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Examiners' report

A LEVEL

CHEMISTRY B (SALTERS)

OCR Level 3 Advanced GCE in Chemistry B (Salters)

H433

For first teaching in 2015

H433/01 Summer 2025 series

Version 1

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate responses is also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from Teach Cambridge.

Paper 1 series overview

As always, there was clear evidence of hard work undertaken by students and their teachers, as shown by the number of students scoring more that 100 marks. The paper discriminated between candidates well with scores ranging from 106 to 11. The rate of candidates omitting to answer questions was low and there was no evidence that there was insufficient time to complete the paper.

The calculation questions showed a clear and logical approach so marks could be given for intermediate steps even if the final answer were incorrect. Students should be encouraged to read the question carefully to make sure that they use all the correct information in the correct context.

Practical aspects continued to be a challenge for candidates, especially the drawing of the distillation apparatus.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• were able to extract the correct information from the question to carry out a multistep calculation • were able to give clear structural formulae, for example for triglycerides and the ester in the spectroscopy question • could clearly explain why the dehydration of butan-1-ol was preferable to butan-2-ol to make but-1-ene • could make full use of spectroscopic and percentage composition information to elucidate a structure.	• were not able to explain the orientation of bonds in the carboxylic acid group clearly • did not recall the mechanism for the bromination of ethene • were not able to balance equations correctly • did not recall the tests for different anions and cations fully.

Section A overview

As in previous years there was clear evidence of good practice in attempts to work out the correct answer before looking at the options. This was shown by clear working in the spaces around the question. The number of questions left unanswered was very small and performance has continued to improve.

Question 1

1 Part of a protein structure can be represented as:

$–CONHCH(CH_3)CONHCH_2CONHCH(CH_3)–$

What is correct about this part of the protein structure?

A All its amino acids show optical isomerism.

B It has three peptide links.

C It is an addition polymer.

D It is made from three different amino acids.

Your answer ☐ **[1]**

This was well answered. Option D was a common incorrect answer.

Question 2

2 What is correct about the greenhouse effect?

A Greenhouse gas bonds vibrate more when warmed by infrared radiation.

B Greenhouse gases reflect infrared radiation back to Earth.

C The Earth emits mostly ultraviolet radiation.

D The principal radiation from the Sun is infrared.

Your answer ☐ **[1]**

More than half the answers were correct; C and D were clearly easily eliminated but B was frequently seen as an incorrect answer.

Question 3

3 An organic compound **A** is oxidised to a different compound which forms a silver mirror with Tollens' reagent.

Which could be compound **A**?

A propanal

B propan-1-ol

C propan-2-ol

D propanone

Your answer ☐ **[1]**

This question proved difficult for the majority of candidates. Option A was a frequently seen answer, suggesting that the question had not been read carefully enough as it is the oxidation product that formed the silver mirror.

Question 4

4 Which statement about transition metals is correct?

A Copper(II) ions form an octahedral complex with chloride ions.

B Most manganese compounds have Mn in the oxidation state of +2, +4 or +7.

C Nickel is used as a catalyst in the hydration of alkenes.

D The dichromate ion is often used as a reducing agent.

Your answer ☐ **[1]**

Another question that was difficult for many candidates; C was often selected, showing confusion between hydration and hydrogenation.

Question 5

5 Which statement about the element astatine, At, is likely to be correct?

A It displaces iodine from sodium iodide.

B It is a gas at room temperature.

C It is a weaker oxidising agent than chlorine.

D It is colourless.

Your answer ☐ **[1]**

This was well answered; halogen chemistry is clearly well understood.

Question 6

6 Which of the following pairs can be structural isomers?

A acid anhydrides and aldehydes

B amines and amides

C carboxylic acids and esters

D diols and esters

Your answer ☐ **[1]**

About half the answers were correct here with no clear majority for any particular incorrect answer.

Question 7

7 Which row shows the correct electron configurations of Cr and Cr^{3+}?

	Cr	Cr^{3+}
A	[Ar] $3d^4$ $4s^2$	[Ar] $3d^3$
B	[Ar] $3d^4$ $4s^2$	[Ar] $3d^1$ $4s^2$
C	[Ar] $3d^5$ $4s^1$	[Ar] $3d^3$
D	[Ar] $3d^5$ $4s^1$	[Ar] $3d^1$ $4s^2$

Your answer ☐ **[1]**

About half the answers were correct. The best answers showed working that eliminated B and D as 4s electrons are lost first in forming positive ions. Candidates then remembered that chromium, like copper, has slightly irregular filling of the 3d orbitals, and selected C.

Question 8

8 What is an advantage of **both** ethanol **and** hydrogen as alternatives to petrol?

A Their only product of combustion is water.

B They can be produced by fermentation.

C They do **not** produce nitrogen oxides in the engine.

D They do **not** produce oxides of sulfur on combustion.

Your answer ☐ **[1]**

This topic was well understood.

Question 9

9 What is correct about chlorine radicals in the atmosphere?

A They act as homogeneous catalysts that increase ozone depletion.

B They are formed by heterolytic fission of CFCs.

C They are formed by homolytic fission of CFCs by infrared radiation.

D They are heterogeneous catalysts that increase the rate of ozone formation.

Your answer ☐ **[1]**

More than three quarters of the answers were correct.

Question 10

10 A colorimeter is used to measure the concentration of a copper(II) sulfate solution.

What is correct?

A A blue filter is used.

B A calibration curve of copper ion concentration against time is used.

C The absorption increases as the concentration of copper ions increases.

D The transmission decreases as the concentration of copper ions decreases.

Your answer ☐ **[1]**

This was a practical technique well understood by the majority.

Question 11

11 Which statement about all sodium compounds is correct?

A They are less reactive than potassium compounds.

B They dissolve in water to give alkaline solutions.

C They form giant structures.

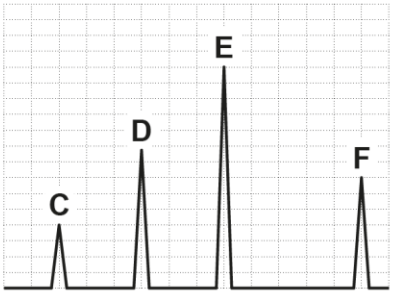
D They give a red flame test.

