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Examiners' report

CHEMISTRY B (SALTERS)

H433
For first teaching in 2015

H433/01 Summer 2019 series

Version 1

www.ocr.org.uk/science

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. 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 can be downloaded from OCR.

Paper 1 series overview

H433/01 is one of three examination components for the A Level examination for GCE Chemistry B Salters. This component covers knowledge and understanding across the full range of the specification in context-based questions, including structured and multiple-choice questions. There are a certain proportion of extended answer questions, practical applications and questions requiring mathematical skills. To do well on this paper, candidates need to be able to apply their knowledge and understanding in a range of contexts, familiar and unfamiliar, practical and theoretical. Chemical literacy is a greater feature of H433/02 and questions set in a practical context are a greater feature of Paper H433/03.

Candidates who did well generally	***Candidates who did less well***
• Were able to complete calculations and convert units successfully, Q 33(d), 34(e)(ii). • Could explain the effect of temperature on total entropy, Q 31(d)(ii). • Could synthesise a clear account of the effect of temperature and pressure on a reversible reaction. • Could apply ideas of enzymes and inhibitors to particular molecules.	• Had trouble converting units. • Confused $\Delta_{sys}S$ and $\Delta_{surr}S$. • Could apply Le Chatelier's Principle to reversible reactions for temperature and pressure but did not explain rate or the effect of catalyst fully. • Could explain enzymes and inhibitors generally but did not apply the ideas to the molecules given in Q 32(d).

Note

From this series students have been provided with a fixed number of answer lines and an additional answer space. The additional answer space will be clearly labelled as additional, and is only to be used when required. Teachers are encouraged to keep reminding students about the importance of conciseness in their answers. Please follow this link to our SIU (https://www.ocr.org.uk/administration/support-and-tools/siu/alevel-science-538595/)

Section A overview

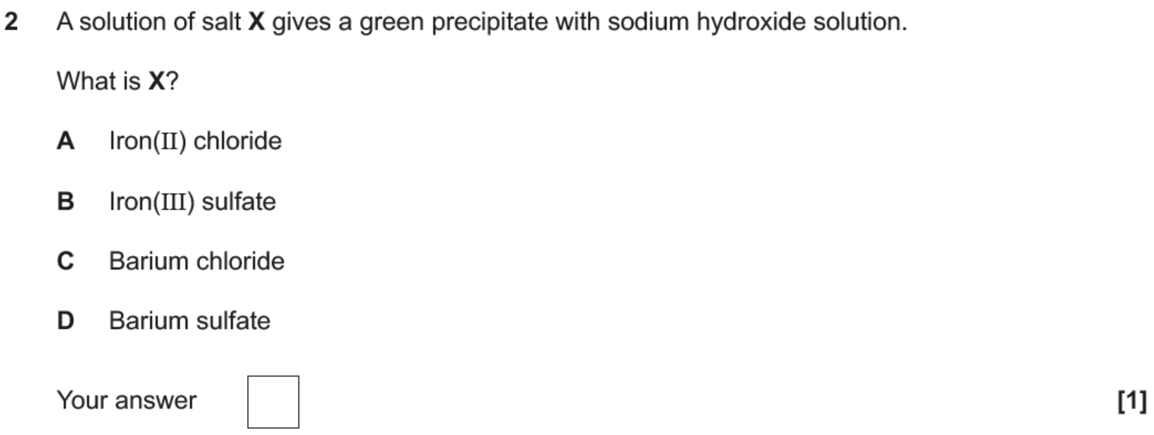
The multiple-choice section allows a wide range of topics to be covered to complement the topics in Section B. The level of demand of the questions was intended to increase as candidates progressed through the section.

There was clear evidence of candidates using the white space around the question for working and this shows good practice as it is quicker to work out the answer and then look for it in the options provided, rather than go through each option.

This section was generally well done and improvements in standards noted last year were seen again this time. There were a significant number of candidates with more than 20 correct answers. Timing still causes difficulties in some cases and there were occasionally some questions not attempted, possibly because the structured questions were done first and time was short.

Most successfully answered questions	***Least successfully answered questions***
1, 4, 5, 6, 7, 16, 23	17, 21, 24, 25, 28,

Question 2



2 A solution of salt **X** gives a green precipitate with sodium hydroxide solution.

What is **X**?

A Iron(II) chloride

B Iron(III) sulfate

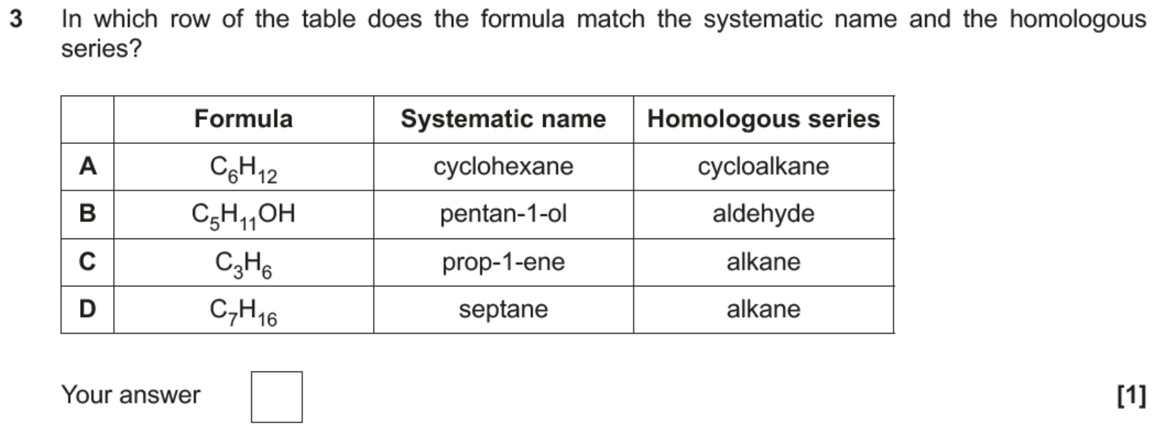
C Barium chloride

D Barium sulfate

Your answer ☐ **[1]**

This was also very well done. The best answers had identified Fe^{2+} in the stem of the question before looking at the suggestions for X. A few were distracted by the apple green flame colour of barium.

Question 3



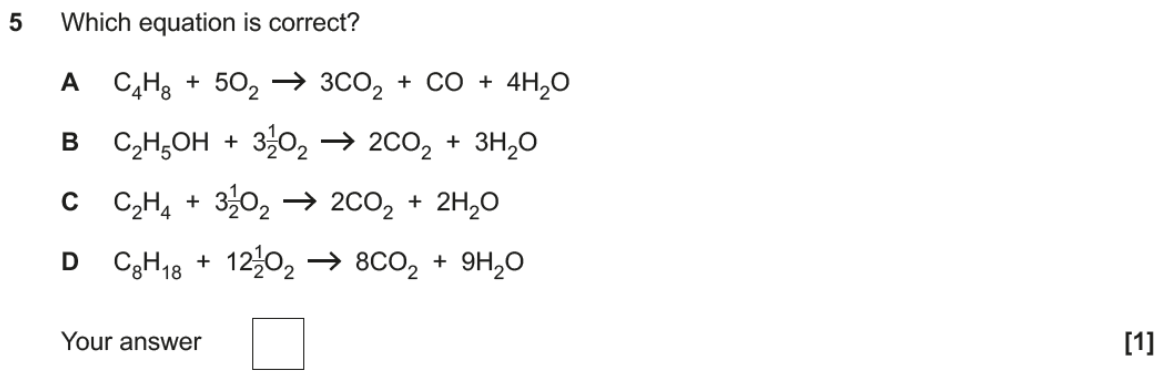
3 In which row of the table does the formula match the systematic name and the homologous series?

	Formula	Systematic name	Homologous series
A	C_6H_{12}	cyclohexane	cycloalkane
B	$C_5H_{11}OH$	pentan-1-ol	aldehyde
C	C_3H_6	prop-1-ene	alkane
D	C_7H_{16}	septane	alkane

Your answer ☐ **[1]**

This was a testing question and most candidates correctly identified A as the correct answer, although a significant number chose D as it fitted the general formula for alkanes but had the incorrect name.

Question 5



5 Which equation is correct?

A $C_4H_8 + 5O_2 \rightarrow 3CO_2 + CO + 4H_2O$

B $C_2H_5OH + 3\frac{1}{2}O_2 \rightarrow 2CO_2 + 3H_2O$

C $C_2H_4 + 3\frac{1}{2}O_2 \rightarrow 2CO_2 + 2H_2O$

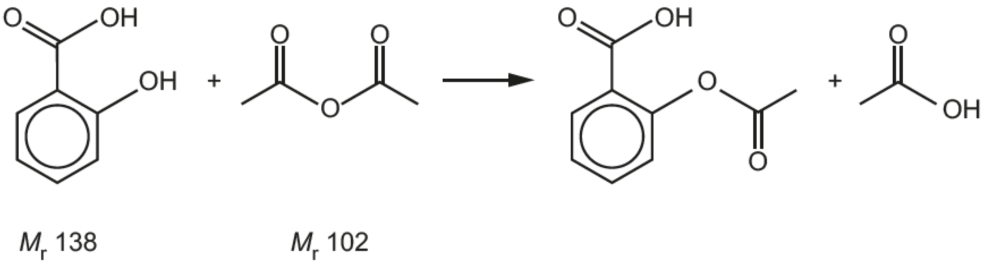
D $C_8H_{18} + 12\frac{1}{2}O_2 \rightarrow 8CO_2 + 9H_2O$

Your answer ☐ **[1]**

There was clear evidence of candidates showing their working above the equations in many answers, leading to a large number of correct answers.

Question 6

6 Aspirin is synthesised by the reaction below.



What is the atom economy of this reaction for producing aspirin?

A 25%

B 43%

C 50%

D 75%

Your answer ☐ **[1]**

This was very well done, candidates understood atom economy well and the provision of the M_r values for the reagents saved the candidates time and reduced the incidence of arithmetical errors, allowing them to concentrate on the key idea. Again, the working was seen in the white space around the question.

