

A LEVEL

Examiners' report

CHEMISTRY B (SALTERS)

H433

For first teaching in 2015

H433/01 Summer 2023 series

Contents

Introduction	4
Paper 1 series overview	5
Section A overview	6
Question 3	7
Question 5	7
Question 7	8
Question 8	8
Question 9	9
Question 10	9
Question 11	10
Question 12	10
Question 13	11
Question 14	11
Question 15	12
Question 16	12
Question 17	13
Question 18	13
Question 19	14
Question 20	14
Question 21	15
Question 22	15
Question 24	16
Question 25	17
Question 26	17
Question 27	18
Question 29	18
Question 30	19
Section B overview	20
Question 31 (a)	20
Question 31 (b)	21
Question 31 (c)	22
Question 31 (d) (i)	23
Question 31 (d) (ii)	23
Question 31 (e)	24

Question 32 (a)	24
Question 32 (b)	25
Question 32 (c) (i)	26
Question 32 (c) (ii)	27
Question 32 (d) (i)	28
Question 32 (d) (ii)	29
Question 32 (d) (iii)	30
Question 32 (e)	30
Question 33 (a) (i)	31
Question 33 (a) (ii)	31
Question 33 (b) (i)	32
Question 33 (b) (ii)	32
Question 33 (b) (iii)	33
Question 34 (a) (i)	34
Question 34 (a) (ii)	35
Question 34 (a) (iii)	35
Question 34 (b)	36
Question 34 (c)*	37
Question 34 (d)	39
Question 35 (a)	40
Question 35 (b) (i)	40
Question 35 (b) (ii)	41
Question 35 (c)	42
Question 35 (d) (ii)	42
Question 35 (e)	43
Question 35 (f)*	44

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 answers 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 OCR.

Would you prefer a Word version?

Did you know that you can save this PDF as a Word file using Acrobat Professional?

Simply click on **File > Export to** and select **Microsoft Word**

(If you have opened this PDF in your browser you will need to save it first. Simply right click anywhere on the page and select **Save as . . .** to save the PDF. Then open the PDF in Acrobat Professional.)

If you do not have access to Acrobat Professional there are a number of **free** applications available that will also convert PDF to Word (search for PDF to Word converter).

Paper 1 series overview

Candidates and their teachers are to be congratulated on their performance in this paper. There was no evidence of lack of time to complete the paper and the attempts at the extended response questions were sound. There was evidence of careful revision, heeding of advice on setting out calculations clearly and good time management. It was good to see an improvement in questions on practical skills. Careful reading of the question is an area that proved difficult in some cases, for example, Question 35 (d) (ii) where the zwitterions should have been used in the equation. Chemical explanations proved difficult in some cases, such as the use of electrode potentials in Questions 34 (b) and 34 (d) and explaining structure and bonding in Questions 32 (d) (ii) and 35 (e). Giving a logical explanation to ethanol being carbon neutral, the solubility of group 2 hydroxides and emission spectrum diagram also proved difficult.

In some cases, the equations proved difficult and candidates should be encouraged to differentiate more clearly between upper and lower case letters in terms of size and form in chemical symbols. Care should also be taken in organic structures that bonds are connected to the correct atom, to the O, not the H on an OH group for example.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
<ul style="list-style-type: none"> • were able to calculate bond enthalpies correctly Question 31 (d) (iii) • were able to calculate the ratio of [salt] to [acid] in a buffer solution Question 31 (b) (iii) • could use electrode potentials to explain protecting iron from rusting • could explain the mechanism of enzyme catalysed reactions in terms of orders of reaction and rate determining step. 	<ul style="list-style-type: none"> • did not manage ionic equations Question 31 (e) • found pH calculations difficult Question 33 (a) (ii) • did not appreciate that an electrochemical cell involving aqueous ions needs a platinum electrode • gave a simple explanation of enzyme catalysed reaction kinetics in terms of availability of active sites at different substrate concentrations.

Section A overview

The standard of answers in this section continues to improve and there is plenty of evidence of a very sensible approach to finding the correct answer and working out the answer to calculations first and then looking for it in the list.

There were many examples where candidates had changed their mind about their choice of answer and had overwritten their original choice. In some instances, it was very difficult to read, and their final intention was not clear. Candidates should be encouraged to cross out their incorrect answer and clearly write their final choice beside the answer box for clarity.