Your answer ☐ **[1]**

This question proved difficult; even high scoring candidates confused the elements and compounds and selected A or B. Very few answers were confused about the flame colour.

Question 12

12 A scientist runs a mixture of four hydrocarbons through a gas-liquid chromatography apparatus. The chromatogram obtained is:



What is correct?

A Compound **C** emerges from the apparatus first.

B Compound **E** has the longest retention time.

C Compound **F** is held least well by the column.

D The x-axis label should be 'abundance'.

Your answer ☐ **[1]**

More than half the candidates correctly answered this.

Question 13

13 Chlorine is added to water to prevent the spread of bacterial diseases.

Why must the levels of chlorine in the water be carefully monitored?

A Chlorine is a green gas.

B Chlorine is a halogen.

C Chlorine is toxic.

D Chlorine prevents the spread of cholera.

Your answer ☐ **[1]**

Almost all the answers were correct here.

Question 14

14 Which row has ammonia, methane and water in order of **increasing** boiling point?

A ammonia < methane < water

B methane < ammonia < water

C methane < water < ammonia

D water < ammonia < methane

Your answer ☐ **[1]**

It was well understood that water had the highest boiling point, but a significant number of answers had methane as the second highest.

Question 15

15 Which pair will react to produce brown vapours?

A NaC*l* and concentrated H_3PO_4

B NaC*l* and concentrated H_2SO_4

C NaBr and concentrated H_2SO_4

D NaI and concentrated H_3PO_4

Your answer ☐ **[1]**

This was well answered.

Question 16

16 Modern petrol cars have catalytic converters.

Which row shows a pollutant removed by these catalytic converters and the environmental problem the pollutant causes?

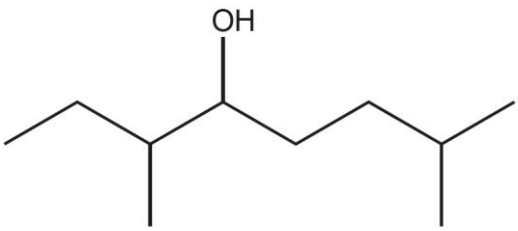
	Pollutant removed by catalytic converters	Problem caused
A	CFCs	Ozone depletion
B	CO	Toxic
C	CO_2	Global warming
D	O_3	Photochemical smog

Your answer ☐ **[1]**

This was well answered by the majority.

Question 17

17 An organic compound is shown:



What is the correct name for this compound?

A 1,1,5-trimethylheptan-4-ol

B 2-methyl-6-methyloctan-5-ol

C 2-ethyl-6-methylheptan-3-ol

D 3,7-dimethyloctan-4-ol

Your answer ☐ **[1]**

There was clear evidence of working for this question. Candidates are encouraged to annotate provided structures to help them determine the correct numbering of substituents.

Question 18

18 In which of the following reactions is the hydrogen halide acting as a reducing agent?

A $2HBr + 2Na \rightarrow 2NaBr + H_2$

B $HCl + AgNO_3 \rightarrow HNO_3 + AgCl$

C $HCl + NaOH \rightarrow NaCl + H_2O$

D $8HI + H_2SO_4 \rightarrow H_2S + 4H_2O + 4I_2$

Your answer ☐ **[1]**

Another example of the good knowledge of the halogens.

Question 19

19 2.00 g of an oxide of copper contains 1.78 g of copper.

What is the oxidation state of the copper in the oxide?

A –1

B 0

C +1

D +2

Your answer ☐ **[1]**

Just over half got the correct answer here and there was good evidence of working out the empirical formula from the masses before deciding on the oxidation state.

Question 20

20 The cracking of one molecule of compound **H** produces but-1-ene, propene and butane in a 2:2:1 mol ratio.

What is the M_r of compound **H**?

A 154

B 156

C 250

D 254

Your answer ☐ **[1]**

There were many factors to take into consideration here and two thirds of answers were correct.

Question 21

21 A gaseous mixture contains 3.803×10^{-5} moles of Cl_2 molecules per dm^3.
$1.00\,dm^3$ of the mixture has a mass of 1.35 g.

What is the concentration of Cl_2 molecules in this mixture, in parts per million, ppm?

A 28

B 500

C 1000

D 2000

Your answer ☐ **[1]**

This was a complex calculation with about a third of answers being correct. It seemed apparent that some did not know how to approach the question as incorrect answers were equally distributed across the other options.

Question 22

22 In a saturated solution of MgF_2, the fluoride ion concentration is $2.4 \times 10^{-3}\,mol\,dm^{-3}$.

What is the solubility product of MgF_2 in $mol^3\,dm^{-9}$?

A 1.7×10^{-9}

B 3.5×10^{-9}

C 6.9×10^{-9}

D 1.4×10^{-8}

Your answer ☐ **[1]**

The ability to handle solubility products has greatly improved in recent years and almost half of the answers were correct. A common error was not realising that $[Mg^{2+}]$ was half the value of $[F^-]$.

Question 23

23 A scientist studies the reaction:

J $\rightarrow$ **K**

After 24 minutes there is $\frac{1}{8}$th as much **J** left as at the start.

What is the half-life of the reaction in minutes?

A 4

B 6

C 8

D 12

Your answer ☐ **[1]**

This question was well answered.

Question 24

24 Iodine is much more soluble in hexane than in water.

What is a reason for this?

A Hydrogen bonds between water molecules are stronger than the instantaneous dipole–induced dipole bonds that iodine would form with water.

B I–I bonds are stronger than the hydrogen bonds in water.

C Iodine is an ionic solid that forms ion–dipole bonds with water that are stronger than the hydrogen bonds broken.

D The I–I bonds that are broken by hexane are weaker than the C–C bonds in hexane.

Your answer ☐ **[1]**

The intermolecular forces operating here were well understood. This was less the case in Question 31 (d) (iii).

Question 25

25 At a certain pH, the amino acid glycine exists as:

$NH_2CH_2COO^-$

What is correct about this structure?

A It exists at acid pHs.

B It is a zwitterion.

C It is the conjugate base of NH_2CH_2COOH.