Question 7

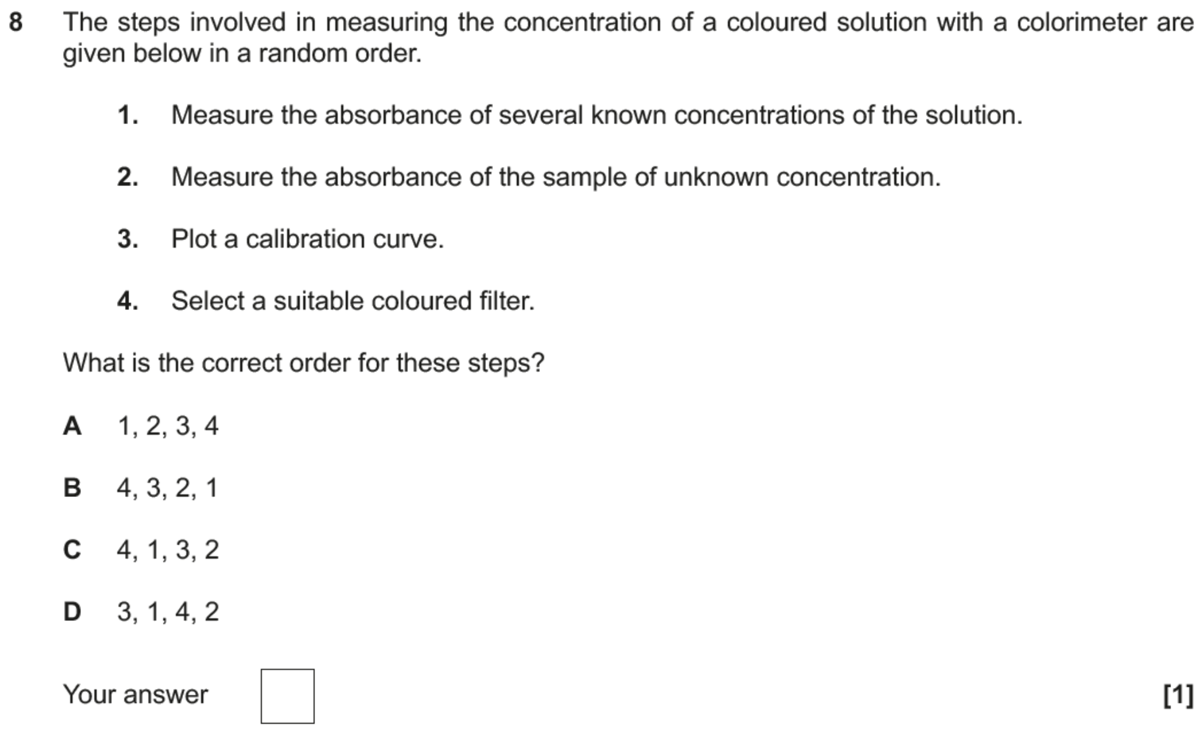
7 Which substance in the table has a giant ionic structure?

Substance	Melting point	Solubility in water	Electrical conductivity
A	High	Insoluble	Conducts when solid or molten
B	High	Insoluble	None
C	Low	Soluble	None
D	High	Soluble	Conducts when molten or in solution

Your answer ☐ **[1]**

This was well done; C was almost never seen, which shows a good understanding of the properties of giant structures. A was the most commonly seen incorrect answer, showing the electrical conductivity information had not been read closely enough.

Question 8



8 The steps involved in measuring the concentration of a coloured solution with a colorimeter are given below in a random order.

1. Measure the absorbance of several known concentrations of the solution.
2. Measure the absorbance of the sample of unknown concentration.
3. Plot a calibration curve.
4. Select a suitable coloured filter.

What is the correct order for these steps?

A 1, 2, 3, 4

B 4, 3, 2, 1

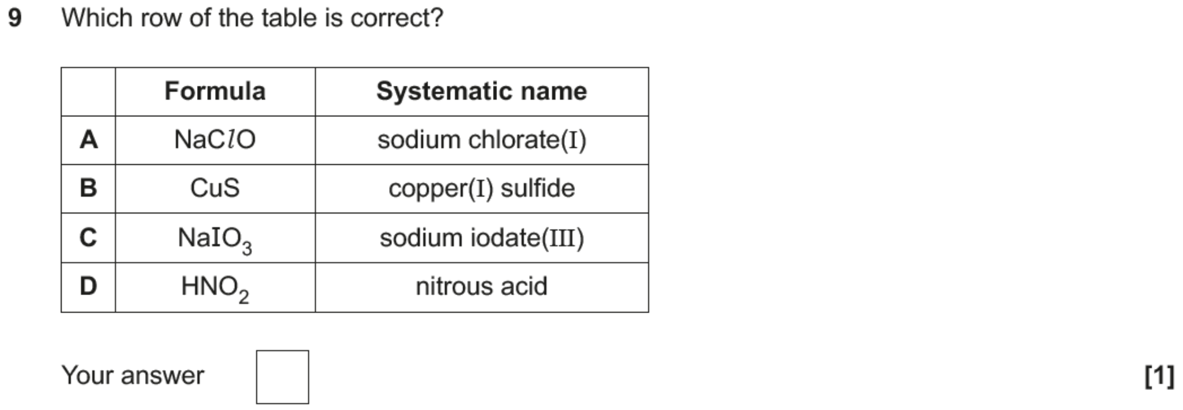
C 4, 1, 3, 2

D 3, 1, 4, 2

Your answer ☐ **[1]**

Candidates had clearly done this practically and could use their experience to narrow the choice down well. Having decided selecting the coloured filter was the first step, they then only had to decide between B and C and the absorbances would be required before plotting the calibration curve, so C was a straightforward choice.

Question 9



9 Which row of the table is correct?

	Formula	**Systematic name**
A	$NaClO$	sodium chlorate(I)
B	CuS	copper(I) sulfide
C	$NaIO_3$	sodium iodate(III)
D	HNO_2	nitrous acid

Your answer ☐ **[1]**

This question proved more challenging as candidates had to work out the oxidation state and match it to the Roman numeral. Many correct answers were seen, but D was the most commonly seen incorrect answer. Candidates selecting this option may not have noted that the question required the correct systematic name.

Question 10

10 The abundance of various gases in the air is shown in the table.

Gas	Abundance (by volume)
N_2	78%
CO_2	3.7×10^{-2}%
CH_4	1.8 ppm

Which statement about the table is correct?

A There is roughly 200 times as much nitrogen as carbon dioxide.

B The abundance of nitrogen is 7.8×10^4 ppm.

C There is roughly 200 times as much CO_2 as CH_4.

D The abundance of CO_2 is 0.0037%.

Your answer ☐ **[1]**

Converting between % and parts per million can be difficult and there was much evidence of working in the correct answers. B was the most frequently seen incorrect answer.

Question 12

12 Which statement about the manufacture of methanol is correct?

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \quad \Delta_r H = -91\,kJ\,mol^{-1}$$

A The best yield of methanol is obtained at high temperature.

B A catalyst increases the yield of methanol.

C The pressure used is limited by the cost of energy and machinery.

D The best yield of methanol is obtained at low pressure.

Your answer ☐ **[1]**

There was evidence of candidates showing working to eliminate the incorrect answers here. A was the most frequently seen incorrect answer; higher temperatures would in fact reduce the yield of the forward reaction as it is exothermic.

Question 13

13 Which reaction does **not** occur?

A $C_6H_5COOH + NaOH \rightarrow C_6H_5COONa + H_2O$

B $C_6H_5OH + NaOH \rightarrow C_6H_5ONa + H_2O$

C $2C_6H_5COOH + CaCO_3 \rightarrow (C_6H_5COO)_2Ca + CO_2 + H_2O$

D $2C_6H_5OH + Na_2CO_3 \rightarrow 2C_6H_5ONa + CO_2 + H_2O$

Your answer ☐ **[1]**

This proved quite a difficult question; B was the answer given by many candidates, as was C, perhaps as equations involving carboxylates of divalent metals look unfamiliar.

Question 14

14 What occurs as Group 2 is descended?

A There is a greater attraction between Group 2 cations and $\mathrm{C}l^{-}$ ions.

B The hydration enthalpies of the Group 2 cations become less negative.

C The charge density of the Group 2 cations increases.

D The lattice enthalpies of the sulfates become more negative.

Your answer ☐ **[1]**

This was another more difficult question. The incorrect answers were equally spread over the other responses, suggesting group 2 trends were not well known by some candidates.

Question 15

15 Which statement about enzyme catalysed reactions is correct?

A The rate determining step is always the formation of an enzyme substrate complex.

B They always speed up at higher temperatures.

C The rate equation can vary depending on the substrate concentration.

D They are zero order with respect to enzyme concentration.

Your answer ☐ **[1]**

This was well answered, some annotations showed candidates eliminating the incorrect answers, such as 'denaturing' opposite B. A was a frequently seen incorrect answer.

Question 16

16 Entropy values for the combustion of propane are shown below.

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

Substance	Entropy / J K^{-1} mol^{-1}
$C_3H_8(g)$	+269.9
$O_2(g)$	+205.0
$CO_2(g)$	+213.6
$H_2O(g)$	+188.7

What is the entropy change for the combustion of propane?

A –829.6

B –72.6

C +100.7

D +1125.7

Your answer ☐ **[1]**

This was very well done with the majority of candidates getting the mark. Again, there was evidence of working at the side. It should have been possible to eliminate the negative values straight away as there were more moles of gas in the products. There were some candidates who confused entropy with enthalpy and selected the negative values as it is an exothermic reaction.

Question 17

17 Excess ammonia solution is added separately to $Cu^{2+}(aq)$ and $Fe^{2+}(aq)$.
The solutions are left in the air.

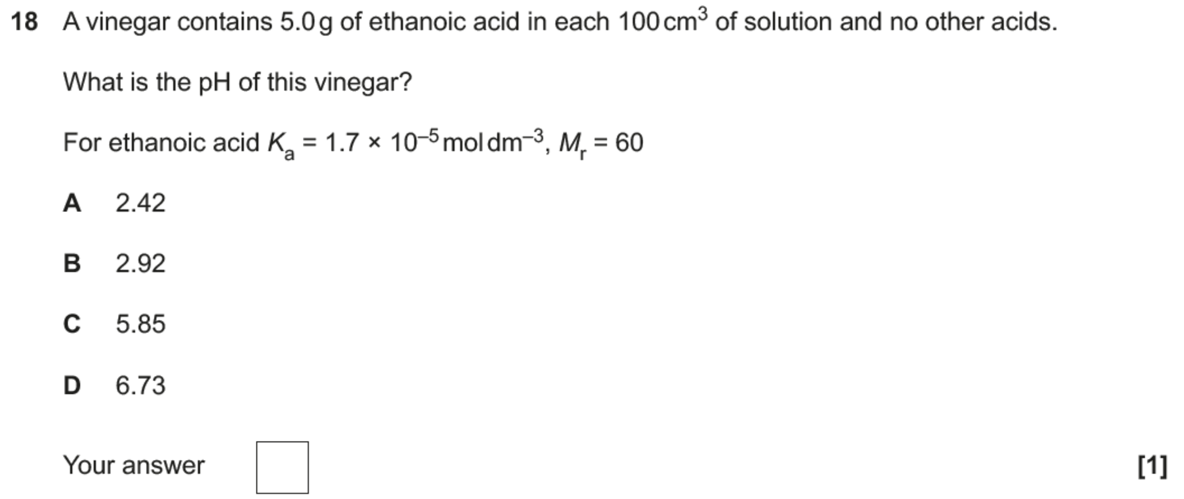
Which row of the table represents the colour changes seen?

