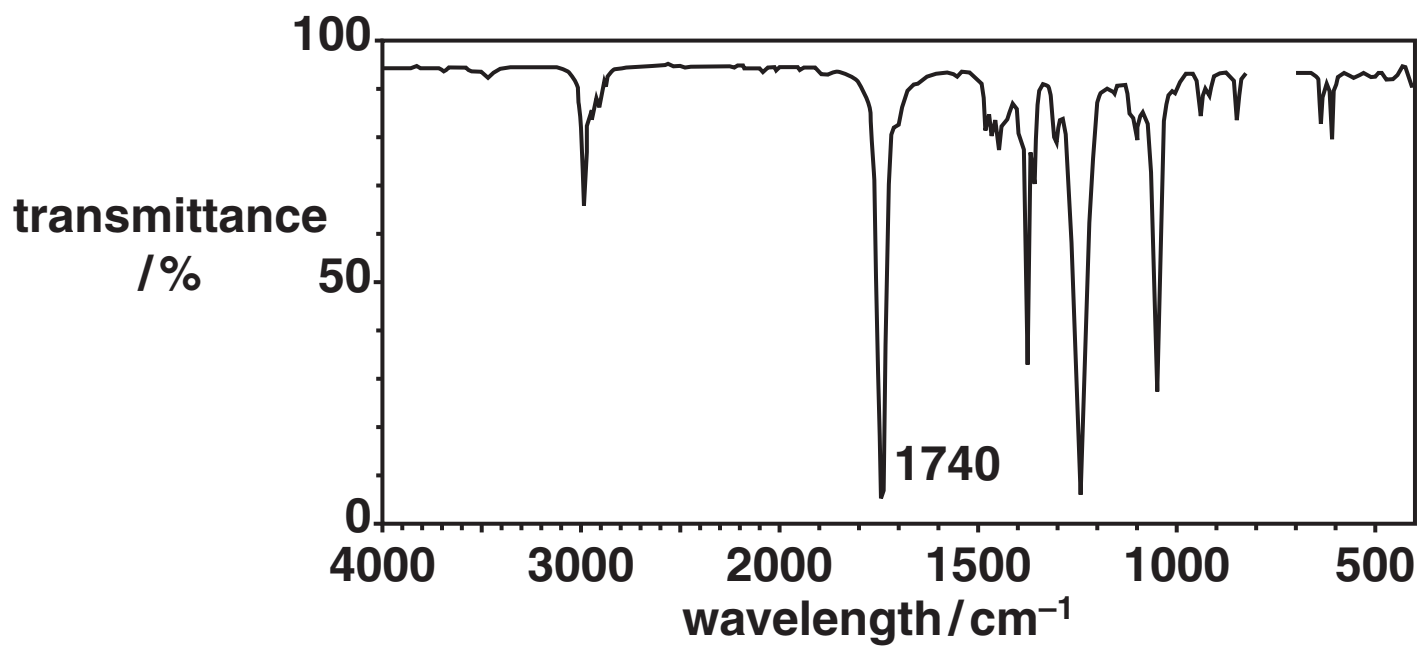
You may do rough working on this page but your answer should be written on page 31.

Use the information on pages 29 and 30 to identify compound A.

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

_____

_____

_____

_____

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_____

_____

_____

_____ **[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).

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