D It will react with NaOH.

Your answer ☐ **[1]**

It was pleasing to see that two thirds of the answers were correct.

Question 26

26 A scientist measures the wavelengths of light from a distant star.

One wavelength measured is 6.56×10^{-11} m.

What is the energy (in J) transferred by a photon at this wavelength?

A 1.45×10^{-52}

B 1.30×10^{-35}

C 3.03×10^{-15}

D 2.61×10^{7}

Your answer ☐ **[1]**

It was good to see clear working here. The majority of answers had converted wavelength to frequency and obtained the correct answer.

Question 27

27 A sample of strontium contains two isotopes, strontium-86 and strontium-88.
The relative atomic mass of the sample is 87.82.

What is the % abundance of the strontium-86 isotope?

A 9%

B 18%

C 90%

D 91%

Your answer ☐ **[1]**

This was well done with many expressions for the abundance correctly solved.

Question 28

28 An organic compound is yellow.

Which statement(s) is/are correct?

1 The compound absorbs blue light.

2 The electron energy levels in the molecule have a separation ΔE so that the frequency given by $\Delta E/h$ is in the visible range.

3 The compound emits yellow light.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

About half the answers were correct but option A, thinking that yellow light was emitted, was also frequently seen.

Question 29

29 A student has high-resolution and low-resolution mass spectra for a gas sample that might be either N_2 or CO.

What would help the student decide which gas was in the sample?

1 The fragmentation pattern at low resolution.

2 The high resolution M^+ value.

3 The low resolution M^+ value.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

This question was well done.

Question 30

30 Which of the following compounds is/are able to form a polymer with $ClOCC_6H_4COCl$?

1 $NH_2CH_2CH_2NH_2$

2 $CH_3CHOHCH_2COOH$

3 $CH_2NH_2CH_2CH_2OH$

A 1, 2 and 3

B Only 1 and 2

C Only 1 and 3

D Only 3

Your answer ☐ **[1]**

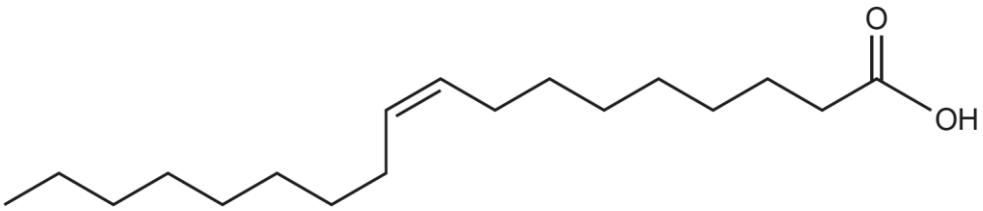
This was quite a complex question but despite this more than half of the answers were correct.

Section B overview

Candidates overall showed reasonable recall of chemical information although those not scoring so well-found stating reagents and conditions required for organic reactions challenging. Candidates' ability to explain chemistry or apply understanding naturally proved more challenging but many were able to show good understanding relating to how buffers work, shapes of molecules, the role of intermolecular forces in determining melting point and provided accurate reaction mechanisms. Many candidates laid calculations out clearly aiding the award of marks, although drawing apparatus clearly needs further work by centres. Many candidates struggled to identify command words in questions, particularly with respect to the Level of Response questions, where lack of a final structure in Question 32 (d) or equations for reactions in Question 35 (b) limited marks. The representation of molecules proved successful for most candidates and the overall degree of presentation/ legibility of responses showed continuing signs of improvement from previous years.

Question 31 (a)

31 Oleic acid, $C_{17}H_{33}COOH$, is an unsaturated carboxylic acid found in many vegetable oils.



(a) Oleic acid contains a carboxylic acid group, COOH.

Name and explain the shape around the carbon atom in the carboxylic acid group.

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..... **[3]**

This was generally well known but the lack of clarity in the answer often meant marks were lost. Areas of electron density were often described as bonding pairs, and a significant number of answers did not use the word electron at all, limiting the mark available.

Question 31 (b) (i)

(b)

(i) The double bond in oleic acid consists of a σ bond and a π bond.

Describe how π bonds are formed.

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

This is a question that has not been asked before and was found difficult. p orbitals were not always mentioned and the location of the π bond above and below the σ bond or lateral overlap of p orbitals was not often seen.

Question 31 (b) (ii)

(ii) The presence of the double bond in oleic acid can be shown by its reaction with bromine.

Draw the mechanism of the reaction of **ethene** with bromine.

Show curly arrows, partial and full charges and the product.

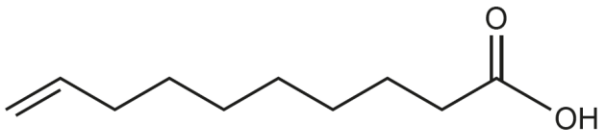
[3]

This was well answered with more than half scoring full marks. Among the others, marks were lost if the partial charges on the bromine atoms were absent or reversed, or if the arrow did not come from the - charge or lone pair in step 2. Occasional answers used propene or hydrogen bromide in error.

Question 31 (b) (iii)

(iii) Oleic acid is a *cis* isomer.

Complete the diagram below to show the skeletal formula of the *trans* isomer of oleic acid.



[1]

Most of the answers were fully correct and trans, but some had the incorrect number of carbon atoms. Candidates are encouraged to check they have depicted the correct number of carbon atoms in longer-chained structures as this is an easy mistake to make.

Question 31 (c) (i)

(c) Oleic acid reacts with hydrogen in the presence of a nickel catalyst.

(i) Give the **skeletal** formula of the product of this hydrogenation.

[1]

This was generally well done, but once again carefully checking the number of carbon atoms is advised and some had not given the hydrogenated product.

Question 31 (c) (ii)

(ii) In this hydrogenation reaction, nickel is acting as a heterogeneous catalyst.

Explain how a heterogeneous catalyst lowers the activation enthalpy of a reaction.