	$Cu^{2+}(aq)$	$Fe^{2+}(aq)$
A	Pale blue precipitate → dark blue solution	Dark green precipitate → orange precipitate
B	Green/blue solution → dark blue solution	Green precipitate remaining green
C	Pale blue precipitate → green/blue solution	Orange precipitate → dark green precipitate
D	Pale blue precipitate → dark blue solution	Orange precipitate → dark green precipitate

Your answer ☐ **[1]**

This proved one of the more difficult questions due to the detailed knowledge required. There was evidence of quick elimination of C and D on the basis of the initial colour of the iron precipitate, but many candidates were unaware that iron(II) hydroxide oxidises in the air.

Question 18



18 A vinegar contains 5.0 g of ethanoic acid in each 100 cm^3 of solution and no other acids.

What is the pH of this vinegar?

For ethanoic acid $K_a = 1.7 \times 10^{-5}\ mol\,dm^{-3}$, $M_r = 60$

A 2.42

B 2.92

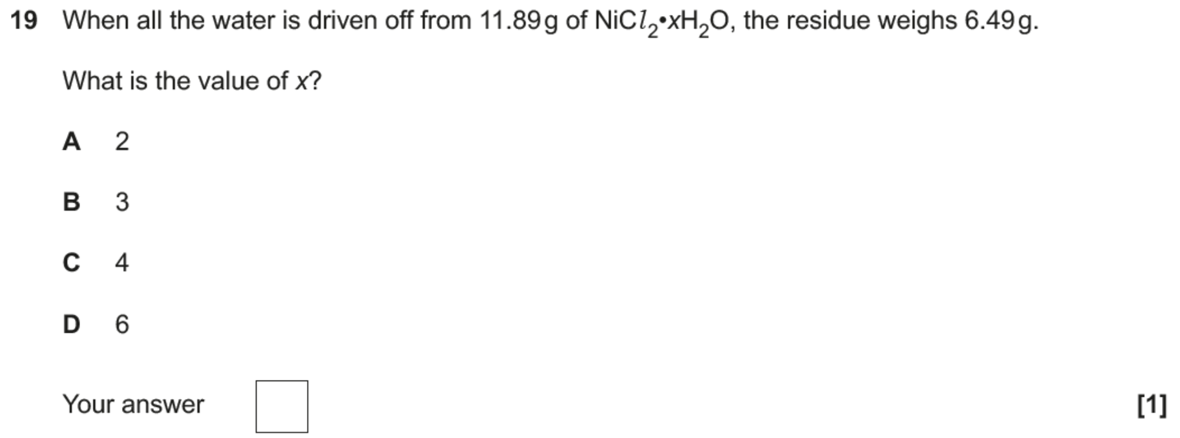
C 5.85

D 6.73

Your answer ☐ **[1]**

This question required close reading to include all the information and candidates generally managed very well. There were some candidates who forgot to find the square root or forgot that the ethanoic acid was dissolved in 100 cm^3 water (or forgot both).

Question 19



19 When all the water is driven off from 11.89 g of $NiCl_2\cdot xH_2O$, the residue weighs 6.49 g.

What is the value of x?

A 2

B 3

C 4

D 6

Your answer ☐ **[1]**

Most candidates worked this out correctly, although some chose B, perhaps as there were 0.3 moles of water.

Question 20

20 A student adds 10 cm^3 of water to 12 cm^3 of a 0.010 mol dm^{-3} solution.

What is the resulting concentration in mol dm^{-3}?

A 0.0045

B 0.0055

C 0.0083

D 0.018

Your answer ☐ **[1]**

This was a difficult question, and many gave the correct answer. B, the answer obtained by multiplying the concentration by 10/12, was often seen.

Question 21

21 Sodium carbonate and hydrochloric acid react as follows.

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$

0.010 mol of Na_2CO_3 is mixed with 0.015 mol of HC*l*.

What volume of CO_2 is formed (in cm^3 at RTP)?

A 180

B 240

C 360

D 720

Your answer ☐ **[1]**

To answer this question correctly required spotting that HC*l* was the limiting reagent and getting the ratio of moles correct. It proved difficult.

Question 22

22 Which statement about the greenhouse effect is correct?

A UV radiation from the Sun increases the vibrational energy of greenhouse gases.

B The Earth absorbs UV radiation and emits IR radiation.

C Greenhouse gases absorb UV radiation from the Earth.

D All gases in the atmosphere contribute to the greenhouse effect.

Your answer ☐ **[1]**

More than half the answers were correct, but a significant number of responses of A and C were seen, focusing on the greenhouse gases but the not noticing that the incorrect type of radiation was indicated.

Question 24

24 The reaction for the formation of sulfur trioxide is shown below.

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

60 cm^3 of sulfur dioxide are mixed with 60 cm^3 of oxygen and allowed to reach equilibrium.

What is a possible equilibrium mixture from this reaction?

	Volume SO_2/cm^3	**Volume O_2/cm^3**	**Volume SO_3/cm^3**
A	0	0	120
B	50	55	10
C	48	54	18
D	20	30	40

Your answer ☐ **[1]**

This question was intended as a stretch and challenge question and on that basis many candidates did well. Candidates realised A was not the answer as it was an equilibrium and many got the ratios of SO_2 and O_2 used, but not always the correct volume of product (C rather than B).

Question 25

25 The solubility product of magnesium hydroxide, $Mg(OH)_2$, is $2.00 \times 10^{-11}\ mol^3\ dm^{-9}$.

What is the solubility of magnesium hydroxide, in $mol\ dm^{-3}$?

A 3.16×10^{-6}

B 4.47×10^{-6}

C 1.71×10^{-4}

D 2.71×10^{-4}

Your answer ☐ **[1]**

This was another stretch and challenge question and proved the most difficult on the paper. Many had obviously learnt a technique for solving this type of question successfully.

Question 26

26 0.125 mol of CuO is reacted with excess sulfuric acid and the solution allowed to crystallise.

What mass of hydrated copper sulfate, $CuSO_4{\bullet}5H_2O$, is formed if the yield is 75.0%?

A 15.0 g

B 20.0 g

C 23.4 g

D 31.2 g

Your answer ☐ **[1]**

This was well done, although in some cases the water of crystallisation was not included and candidates consequently selected option A.

Question 28

28 Which type(s) of radiation can break covalent bonds?

1 IR

2 UV

3 visible

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

This proved difficult and B was often seen, despite visible radiation being between IR and UV on the electromagnetic spectrum.

Question 29

29 Which statement(s) is/are correct about the active site of an enzyme?

1 It is formed by the tertiary structure of a protein.

2 It changes shape at high temperature.

3 It has the same shape as the substrate.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

Many candidates annotated option 3 with the word complementary and chose the correct answer, B. Others selected option A, all three correct.

Question 30

30 Which statement(s) is/are correct about amino acids?

1 They all have a chiral centre.

2 They form buffer solutions in aqueous solution.

3 They form crystalline solids.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

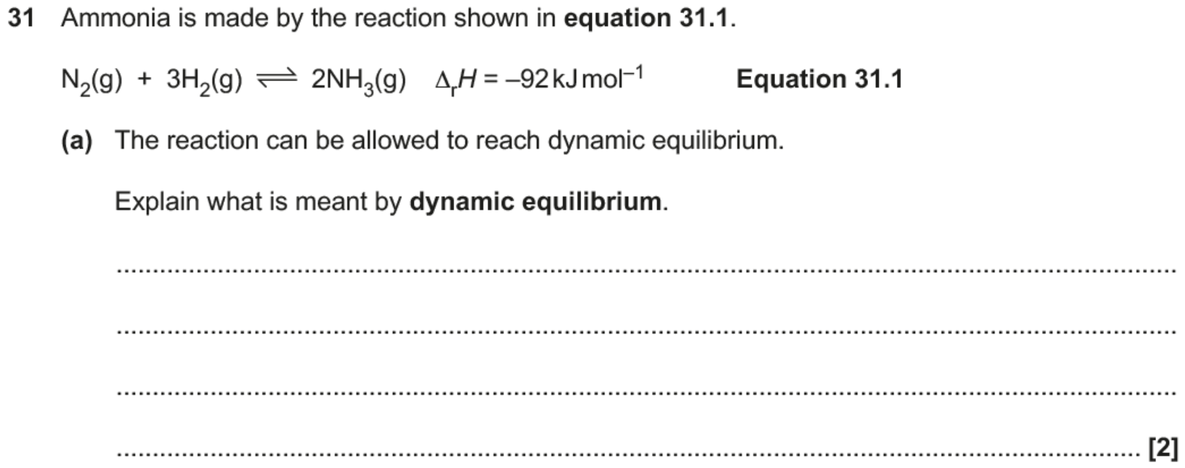
Your answer ☐ **[1]**

Many candidate answers to this question assumed that all amino acids had a chiral centre. While this is true for almost all amino acids, it is not true of glycine.

Section B overview

There was much evidence of careful preparation for this examination by candidates and their teachers. Calculations were well set out and it was possible to follow the stages in the working and credit correct steps, even if the final answer was not correct. Areas where candidates were less successful were practical techniques (Question 34 (e) (iv), 35 (d)), remembering organic syntheses (Question 35), and mechanisms, especially the placing or curly arrows and drawing organic structures. This included missing hydrogen atoms or double bonds or drawing bonds imprecisely so that the bonds connected with the wrong atom.

Question 31 (a)



31 Ammonia is made by the reaction shown in **equation 31.1**.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta_r H = -92\,kJ\,mol^{-1}$ **Equation 31.1**

(a) The reaction can be allowed to reach dynamic equilibrium.

Explain what is meant by **dynamic equilibrium**.

....