Question 3

3 Which molecule is the most polar?

- A CCl_4
- B CF_4
- C CHF_3
- D CHCl_2F

Your answer

[1]

Based on working around the question, candidates usually eliminated A and B, but only just over half the candidates selected the correct answer, C.

Question 5

5 Sodium phosphate(V) has the formula Na_3PO_4 .

What is the formula of calcium phosphate(V)?

- A CaPO_4
- B $\text{Ca}_2(\text{PO}_4)_3$
- C Ca_3PO_4
- D $\text{Ca}_3(\text{PO}_4)_2$

Your answer

[1]

This question was well answered and those scoring the mark showed evidence of working out the formula before picking it from the list.

Question 7

7 A student studies a reaction that 'goes to completion'.

The student estimates the numerical value of K_c for the reaction.

What is a valid estimate for K_c for this reaction?

- A 0
- B 1×10^{-10}
- C 1
- D 1×10^{10}

Your answer

[1]

This question proved more challenging. The key information, 'goes to completion' was not always appreciated by candidates.

Question 8

8 Which of the following is correct for gas-liquid chromatography?

- A A reactive carrier gas is used.
- B The column consists of a volatile liquid on a porous support.
- C The emerging compounds can be detected by mass spectrometry.
- D The largest molecules usually have the shortest retention times.

Your answer

[1]

This question was well done by more than half the candidates.

Question 9

9 Which of the following molecules is linear?

- A HCN
- B H₂S
- C NO₂
- D SO₂

Your answer

[1]

There was much evidence of working here and just over half of the candidates scored this mark. B was the most frequently seen incorrect answer.

Question 10

10 Sodium nitrate(V) is warmed with Devarda's alloy and NaOH(aq).

Which gas is released?

- A ammonia
- B nitrogen
- C nitrogen dioxide
- D nitrogen monoxide

Your answer

[1]

Candidates had clearly learned their chemical tests, which showed in their response to this question.

Question 11

- 11 Which row shows the number of sigma (σ) and pi (π) bonds in one molecule of buta-1,3-diene, $\text{CH}_2=\text{CHCH}=\text{CH}_2$?

	Sigma (σ) bonds	Pi (π) bonds
A	7	2
B	7	4
C	9	2
D	9	4

Your answer

[1]

This question was very well answered; incorrect answers were generally A, assuming the double bond was a π bond, or B, assuming both parts of the double bond were π bonds.

Question 12

- 12 Which combination of organic molecules can be formed during the cracking of octane?

- A propane + pentane
- B propene + pentane
- C propene + pent-1-ene
- D 2 molecules of butane

Your answer

[1]

Over three quarters of answers were correct for this question. The incorrect answers were equally distributed over the other possibilities.

Question 13

13 Which of the following compounds can display *E/Z* isomerism?

- A $\text{CH}_2\text{BrCH}=\text{CHCH}_2\text{Br}$
B $(\text{CH}_3\text{CH}_2)_2\text{C}=\text{CBr}_2$
C $(\text{CH}_2\text{Br})_2\text{C}=\text{CH}_2$
D $\text{CH}_2\text{BrCH}_2\text{BrCH}=\text{CH}_2$

Your answer

[1]

This was an excellently answered question with many diagrams drawn to help work out the answer.

Question 14

14 Which row is possible for a transition metal complex?

	Shape	Bond angle	Co-ordination number
A	octahedral	90°	8
B	octahedral	120°	6
C	square planar	90°	4
D	tetrahedral	120°	4

Your answer

[1]

This question discriminated well between students at different grades and over half the answers seen were correct.

Question 15

15 What is the correct order of boiling points for $\text{CH}_3\text{CH}_2\text{OH}$, CH_3CHO and CH_3COOH ?

- A $\text{CH}_3\text{CHO} > \text{CH}_3\text{CH}_2\text{OH} > \text{CH}_3\text{COOH}$
B $\text{CH}_3\text{COOH} > \text{CH}_3\text{CH}_2\text{OH} > \text{CH}_3\text{CHO}$
C $\text{CH}_3\text{CH}_2\text{OH} > \text{CH}_3\text{COOH} > \text{CH}_3\text{CHO}$
D $\text{CH}_3\text{CH}_2\text{OH} > \text{CH}_3\text{CHO} > \text{CH}_3\text{COOH}$

Your answer

[1]

This proved a challenging question for some; the incorrect answers had ethanol as the highest boiling point.