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..... **[3]**

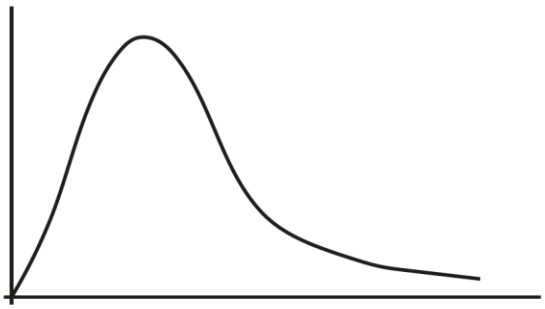
There were a significant number of high scoring answers, but it is advised that candidates should note the 'how' in the question. They needed to explain the mechanism by which a heterogeneous catalyst works and avoid statements on what a catalyst did, which was information provided in the question stem.

Question 31 (c) (iii)

(iii) Catalysis can be explained using a Boltzmann distribution.

Use the diagram to explain how a catalyst speeds up a reaction.

Label the diagram and write on the lines below.



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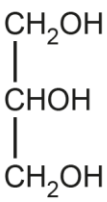
..... **[3]**

Few candidates scored the third marking point, referring to the proportion of molecules with enough energy to react, rather than relating it to the area under the curve. In some answers, two curves were drawn, confusing the effect of temperature. Others did not have the correct quantities labelled on the axes. Better understanding of what the distribution represents would help to yield better explanations.

Question 31 (d) (i)

(d) Oleic acid and glycerol (propane-1,2,3-triol) react together to form a triglyceride oil.



Glycerol

(i) State the **type** of reaction that occurs between oleic acid and glycerol.

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

This was well answered.

Question 31 (d) (ii)

(ii) Write a balanced equation for the reaction between oleic acid, $C_{17}H_{33}COOH$, and glycerol.

[2]

Most candidates scored at least 1 mark here. Insufficient clarity on the structure of the triglyceride sometimes resulted in the loss of a mark as did omitting the 3 molecules of water produced.

Question 31 (d) (iii)

(iii) Hydrogenation reactions convert vegetable oils into solid fats.
Fats have higher melting points than oils because fats have more flexible molecules.

Explain in terms of intermolecular forces why fats have higher melting points than oils.

.....

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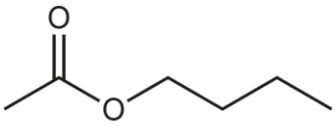
..... **[3]**

There was a roughly even distribution between 0,1, 2 and 3 marks here. In many cases the fact that fats could pack more closely was understood but the nature of the intermolecular forces in each case was unclear and the energy needed to overcome them was not always explicit.

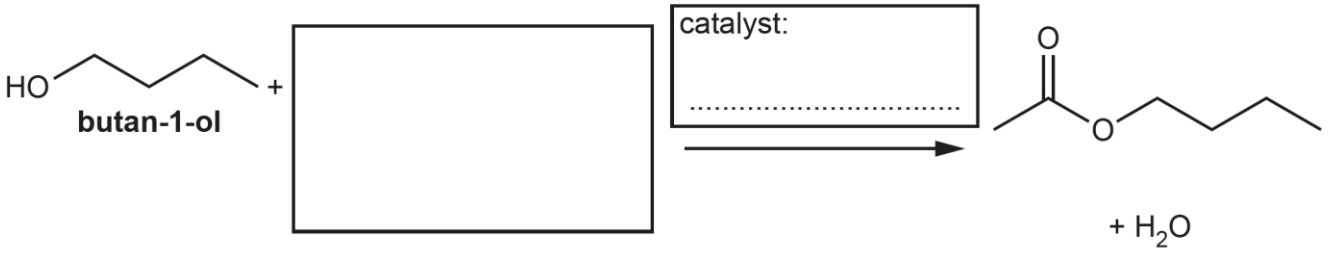
Question 32 (a) (i)

32 Butyl ethanoate is an ester found in apples.



(a) Butyl ethanoate can be made by reacting butan-1-ol with a carboxylic acid.

(i) Complete the equation below by drawing the **skeletal** formula of a suitable carboxylic acid and suggesting a suitable catalyst.



[2]

The skeletal formula was generally well done, but in a number of cases the catalyst was not known, acidified dichromate being given in a number of cases. In others, the incorrect acid or not specifying concentrated sulfuric acid caused the second mark not to be gained.

Question 32 (a) (ii)

(ii) After synthesis, the ester can be separated from the reaction mixture by distillation. Draw a labelled diagram to show how equipment is set up for distillation.

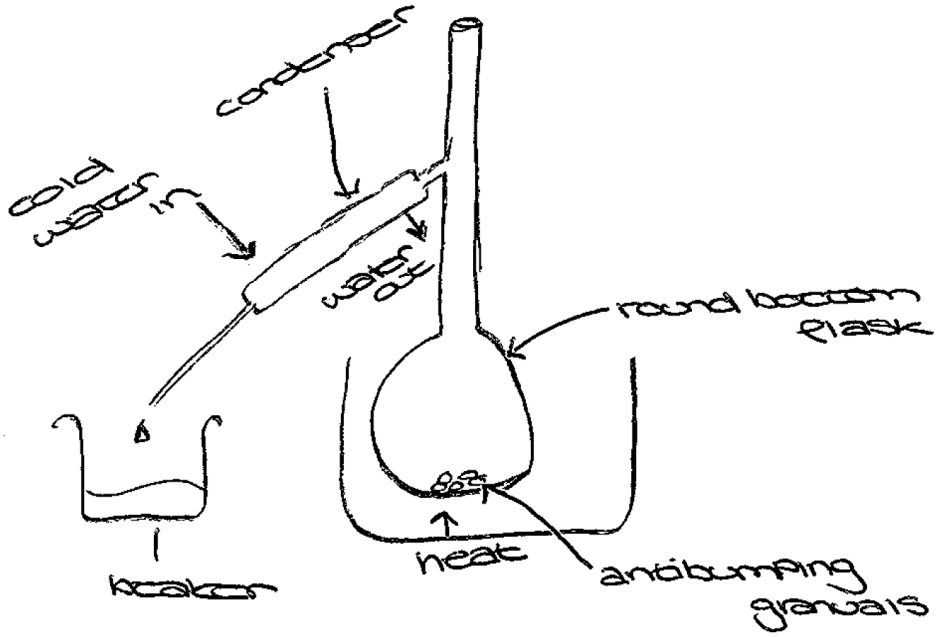
[3]

This question proved difficult with almost half the answers scoring no marks at all and only a very small proportion scoring full marks.