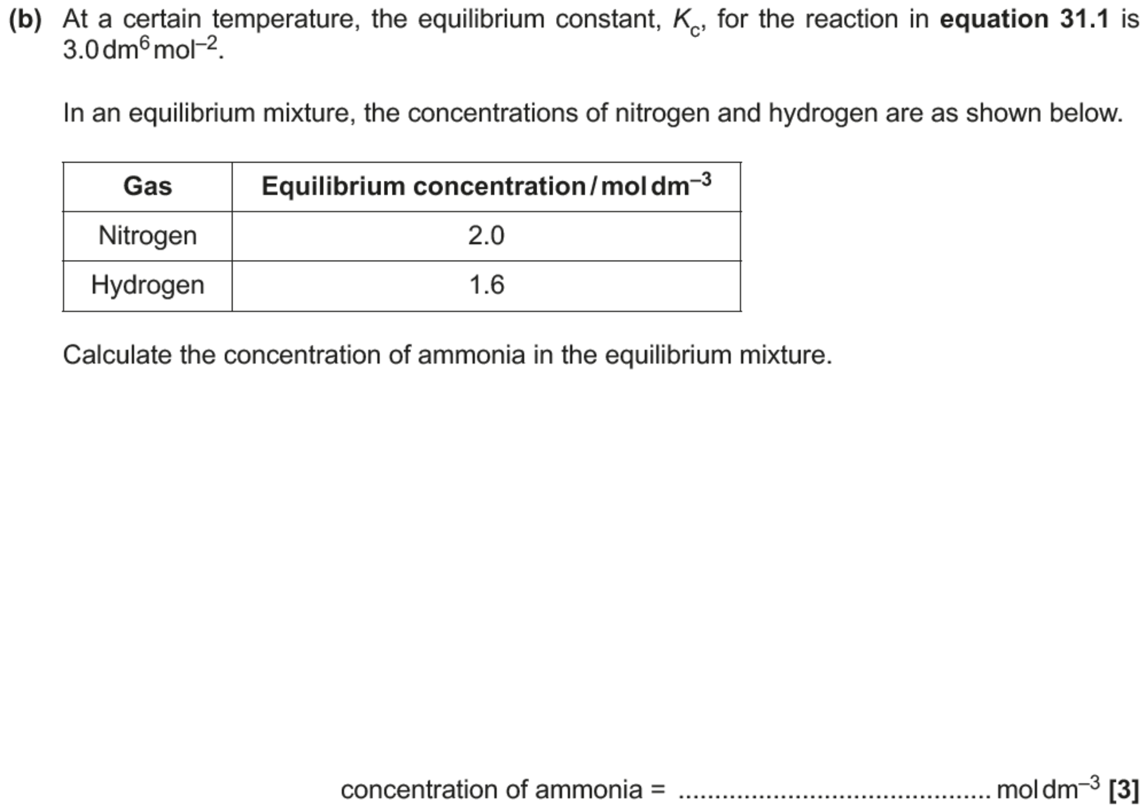
....

....

.... **[2]**

This was generally well answered, especially as they could give two out of three features of dynamic equilibrium. There was some confusion in wording, such as 'The concentration of reactants and products is the same' or 'The forward and reverse reactions occur at a constant rate'.

Question 31 (b)



(b) At a certain temperature, the equilibrium constant, K_c, for the reaction in **equation 31.1** is $3.0\,dm^6\,mol^{-2}$.

In an equilibrium mixture, the concentrations of nitrogen and hydrogen are as shown below.

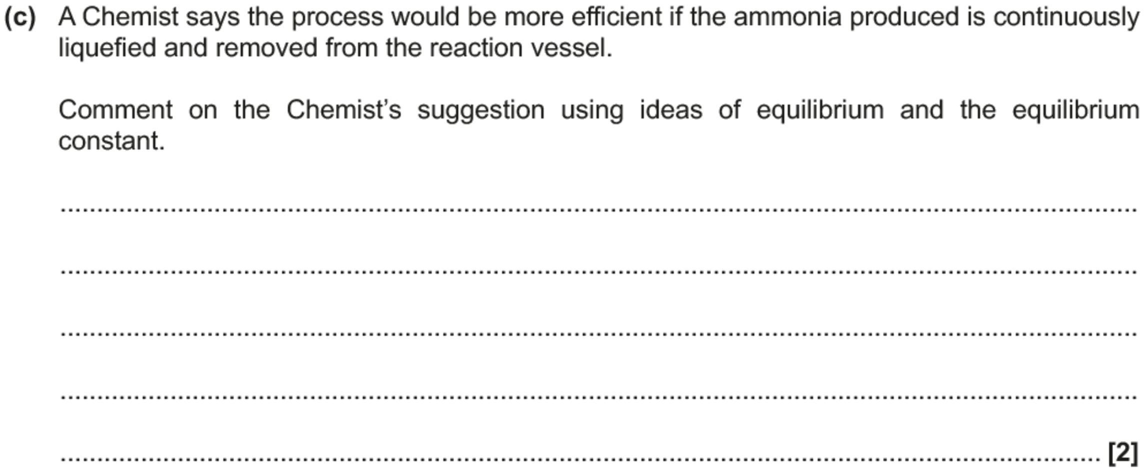
Gas	Equilibrium concentration / $mol\,dm^{-3}$
Nitrogen	2.0
Hydrogen	1.6

Calculate the concentration of ammonia in the equilibrium mixture.

concentration of ammonia = ... $mol\,dm^{-3}$ **[3]**

This was very well answered by most candidates. If fewer than 3 marks were scored it was due to inverting the expression for K_c, miscopying the $[H_2]^3$ so it became $[H_2]^2$ on the next line, or not taking the square root to get $[NH_3]$.

Question 31 (c)



(c) A Chemist says the process would be more efficient if the ammonia produced is continuously liquefied and removed from the reaction vessel.

Comment on the Chemist's suggestion using ideas of equilibrium and the equilibrium constant.

....

....

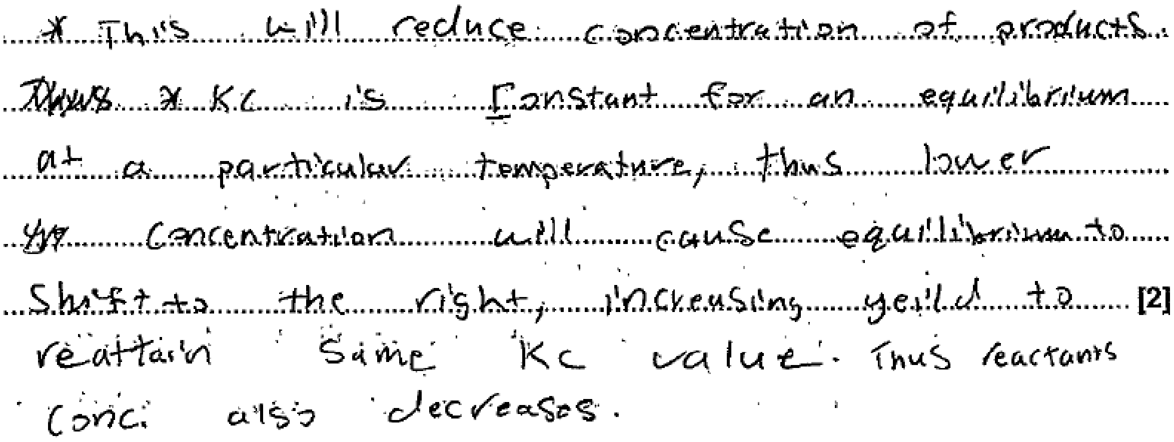
....

....

.... **[2]**

This proved a difficult question. Candidates needed to state that $[NH_3]$ would decrease and that equilibrium would shift to the right to maintain K_c. Some were able to do this, but others neglected to refer to either the equilibrium constant and/or concentrations, as the examples below illustrate.

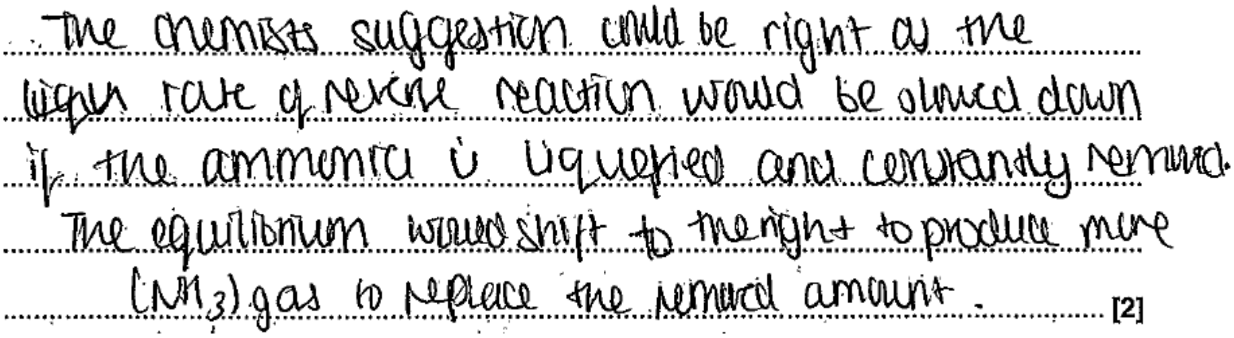
Exemplar 1



* This will reduce concentration of products. ~~Thus~~ * Kc is Constant for an equilibrium at a particular temperature, thus lower ~~yy~~ concentration will cause equilibrium to shift to the right, increasing yeild to [2] reattain same Kc value. Thus reactants conc. also decreases.

This response has clearly explained the effect of removing the product.

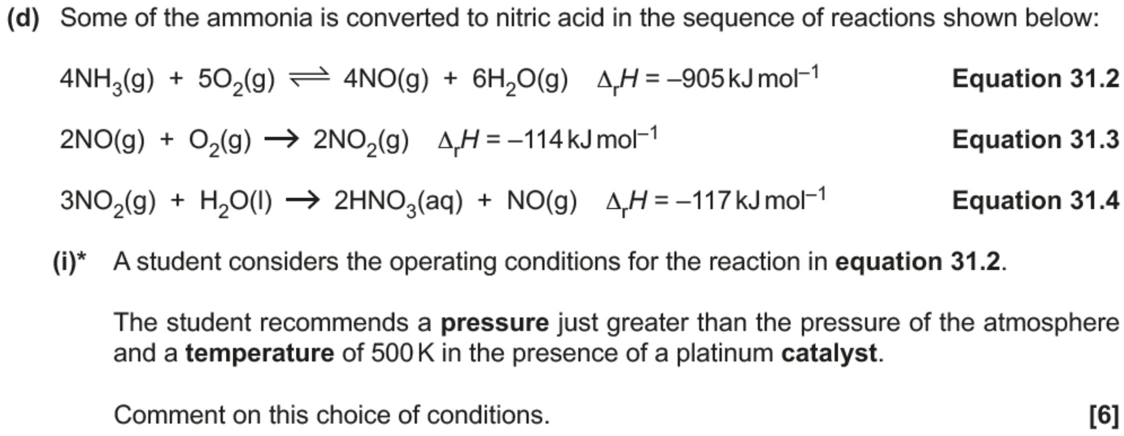
Exemplar 2



The chemists suggestion could be right as the [illegible] rate of reverse reaction would be slowed down if the ammonia is liquefied and constantly removed. The equilibrium would shift to the right to produce more (NH_3) gas to replace the removed amount. [2]

This response has not referred to the equilibrium constant at all, or the concentrations.