Assessment for learning

Centres should practice drawing diagrams for practical techniques. Some confusion was seen between refluxing and distillation and in many cases the apparatus as drawn would not be safe, allowing vapours out near a naked flame.

Exemplar 1



[3]

This is one of the better examples we saw; it looks even though there is a heating jacket or similar for heating, which is what we wanted as direct heating with a Bunsen flame is not appropriate for volatile and flammable esters. In many cases, as here, there was insufficient detail in the condenser arrangement, or the water was the wrong way round. In many cases the top was open, and no thermometer was included.

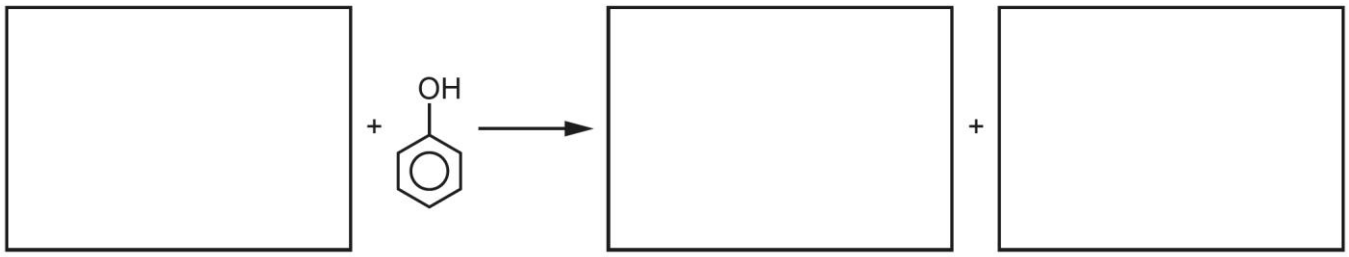
Question 32 (b) (i)

(b) Phenols share some of their reactions with alcohols.

(i) They react with acid anhydrides to form esters.

Ethanoic anhydride reacts with phenol to form an ester and one other product.

Show the structures of these compounds in the boxes below



ethanoic anhydride **phenol** **ester** **other product**

[3]

The majority of marks were either 3 or 0, depending on whether the structure of ethanoic anhydride was known or not. Error was carried forward for incorrect anhydrides such as methanoic or propanoic.

Question 32 (b) (ii)

(ii) Sodium phenoxide can be made from phenol.

Explain whether sodium carbonate or sodium hydroxide should be used for this synthesis.

.....

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

The command word 'explain' proved difficult in many cases resulting in this being a low scoring question. Most answers simply stated that phenol didn't react with sodium carbonate without the explanation that phenol was too weak an acid to react with it and therefore the stronger base, sodium hydroxide was needed.

Question 32 (c) (i)

(c) Butan-1-ol can be dehydrated to make but-1-ene.

(i) Give suitable conditions for this reaction.

.....

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

Candidates did not always recall the correct conditions, despite there being three acceptable alternatives.

Question 32 (c) (ii)

(ii) State the **type** of reaction that occurs during the dehydration of an alcohol.

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

Many instances of condensation or dehydrogenation were given here.

Question 32 (c) (iii)

(iii) The dehydration of butan-2-ol also makes but-1-ene.

Suggest, with reasons, whether butan-1-ol or butan-2-ol would be better for making but-1-ene.

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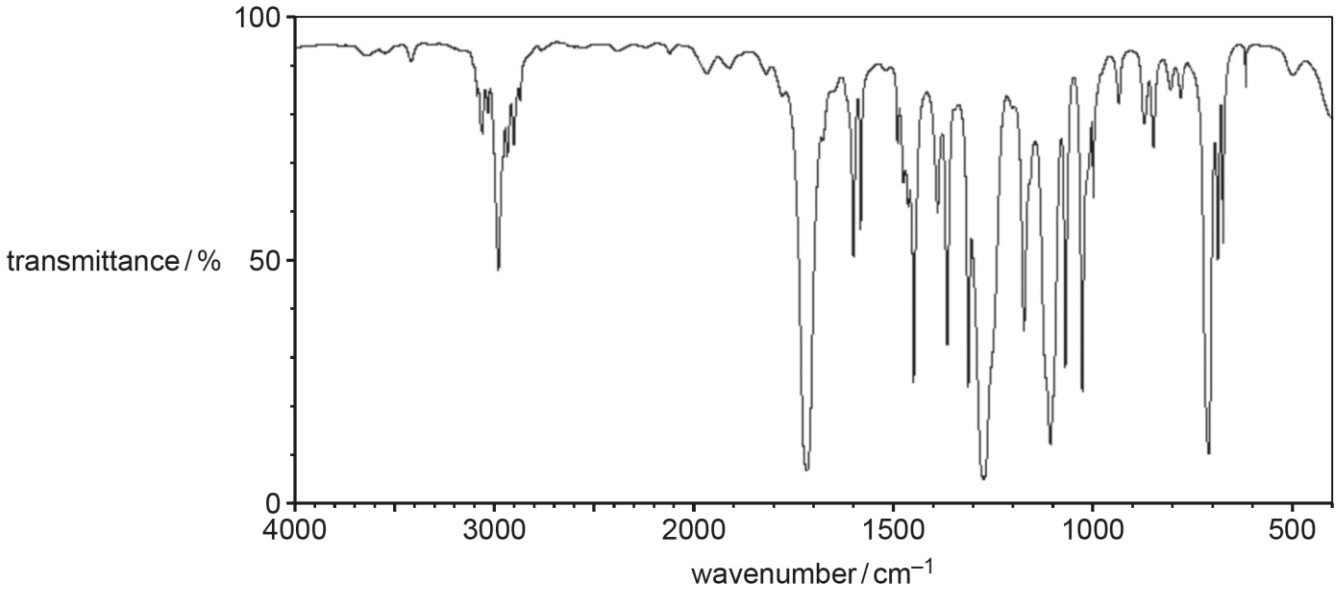
..... **[3]**

Some answers got sidetracked on the relative reactivity of primary and secondary alcohols. A number of answers understood that butan-1-ol would only give but-1-ene but butan-2-ol would give but-2-ene as well. The clarity of expression meant that the marks were not always scored. Few considered the yield implications, separation issues or reduced atom economy if butan-2-ol was used.