Question 31 (d) (i)



(d) Some of the ammonia is converted to nitric acid in the sequence of reactions shown below:

$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \quad \Delta_rH = -905\,kJ\,mol^{-1}$ **Equation 31.2**

$2NO(g) + O_2(g) \rightarrow 2NO_2(g) \quad \Delta_rH = -114\,kJ\,mol^{-1}$ **Equation 31.3**

$3NO_2(g) + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g) \quad \Delta_rH = -117\,kJ\,mol^{-1}$ **Equation 31.4**

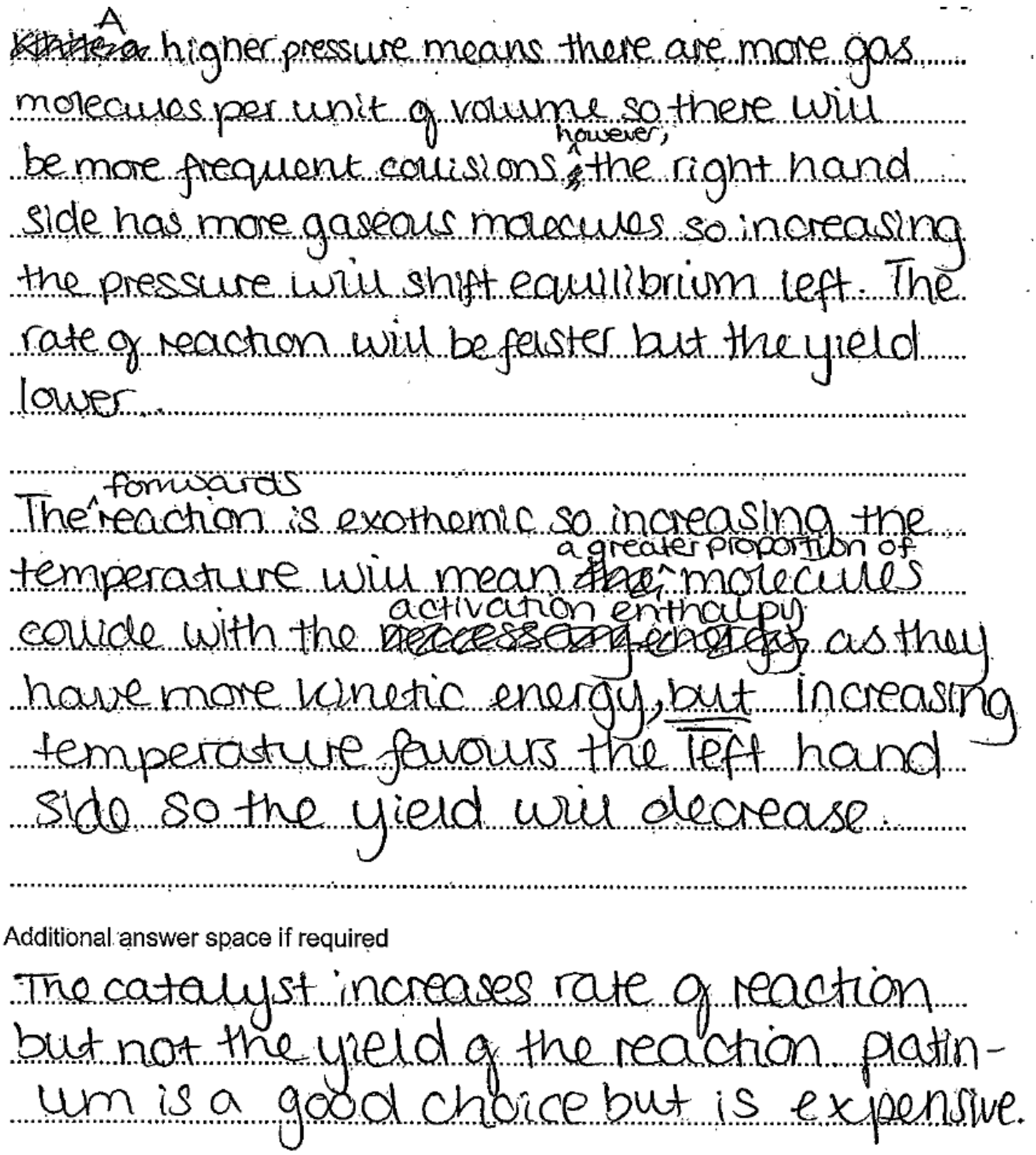
(i)* A student considers the operating conditions for the reaction in **equation 31.2**.

The student recommends a **pressure** just greater than the pressure of the atmosphere and a **temperature** of 500 K in the presence of a platinum **catalyst**.

Comment on this choice of conditions. **[6]**

Candidates did not always address the full range of conditions and did not include rate of reaction as well as yield. A few candidates considered all three equations which made it difficult to fit their answer into the space. Most answers only addressed yield with respect to temperature and pressure, and rate with respect to catalyst, although some said it would not alter position of equilibrium.

Exemplar 3



A higher pressure means there are more gas molecules per unit of volume so there will be more frequent collisions, however, the right hand side has more gaseous molecules so increasing the pressure will shift equilibrium left. The rate of reaction will be faster but the yield lower.

The forwards reaction is exothemic so increasing the temperature will mean ~~the~~ a greater proportion of molecules collide with the ~~necessary energy~~ activation enthalpy as they have more kinetic energy, but increasing temperature favours the left hand side so the yield will decrease.

Additional answer space if required

The catalyst increases rate of reaction but not the yield of the reaction platinum is a good choice but is expensive.

This response has addressed rate and equilibrium for all three conditions in a clear and concise way. There is good detail for temperature and pressure, but the clarity and detail for the catalyst was less. This was a Level 3 response and was given 5 marks.

Exemplar 4

Pressure

Pressure just greater than the atmosphere is low. At a low pressure, the equilibrium will shift to ~~sid~~ the side with greater moles of gas. In equation 31.2, there are more moles on the product side, so the equilibrium will shift to the right. More ~~nitric acid~~ NO(g) will be produced. Therefore this pressure is a suitable choice for the reaction, to increase NO(g) yield

Temperature

At 500K, the high temperature will cause the equilibrium to shift to the endothermic side of the reaction. For equation 31.2, this means that the equilibrium will shift to the left and the yield of ~~nitric acid~~ NO(g) will decrease. This high temperature is not a ~~good~~ suitable choice.

Additional answer space if required

A catalyst would speed up the rate of both the forward and reverse reactions. ~~Therefore the reaction to produce nitrogen monoxide will~~

This response is limited to Level 1 as rate **and** equilibrium has not been considered for any of the conditions.

Question 31 (d) (ii)

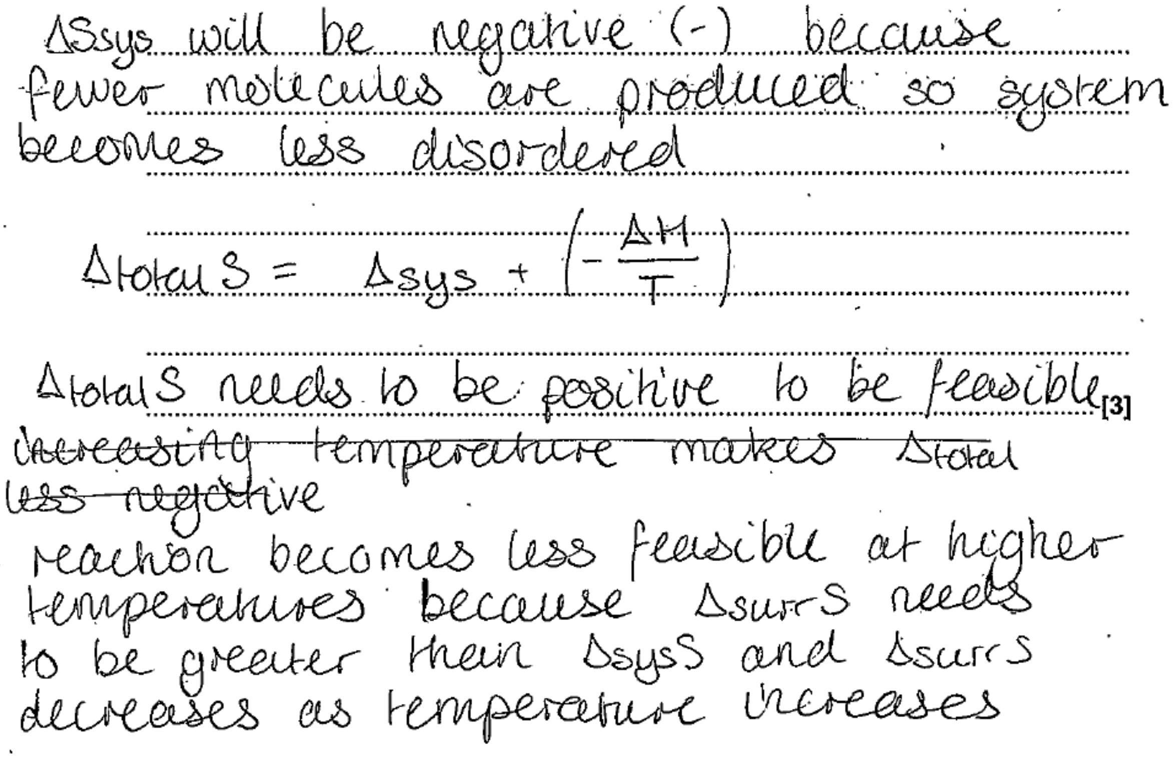
(ii) Give the sign of ΔS_{sys} in **equation 31.3**, with a reason.

Use this to explain whether the reaction becomes more or less feasible at higher temperatures.

[3]

This was a difficult question and has not been asked for a few years. The first area of difficulty was confusing $\Delta_{sys}S$ and $\Delta_{surr}S$, with candidates saying it was positive as the reaction was exothermic. Many of the explanations lacked clarity, not clearly stating $\Delta_{total}S$ had to be positive and that $\Delta_{sys}S$ was $-\Delta H/T$

Exemplar 5



ΔSsys will be negative (-) because fewer molecules are produced so system becomes less disordered

$\Delta_{total}S = \Delta_{sys} + \left(-\frac{\Delta H}{T}\right)$

ΔtotalS needs to be positive to be feasible **[3]**

~~increasing temperature makes Δtotal less negative~~

reaction becomes less feasible at higher temperatures because ΔsurrS needs to be greater than ΔsysS and ΔsurrS decreases as temperature increases

This response has addressed all the ideas clearly.

Question 32 (a)

32 DNA carries the instructions for synthesising the primary structures of protein molecules. Its backbone consists of alternating phosphate and deoxyribose sugar units. Bases are attached to the sugar units.

(a) Use the Data Sheet to draw a section of DNA.

The section of DNA must consist of two phosphate units, one deoxyribose sugar unit and one thymine unit, all joined by condensation reactions.