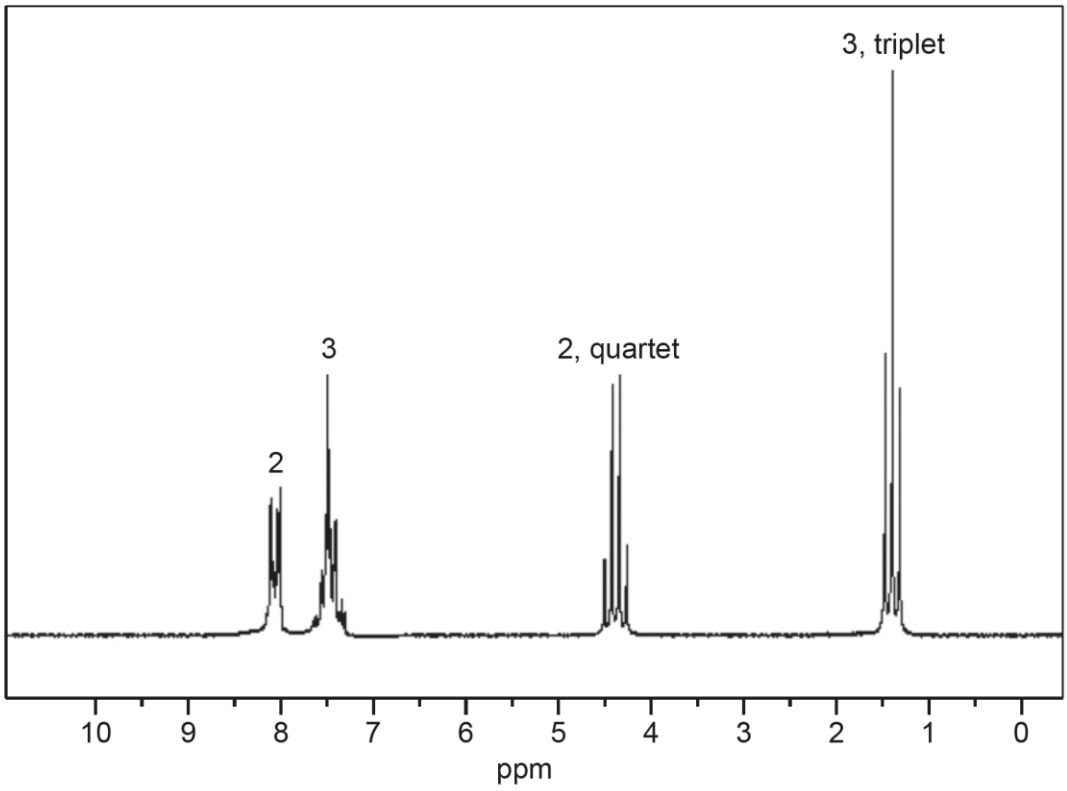
Question 32 (d)*

(d)* A scientist extracts an aromatic compound from cherries, which contains 72.0% C, 6.7% H and 21.3% O by mass. The scientist analyses the compound by IR and ^{1}H NMR spectroscopy.

IR spectrum



^{1}H NMR spectrum



The numbers by the peaks are the relative peak areas and the splitting is shown where appropriate.

Use the percentage composition data and the spectra to identify the aromatic compound, showing your reasoning.

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.....

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

There were many good aspects in the answers to this question. Many answers used the composition data, but some struggled to arrive at a whole number ratio for the elements. The interpretation of the IR spectrum was sound, and it was pleasing to see good discussion of the splitting pattern in the NMR spectrum. In many instances piecing together the evidence to get an aromatic ester proved challenging.

Question 33 (a)

33 Ammonium nitrate, NH_4NO_3, is a compound that can be used in cold packs.

A student wants to measure the cooling effect of ammonium nitrate.

The student carries out an experiment using the method below.

The student:

- Measures 100 cm^3 of deionised water in a measuring cylinder.
- Pours the water into a polystyrene cup.
- Records the mass of an empty weighing bottle.
- Adds about 10 g of ammonium nitrate to the weighing bottle.
- Records the mass of the weighing bottle containing the ammonium nitrate.
- Subtracts the mass of the empty weighing bottle.
- Records the initial temperature of the water and adds the ammonium nitrate.
- Stirs the mixture and records the minimum temperature of the water.

(a) The student uses an incorrect method for measuring the mass of ammonium nitrate.

Explain what the student should do to correctly measure the mass of ammonium nitrate.

.....

.....

.....

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

This was another instance, like the distillation, where practical techniques were found challenging and it was clear that candidates had not recalled the need to weigh by difference as they simply tared the balance before adding ammonium nitrate.

Question 33 (b) (i)

(b) The student corrects this error and obtains the following results:

Mass of ammonium nitrate	10.10 g
Initial temperature of water	20.5 °C
Minimum temperature of water	14.0 °C

(i) Another student says this method only gives a small temperature change and this will cause a large percentage uncertainty.
The thermometer has an uncertainty of 0.5 °C.

Calculate the percentage uncertainty in the temperature **change**.

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

About half the answers did not gain the mark as they did not account for the fact that the thermometer was used twice, therefore doubling the percentage uncertainty.

Question 33 (b) (ii)

(ii) Suggest **one** change the student could make to the method (apart from changing the thermometer) to reduce this percentage uncertainty.

Explain why this change will reduce the percentage uncertainty.

.....

.....

.....

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

Some answers suggested using a thermometer with higher resolution, despite the question excluding this possibility. Other answers suggested using a lid or better stirring.

More than a third of candidates scored both marks, understanding that a larger temperature change would reduce the percentage uncertainty and appreciating that a larger mass of ammonium nitrate or smaller volume of water could achieve this. Sadly, some answers were contradictory, e.g. 'larger mass of solid and larger volume of water', but the mark for a larger temperature change could still be scored.

Question 33 (c)

(c) Use the student's results to calculate a value for the enthalpy change of solution, $\Delta_{solution}H$, for ammonium nitrate, NH_4NO_3, in $kJ\,mol^{-1}$.

Assume that the solution weighs 110.10 g and has a specific heat capacity the same as that of water.

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

$\Delta_{solution}H$ = ...$kJ\,mol^{-1}$ **[4]**

There was a lot to remember in this question so scores of 4 were comparatively rare but 3 marks were frequently obtained. The sign of Δ*H* was most frequently omitted. Significant figures were also assessed in this question.

Assessment for learning

It is very important to read the question carefully so that the information is used appropriately, the correct masses for the solid and solution for example. The temperature was given in Kelvin in some cases and in all Δ*H* questions a sign should be given as a matter of course.

Exemplar 2

$q = m_{water} \times C \times \Delta T$

$q = 100 \times 4.18 \times 16.5$

$= 6897\ J$

$= 6.9\ kJ$

$= \frac{6.9}{1.38} = 5$

n of NH_4NO_3 $= \frac{110.1}{14+4+14+48} = 1.38$ moles

$\Delta_{solution}H$ = ...5.....$kJ\,mol^{-1}$ **[4]**

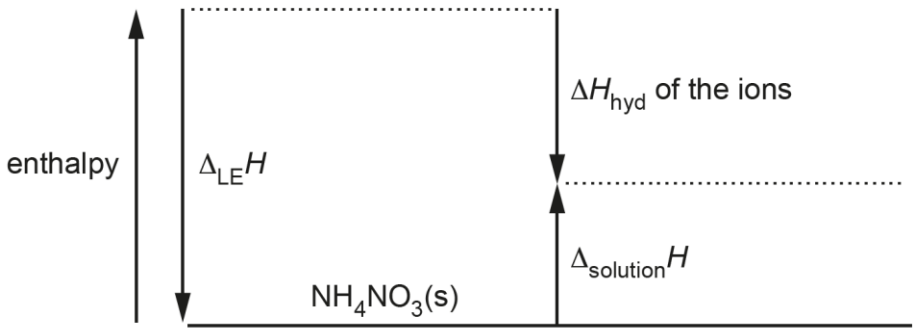
In this example 100 g has been used as the mass of the solution despite the question saying it is 110.10, and the mass of ammonium nitrate was taken as 110.10 despite the fact that it was given as 10.10 in part (b) of the question. Both of these errors were quite a common occurrence. The temperature change has been incorrectly calculated so neither of the first two marking points have been scored. They have nevertheless used their numbers in the correct way for the third marking point. The significant figures and lack of a sign preclude the award of marking point 4.

Question 33 (d) (i)

(d) The student looks up data and uses an enthalpy cycle to work out a value for $\Delta_{solution}H$.

(i) NH_4NO_3 is dissolved in water.

Complete the enthalpy cycle for this by adding ions and their state symbols on the dotted lines.



[2]

Most candidates scored 2 marks here; occasional incorrect state symbols or errors in the charge were the cause of not gaining marks.

Question 33 (d) (ii)

(ii) Use the data in the table below to calculate the theoretical value for the enthalpy change of solution of NH_4NO_3.

Enthalpy change	Value / kJ mol^{-1}
$\Delta_{hyd}H$ NH_4^+	–307
$\Delta_{hyd}H$ NO_3^-	–314
$\Delta_{LE}H$ NH_4NO_3	–646

$\Delta_{solution}H$ = ... kJ mol^{-1} **[1]**

Occasionally the sign was given as negative in this question.

Question 33 (e)

(e) The lattice enthalpy of sodium nitrate, $NaNO_3$, is $-755\,kJ\,mol^{-1}$.

Suggest why the lattice enthalpy for NH_4NO_3 is less exothermic than the lattice enthalpy for $NaNO_3$.

.....

.....

.....

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

Although about a third of candidates gained at least 1 mark, there were a lot of responses with no marks at all.

Misconception

Very few candidates addressed the charge density of Na^+ compared with NH_4^+, instead thinking of the charge density of the whole compound. Others did not consider ions, and the charge density of a neutral atom is a contradiction. Others discussed the difference in terms of ammonium nitrate being covalent and sodium nitrate ionic and others considered the strength of ion dipole interactions with water when dissolving was not the focus of this question part.

Question 34 (a) (i)

34 This question is about acids and buffers.

(a) Lateral flow tests can be used to test for viral infections in people.

These tests involve a sample being taken from the inside of a person's nose. A phosphate buffer is then added to this sample.

One type of lateral flow test uses phosphate buffers with the following reaction:

$$H_2PO_4^- \rightleftharpoons HPO_4^{2-} + H^+$$

(i) Explain why this equation shows that $H_2PO_4^-$ is a **weak** acid.

.....

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

Although many answers showed knowledge of what a weak acid was in general, they did not refer to the equation in their answer.

Question 34 (a) (ii)

(ii) Write the formula of the conjugate acid of $H_2PO_4^-$.

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

This proved difficult; H^+ was a frequently seen answer, and some correct formulae had unfortunately been given a negative charge.

Question 34 (a) (iii)

(iii) Explain how this buffer works.

.....

.....

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.....

.....

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

The most common score on this question was 3. Many of the answers gave a generic description of how a buffer solution works in terms of HA and A^-, which was acceptable. The point most often omitted was that the concentrations of the acid and conjugate base were high.

Question 34 (a) (iv)

(iv) This type of lateral flow test only works at a pH around 7.4.

A scientist wants to make a buffer of pH 7.40, using NaH_2PO_4 and Na_2HPO_4.