[3]

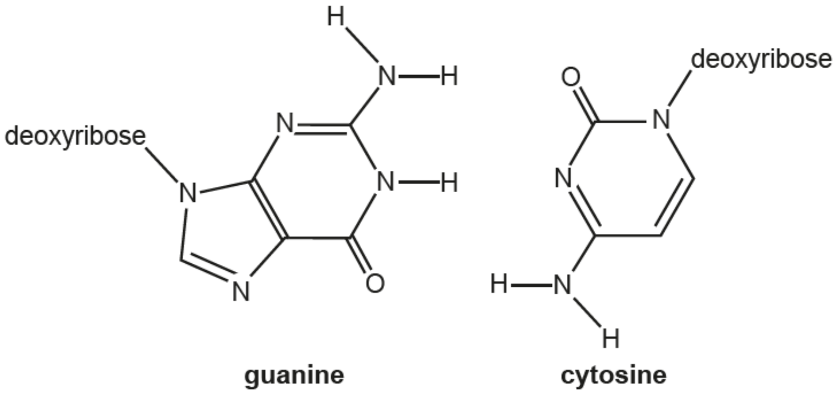
This was well done; many candidates scored full marks. If fewer marks were scored it was because a CH_2 group was missing on the deoxyribose unit, or there was an oxygen atom between the sugar and thymine, or the structure of thymine was incorrectly drawn.

Question 32 (b)

(b) The double helix of DNA is formed by the bases pairing using hydrogen bonds.

Complete the diagram to show all the hydrogen bonds between guanine and cytosine.

Show the relevant lone pairs and partial charges.



[3]

Candidates most frequently scored 2 marks for this question. We have not asked this for a number of years and marks were lost because the partial charges were not included on all three atoms across the hydrogen bond, or lone pairs were not placed along the direction of the bond.

Question 32 (c)

(c) The sequence of bases in DNA determines the primary structure of the protein synthesised.

Draw the structural formula for a section of a protein molecule formed from one each of the amino acids shown in **Fig. 32.1**.

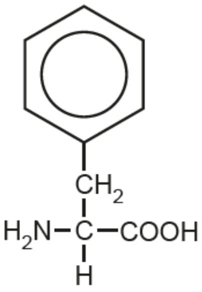
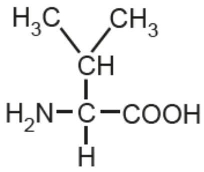
Phenylalanine	**Valine**
	

Fig. 32.1

[2]

This was difficult question. Some candidates had an oxygen atom in the middle of the amide link, but many lost a mark because they did not draw 'a section of a protein molecule' and hence leave the 'end bonds' open, rather than NH_2 or COOH.

Question 32 (d)

(d)* An HIV protease enzyme acts on the protein substrate shown in **Fig. 32.2**.

Protein substrate

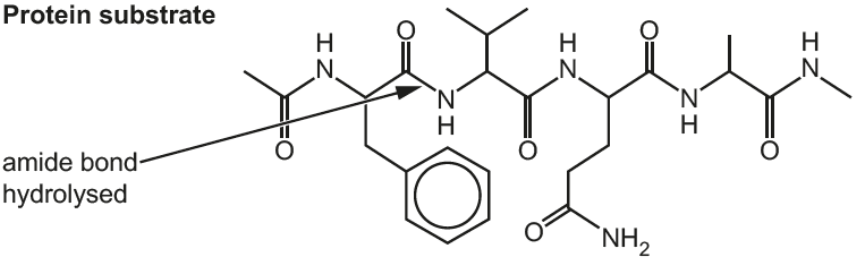


Fig. 32.2

The substrate in **Fig. 32.3** acts as an inhibitor to the HIV protease enzyme.

HIV protease inhibitor

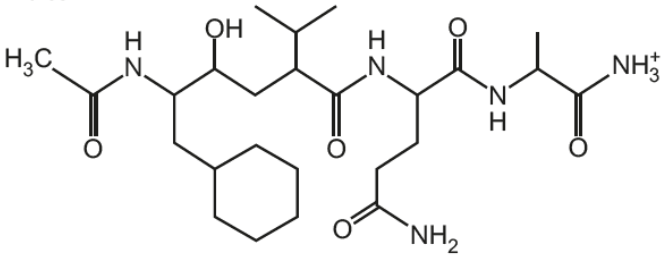


Fig. 32.3

Explain how an enzyme works and suggest how the HIV protease inhibitor affects the function of the protease enzyme. **[6]**

Many answers focused on detailing primary, secondary and tertiary structure details as well as the types of bonds used to bind to active site, rather than addressing the exact demands of the question. The answers tended to focus on enzymes and inhibitors in general, rather than using the specific structures given in the question to suggest areas of commonality between molecules and why one would be able to act as an inhibitor. This could have been accomplished with annotations on Fig. 32.2 and 3. Most answers were Level 2 as a result.

Exemplar 6

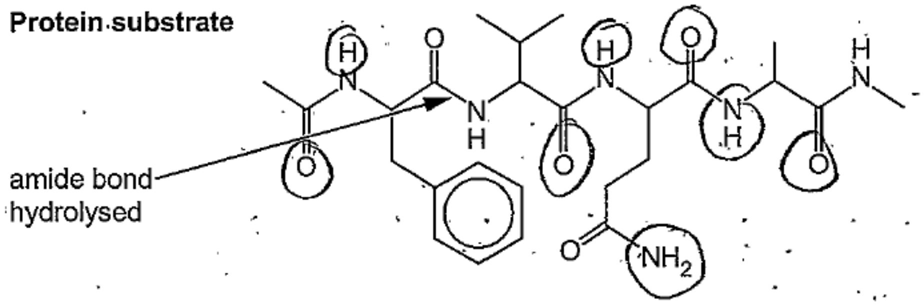


Fig. 32.2

The substrate in **Fig. 32.3** acts as an inhibitor to the HIV protease enzyme.

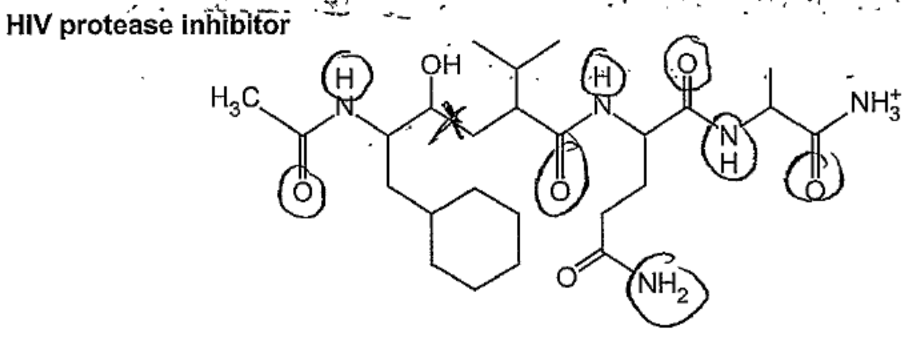


Fig. 32.3

Explain how an enzyme works and suggest how the HIV protease inhibitor affects the function of the protease enzyme. **[6]**

An enzyme has a region called the active ~~fore~~ site. It has a very specific ~~region~~ shape caused by its ~~tertat~~ tertiary structure that is exactly complements the shape of the ~~substract~~ substrate. Groups within the substrate form bonds to the enzyme, which cause bonds within the substrate to break and products to form. The HIV protease inhibitor has almos the same shape ~~as the~~ as the desired protein substrate. I have circled the groups which both substrates ~~cotain~~ contain which can bond to the enzyme. This means the HIV protease inhibitor fits the ~~sa~~ shape of the enzyme and bonds to it. However, ~~there is no peptide link in HIV protease inhibitor~~ the peptide link in the protein substrate that is broken by the enzyme is

Additional answer space if required

not in the HIV protease inhibitor. This means the inhibitor will not break up and will not be released from the enzyme. This prevents the enzyme from going on and catalysing the breakdown of the protein substrate.

This response has addressed all the ideas clearly, and has annotated the diagrams of the structures provided to clearly identify elements of commonality.

Question 33 (a)

33 Ozone in the stratosphere causes the absorption of UV radiation.

(a) When ozone absorbs UV radiation the following reaction occurs:

$$O_3 \xrightarrow{h\nu} O_2 + O$$

This reaction is one that absorbs the harmful UV radiation that causes sunburn.
One wavelength in this radiation is 330 nm.

Calculate the bond enthalpy of the bond broken in ozone by this wavelength.
(1 nm = 1 × 10^{-9} m)

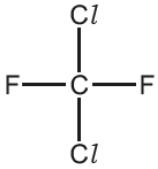
bond enthalpy = ...kJ mol^{-1} **[3]**

There were many good complete answers with working out that was clear to follow. The presentation of working out was better than in previous years. Some candidates did not multiply their answer by Avogadro's constant but still got 2/3 marks.

Question 33 (b)

(b) The natural reactions involving ozone in the atmosphere are disrupted by the presence of chlorine radicals from CFCs, for example CCl_2F_2.

Show, by means of curly arrows, the formation of a chlorine radical from the molecule below.



Name the type of bond breaking. .... **[1]**

Slightly over half of candidates scored this mark. Reasons for not doing so were incomplete arrows on the formula or, more commonly, describing this as heterolytic fission.

Question 33 (d) (i)

(d) Ozone in the stratosphere is at a pressure of 1100 Pa and a temperature of –20 °C.

(i) Calculate the amount in moles of ozone in 1.5 dm^3 of ozone from the stratosphere.

amount of ozone = ...mol **[2]**

Unit conversions are usually a difficulty with questions of this type, and it was pleasing to see so many fully correct answers.

Question 33 (d) (ii)

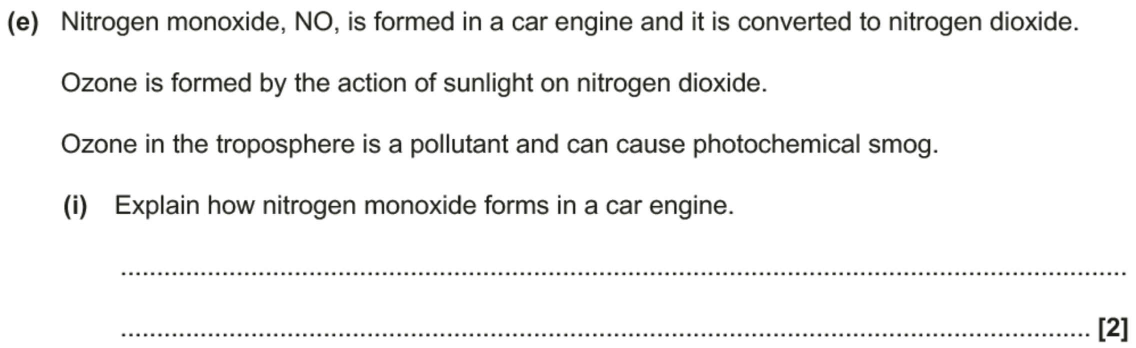
(ii) Calculate the volume (in cm^3) that this number of moles would occupy on the surface of the Earth where the pressure is 97 kPa and the temperature is 298 K.

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

volume of ozone = ... cm^3 **[2]**

Unit conversions created difficulties for some candidates here, as did deciding on the correct number of significant figures.

Question 33 (e) (i)



(e) Nitrogen monoxide, NO, is formed in a car engine and it is converted to nitrogen dioxide.

Ozone is formed by the action of sunlight on nitrogen dioxide.

Ozone in the troposphere is a pollutant and can cause photochemical smog.

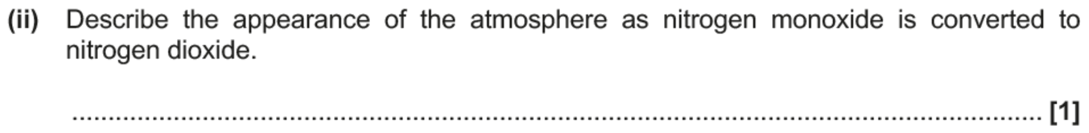
(i) Explain how nitrogen monoxide forms in a car engine.

....

.... **[2]**

This is a question that has not been asked for a number of years. Candidates did not always make it clear that the nitrogen and oxygen had come from the atmosphere.

Question 33 (e) (ii)

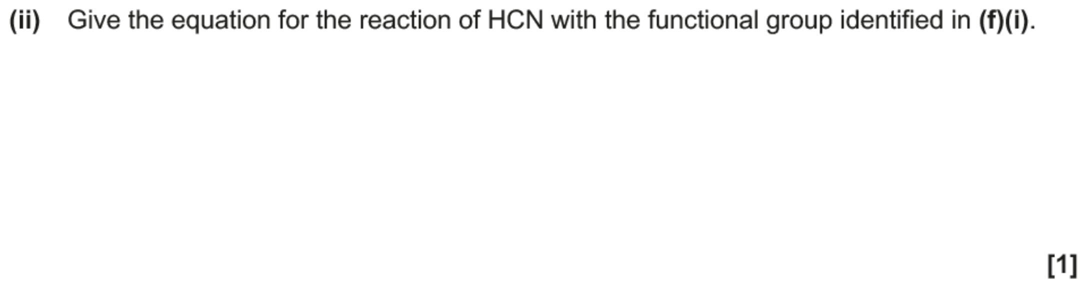


(ii) Describe the appearance of the atmosphere as nitrogen monoxide is converted to nitrogen dioxide.

.... **[1]**

A significant number of candidates knew that nitrogen dioxide was a brown gas. Some had the colour change the wrong way round and some answers were vague, such as 'smog'.

Question 33 (f) (ii)



(ii) Give the equation for the reaction of HCN with the functional group identified in **(f)(i)**.

[1]

Having identified the functional group in the previous part of this question, this 1 mark question required an equation to show how the aldehyde functional group reacts with HCN. —CHO or RCHO would have been sufficient to represent the aldehyde. Some candidates gave the whole mechanism with the aldehyde mentioned in (f)(i), which was not necessary. The best answers drew a semi-displayed product, as RCHOHCN was not clear enough without brackets, e.g. RCH(OH)(CN).

Question 34 (a)

34 Over the years, Chemists have investigated the origins of the elements and how life on Earth began.

(a) Helium is formed in the Sun by fusion reactions.

Complete the nuclear equations below to show how helium is formed.

$$ {}^{2}_{\dots\dots}\mathrm{H} \quad + \quad {}^{1}_{\dots\dots}\mathrm{H} \quad \rightarrow \quad {}^{3}_{\dots\dots}\mathrm{He} \quad + \quad \chi $$

$$ {}^{3}_{\dots\dots}\mathrm{He} \quad + \quad {}^{3}_{\dots\dots}\mathrm{He} \quad \rightarrow \quad {}^{4}_{\dots\dots}\mathrm{He} \quad + \quad \dots\dots\dots\dots \quad + \quad \dots\dots\dots\dots $$

[2]

Most candidates did not have difficulties filling the atomic numbers but some found working out the 2 hydrogen atoms more problematic.

Question 34 (b)

(b) There is a theory that the molecules of life were formed from elements made in stars. These molecules came to Earth from space on comets.

Recent analysis of comets has found compounds including methylamine.

Draw a 'dot-and-cross' diagram for methylamine, CH_3NH_2.

Label two **different** bond angles.

[3]

Many candidates scored well on this question. Common errors were omitting the lone pair on the nitrogen, drawing the bond angle between the lone pair and a bond, or mis-remembering the bond angles, e.g.109^0 and 107.5^0.

Question 34 (c)

(c) Another theory is that life developed near hot vents deep under the sea. At these hot vents geothermally heated water rich in minerals emerges from the ocean floor.

Bacteria evolve and synthesise carbohydrates using hydrogen sulfide from the hot vent. These bacteria then form the basis of food chains for organisms such as tube worms.

$12H_2S + 6CO_2 \rightarrow C_6H_{12}O_6 + 6H_2O + 12S \quad \Delta_rH = -379.9\,kJ\,mol^{-1}$ **Equation 34.1**

Use the data in the table to find the enthalpy change of formation of glucose, $C_6H_{12}O_6$.

Substance	Δ_fH / kJ mol^{-1}
H_2S	–20.6
CO_2	–393.5
H_2O	–285.8
S	0

Δ_fH $C_6H_{12}O_6$ = ...kJ mol^{-1} **[3]**

Many candidates scored the full 3 marks for this question even though there are many ways to make a mistake. The work was often well set out, so it was easy to give credit for correct parts. The most common sources of error were not using the overall enthalpy change or getting the incorrect sign for some of the terms.

Question 34 (d)

(d) Analysis of water from a hot vent showed a variety of other minerals dissolved from the Earth's crust, such as copper chloride.

Give the electronic configuration of the chloride ion, using subshells and atomic orbitals.

.... **[1]**

Almost half the candidates did not get this mark, despite a chloride ion being a relatively straightforward configuration. There were some instances of subscripts or upper-case letters, but the most common errors were giving the configuration of the atom, having not read the question carefully, or removing an electron from chlorine rather than adding one.

Question 34 (e) (i)

(e) Two students want to find the concentration of Cu^{2+} ions in some seawater from near a hot vent.

They use a titration method involving potassium iodide and sodium thiosulfate.

The potassium iodide is oxidised to iodine by the Cu^{2+} ions and the liberated iodine is titrated with sodium thiosulfate of known concentration.

$$2Cu^{2+}(aq) + 4I^-(aq) \rightarrow 2CuI(s) + I_2(aq)$$

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

(i) Name a suitable indicator the students should use and give the expected colour change observed.

Indicator ....

Colour change observed .... **[1]**

This proved a difficult question; many candidates used phenolphthalein, others had the colour change the wrong way round or described the change when the starch was added (straw colour to blue black).

Question 34 (e) (ii)

(ii) The students are supplied with 0.020 mol dm^{-3} sodium thiosulfate. The students add excess potassium iodide to 50 cm^3 of the seawater and titrate with the sodium thiosulfate.

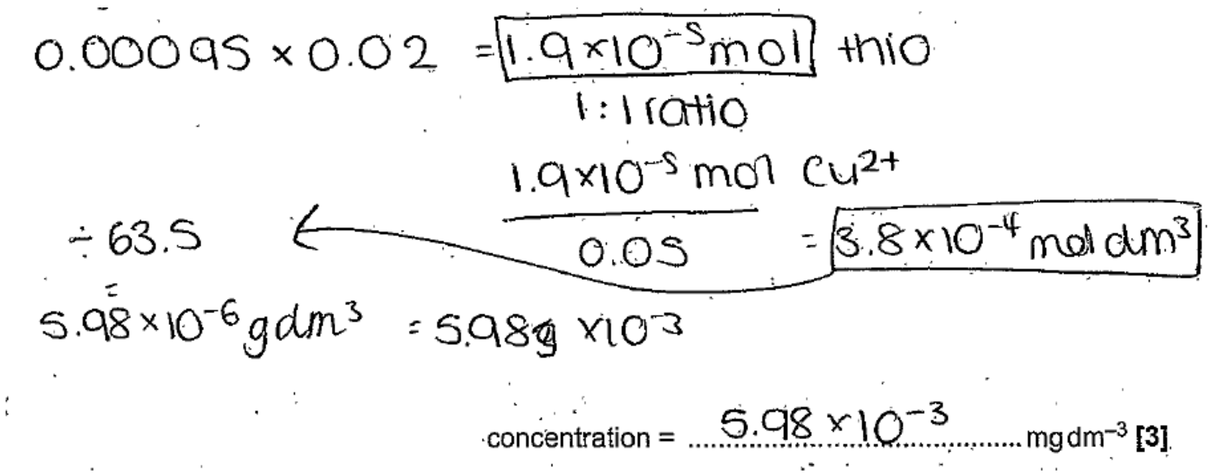
They find that their mean titre is only 0.95 cm^3 of sodium thiosulfate solution.

Use the students' results to calculate the concentration of Cu^{2+} ions in milligrams per dm^3 of seawater.

concentration = ... mg dm^{-3} **[3]**

Many candidates scored full marks for this, but a significant proportion also scored 0. The conversion from grams to milligrams was not always correct, and the ratios of moles and converting moles to mass gave some candidates problems. If the working was clear, which was not always the case, credit could be given for the correct steps.

Exemplar 7



$0.00095 \times 0.02 = \boxed{1.9 \times 10^{-5} \text{mol}}$ thio

1 : 1 ratio

$\frac{1.9 \times 10^{-5} \text{ mol Cu}^{2+}}{0.05} = \boxed{3.8 \times 10^{-4} \text{ mol dm}^3}$

$\div 63.5$

$= 5.98 \times 10^{-6} \text{ g dm}^3 = 5.98\text{g} \times 10^{-3}$

concentration = 5.98×10^{-3} mg dm^{-3} **[3]**

In this response the extremely clear working allows the award of marking points 1 and 2, but not 3 as they have divided by the atomic mass of copper instead of multiplying.

Question 34 (e) (iii)

(iii) Calculate the percentage uncertainty in a titre of 0.95 cm^3.

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

Some candidates were possibly put off by the large % error and divided it by 10.

Some omitted to account for using a burette twice in a titration.

i	**OCR support**	Guidance on calculating uncertainties is provided in the Practical Skills handbook (appendix 4, https://www.ocr.org.uk/Images/208932-chemistry-practical-skills-handbook.pdf) and can be shared with students.

Question 34 (e) (iv)

(iv) What could the students do to reduce this percentage uncertainty to around 0.5%?

Describe their experimental method.

....

....

....

.... **[2]**

This was a challenging question. Many answers suggested diluting the thiosulfate or using a larger volume of sea water but did not specify quantities. Almost no answers gave any details as to how the dilution could be done. There was a similar question on the 2018 paper about making solutions, also one of the lowest scoring questions. Many answers just suggested more repeats or a burette with better resolution.

Exemplar 8

They justly would want to dilute the Sodium thiosulphate solution. This would cause the titre volume to increase. Also could concentrate the pottasium iodide **[2]**

This response had the right idea but did not specify quantities.