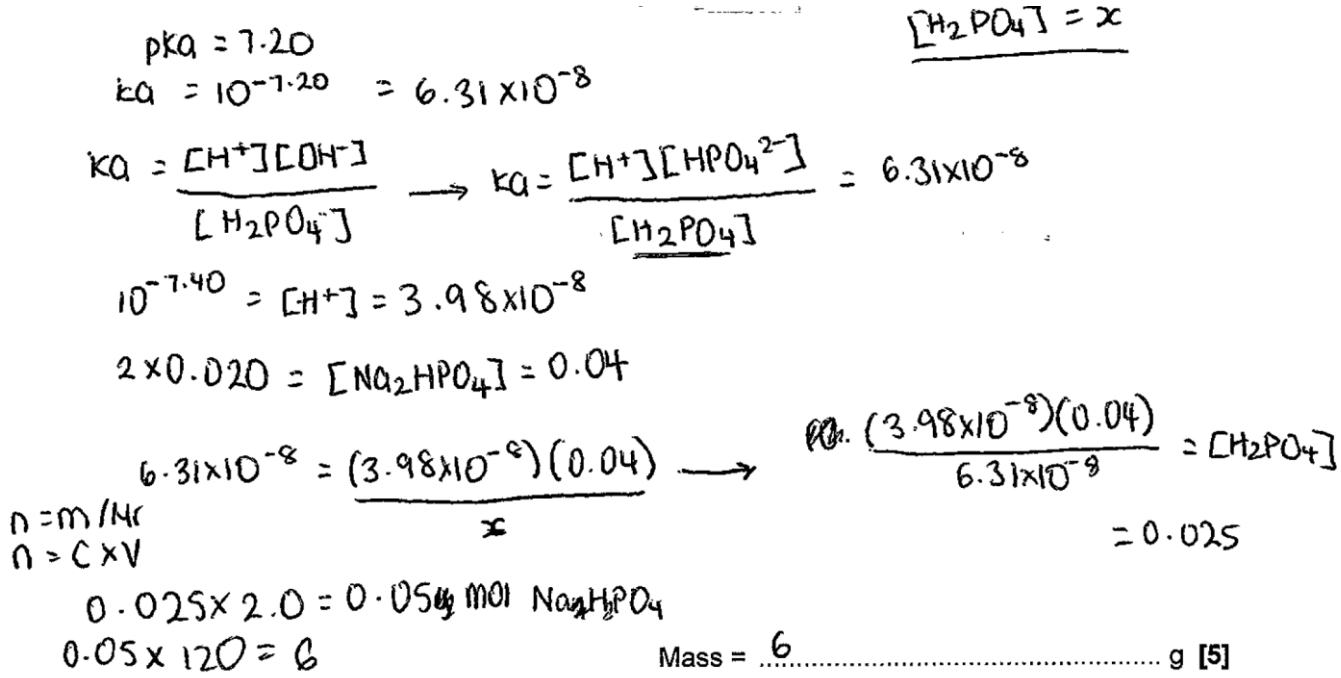
$H_2PO_4^- \rightleftharpoons HPO_4^{2-} + H^+$ $\quad pK_a = 7.20$

Calculate the mass of NaH_2PO_4 that must be added to $2.0\,dm^3$ of $0.020\,mol\,dm^{-3}$ Na_2HPO_4 to make a buffer with pH 7.40.

Assume that the total volume of the solution stays at $2.0\,dm^3$.

Mass = ... g **[5]**

Exemplar 3



This answer was clearly set out so marks for correct steps could easily be given. The calculation of $[H^+]$ and K_a are correct. Unfortunately, the incorrect value for $[Na_2HPO_4]$ has been used so the expression and its evaluation are not correct, marking points 3 and 4. The answer has been multiplied by 2 and 120, the M_r of NaH_2PO_4, so marking point 5 has been given.

Other common errors were an incorrect M_r or incorrect rearrangement of the expression so that [acid] and [salt] were reversed. A large number of answers got marking points 1 and 2.

Question 34 (b) (i)

(b) Hydrochloric acid is a strong acid.

(i) Complete the equation for the reaction of hydrochloric acid with water.

$$HCl + H_2O \rightarrow$$

[1]

Only about half the answers to this question were correct. Common incorrect answers included ignoring or carrying forward the water and giving H^+ and Cl^- or splitting off all the hydrogen as 3 H^+ and ClO^-.

Question 34 (b) (ii)

(ii) Calculate the pH of 0.050 mol dm^{-3} hydrochloric acid.

pH = ... **[1]**

Almost all the answers were correct.

Question 35 (a) (i)

35 This question is about halides.

(a) Iodide ions react with BrO_3^- ions in acid solution to form iodine, water and bromide ions.

(i) Give the systematic name of the BrO_3^- ion.

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

The systematic naming of the oxyanions of halogens was not well known, with only a third of answers gaining the mark. Many answers omitted the oxidation state; others gave bromine trioxide.

Question 35 (a) (ii)

(ii) Write a balanced ionic equation for the reaction.

[2]

Balancing this equation proved very difficult with very few answers getting both marks. 1 mark was available for the correct species in an unbalanced or incorrectly balanced equation. Balancing this type of redox equation is something that needs more work in the future.

Question 35 (a) (iii)

(iii) A chemist measures the rate constant for this reaction at two temperatures.
The chemist's results are shown in the table.

	***T*/K**	**ln *k***
Temperature 1	313	4.777
Temperature 2	296	3.645

The expression below can be derived from the Arrhenius equation.

$$\ln k_1 - \ln k_2 = \frac{E_a}{R}(1/T_2 - 1/T_1)$$

Use this expression and the chemist's results to calculate a value for the activation enthalpy, E_a, in $kJ\,mol^{-1}$.

E_a = ... $kJ\,mol^{-1}$ **[3]**

Almost half the answers scored full marks. Many answers that did not gain marks because they didn't use the information correctly. Taking the ln of ln *k* was a common error as was using T instead of 1/T.

Question 35 (b)*

(b)* A student wishes to identify three unlabelled salts.

The student has been told:
- the cations in the three salts are ammonium, copper(II) and iron(II) respectively.
- the anions present (one per salt) are chloride, bromide and iodide.

Describe the chemical tests that the student could carry out to identify the salts.

Include the observations from positive tests and equations for the reactions that occur.

.....

.....

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.....

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

The full range of marks were given here, although 2 was the most common, followed by 4. Not including all the equations limited the marks for some; the equation for the reaction of ammonium ions with sodium hydroxide was most often missed and the observations for this reaction sometimes omitted warming. Good answers included the use of dilute and concentrated ammonia to distinguish between the silver halide precipitates.

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