Exemplar 9

Dilute the Sodium thiosulfate solution, hence increasing the titre amount & therefore reducing the uncertainty. Make the Sodium thiosulfate solution **[2]** around 20x more dilute so its concentration was 1×10^{-3} $mol\,dm^{-3}$. Do this by adding 20 cm^3 of water to 1 cm^3 of thiosulfate solution, and then using this instead.

This had made good suggestions but is not quite clear enough on experimental detail.

Question 35 (b)

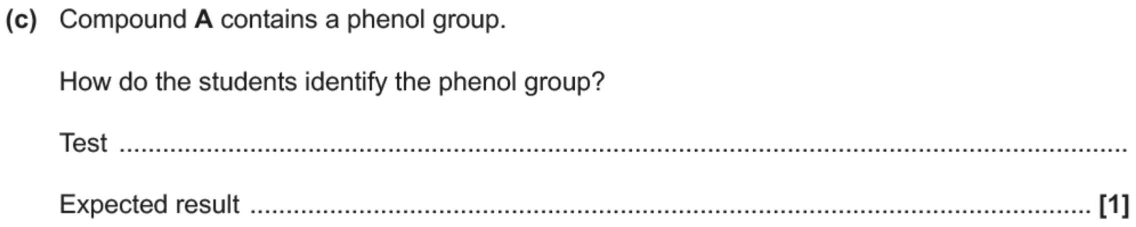
(b) They then decide that the molecules could be aromatic.

What does aromatic mean?

.... **[1]**

This was well answered, although some answers lacked clarity, such as 'delocalised electrons' or 'cyclic rings'.

Question 35 (c)



(c) Compound **A** contains a phenol group.

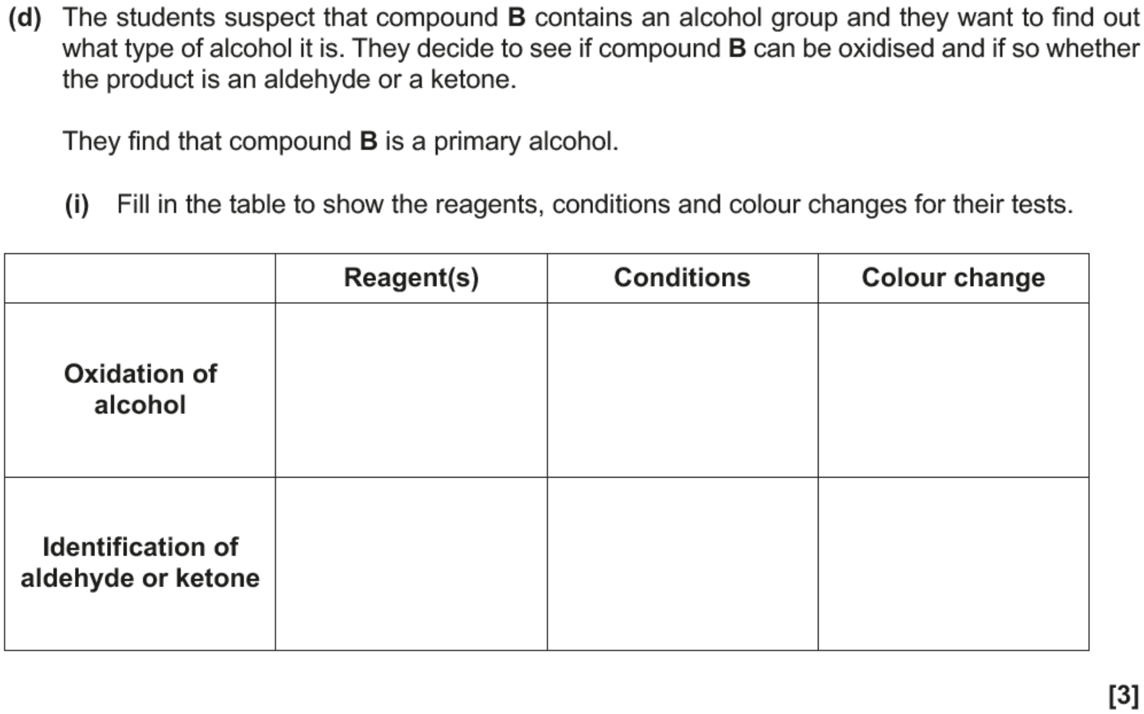
How do the students identify the phenol group?

Test ....

Expected result .... **[1]**

Colour changes generally were not well known and there were a variety of incorrect starting colours given.

Question 35 (d) (i)



(d) The students suspect that compound **B** contains an alcohol group and they want to find out what type of alcohol it is. They decide to see if compound **B** can be oxidised and if so whether the product is an aldehyde or a ketone.

They find that compound **B** is a primary alcohol.

(i) Fill in the table to show the reagents, conditions and colour changes for their tests.

	Reagent(s)	**Conditions**	**Colour change**
Oxidation of alcohol			
Identification of aldehyde or ketone			

[3]

More candidates scored 2 for this than any other mark because they had heating under reflux for the conditions when distillation is appropriate for an aldehyde. Forgetting to acidify the dichromate was another problem, as well as not including the starting colour for Fehling's solution if that was used.

Question 35 (d) (ii)

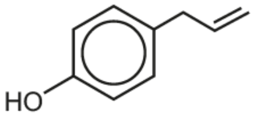
(ii) Draw a **skeletal** formula for the **unsaturated** aromatic compound **B**.

[1]

This was a difficult question and relatively few candidates scored the mark. Some had forgotten that A and B were aromatic so drew chains with multiple double bonds, others had the C=C in the incorrect place or too few carbons.

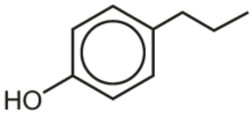
Question 35 (e) (i)

(e) The students are told that the structure of compound **A** is as shown below.



Other organic products can be made from compound **A**.

(i) Give the reagent and conditions to convert compound **A** into the compound shown below.



Reagent ....

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

This was a question where knowledge of factual details of organic reactions was not always strong enough. Many candidates gave the nickel catalyst but omitted the reagent, hydrogen.

Question 35 (e) (ii)

(ii) The students want to make the ethanoate ester of compound **A**.

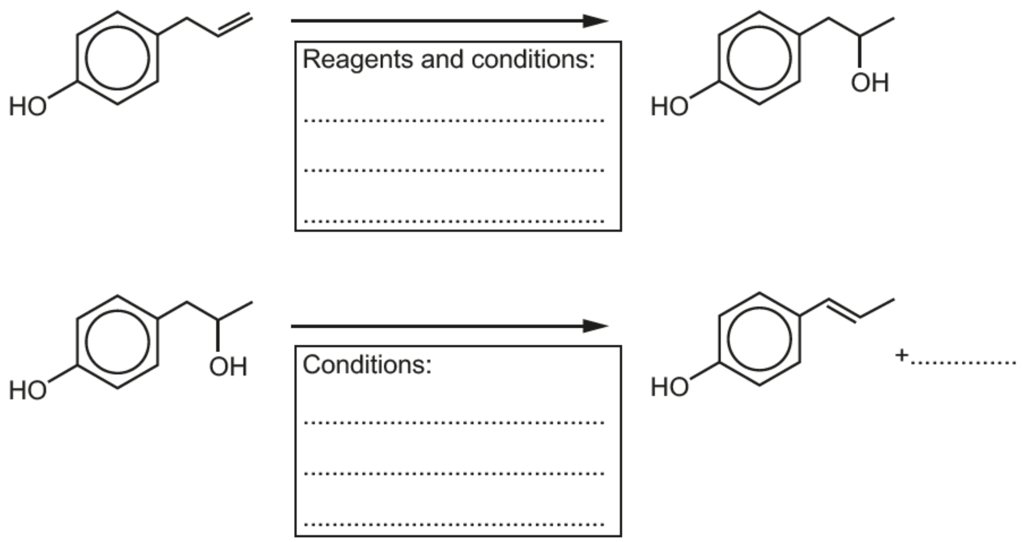
Give the equation for a reaction to do this.
Use structural formulae for the organic molecules.

[2]

Most candidates had forgotten that ethanoyl chloride or ethanoic anhydride were the reagents needed to esterify a phenol. Many of those who did remember used generic acyl chlorides or forgot the HCl or ethanoic acid product.

Question 35 (f) (i)

(f) One of the students suggests the method below to change the position of the double bond on the side chain in two steps.



(i) Complete the reaction sequence by writing on the dotted lines. **[2]**

This was also a low scoring question due to lack of detailed knowledge of reaction conditions studied at the beginning of the course.

Question 35 (f) (ii)

(ii) Comment on the student's method of changing the position of the double bond.

....

....

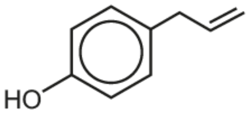
....

.... **[2]**

This was intended to be a testing question. A significant number of candidates were able to suggest that the double bond might re-form in the original place but did not always make clear that a mixture of the two products would form.

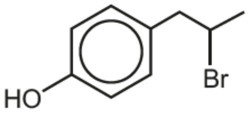
Question 35 (g) (i)

(g) Compound **A** is repeated below.



compound **A**

Hydrogen bromide reacts with compound **A** to give the compound shown below.



(i) Show the mechanism of the reaction of compound **A** with hydrogen bromide.

Use curly arrows and partial and full charges where appropriate.

[2]

Although many candidates scored at least 1 mark, it proved difficult for others. In some cases the arrows were in the wrong direction or unclearly drawn. Some answers had the + charge on the incorrect carbon in the intermediate leading to the wrong product or attacked with the $Br^{\delta-}$ first.

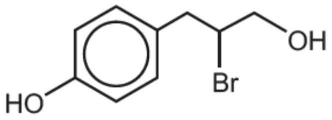
Question 35 (g) (ii)

(ii) Compound **A** is reacted with aqueous hydrogen bromide containing dissolved sodium chloride.

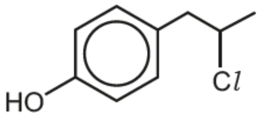
A student suggests that the products shown below are formed in addition to the product in part **(i)**.

Comment on whether the student's suggestions are correct, giving the chemistry involved.

Product 1



Product 2



....

....

....

....

....

....

.... **[3]**

This was designed to be a stretching question and proved predictably difficult. This idea is studied in connection with establishing the mechanism of addition to alkenes (DFq), but with bromine and other anions and water. It was more difficult to apply the idea to addition of HBr. Many candidates could explain that product 2 could be formed by the reaction of C*l*⁻ ions to the carbocation. Sometimes this included the irrelevant comparison of reactivity of chlorine and bromine. Candidates found it less easy to explain why product 1 could not form as it involved the addition of 2 nucleophiles (Br^- and H_2O).

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Question 23

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Question 32d

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