Question 16

16 Which compound can undergo an elimination reaction to produce an alkene?

- A $(\text{CH}_3)_3\text{CH}$
B $\text{C}_6\text{H}_5\text{OH}$
C $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$
D $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$

Your answer

[1]

There was good evidence of working from candidates here; C and D were the most popular answers.

Question 17

- 17 An organic liquid is being purified. The liquid does not mix with water and contains a small aqueous acidic impurity.

What is the correct order for the following stages in the purification?

	shake with Na ₂ CO ₃ (aq)	dry with Na ₂ SO ₄ (s)	distil
A	1st	2nd	3rd
B	2nd	3rd	1st
C	3rd	1st	2nd
D	3rd	2nd	1st

Your answer

[1]

This practical technique proved challenging for many; there were even some instances where shaking with aqueous Na₂CO₃ was done after drying.

Question 18

- 18 10 cm³ of pentane gas is burned in 100 cm³ of oxygen at constant pressure and 390 K.



What volume of gas is present when all the pentane has burned under these conditions?

- A 50 cm³
B 110 cm³
C 130 cm³
D 138 cm³

Your answer

[1]

This question proved very challenging. The working showed that many candidates initially thought $pV=nRT$ was the approach. The incorrect answers were equally distributed between B (not including the excess oxygen) and A (also not realising that the water would be gaseous at the temperature specified).

Question 19

19 Which statement is correct for the Group 1 chlorides, going down the group?

- A The charge density of the anion becomes smaller.
- B The charge density of the cation becomes greater.
- C The hydration energy of the cation becomes less exothermic.
- D The lattice enthalpy becomes more exothermic.

Your answer

[1]

The ideas and terminology made this a difficult question; D and A were frequently seen incorrect answers.

Question 20

20 10 cm^3 of 0.30 mol dm^{-3} AgNO_3 is mixed with 20 cm^3 of 0.10 mol dm^{-3} NaCl .

What is the maximum mass (in grams) of silver chloride ($M_r = 143$) that could be formed?

- A 0.13
- B 0.29
- C 0.43
- D 0.71

Your answer

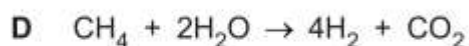
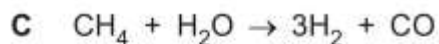
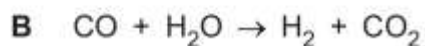
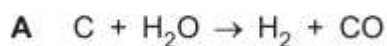
[1]

Just over half of candidates recognised which reagent was in excess and got this correct.

Question 21

21 The following equations represent reactions for making hydrogen from water.

Which reaction produces hydrogen with the greatest atom economy?



Your answer

[1]

There was plenty of evidence of working here and many correct answers were seen.

Question 22

22 A student plots a graph of $\ln k$ (y-axis) against $1/T$ for a reaction. The student draws the straight line of best fit.

The Arrhenius equation is $\ln k = -E_a/RT + \ln A$

Which statement is correct?

A The graph shows that $\ln k$ is proportional to T .

B The intercept of the line on the y-axis is $\ln A$.

C The slope of the line is E_a/RT .

D When $T = 0$, $\ln k = \ln A$.

Your answer

[1]

This question was very well answered; a lot of sketch graphs were drawn to help.

Question 24

24 The data below is for the dissolving of MgCl_2 in water.

	kJ mol^{-1}
Lattice enthalpy of $\text{MgCl}_2(\text{s})$	-2526
Enthalpy change of hydration of $\text{Mg}^{2+}(\text{g})$	-1926
Enthalpy change of hydration of $\text{Cl}^{-}(\text{g})$	-378

What is the enthalpy change of solution of MgCl_2 in kJ mol^{-1} ?

- A -222
- B -156
- C +156
- D +222

Your answer

[1]

The need to multiply the enthalpy of hydration of chloride ions by 2 and getting the signs correct made this a challenging question for many candidates.

Question 25

25 A student records the following readings for a titration:

	Trial	1	2	3
2nd burette reading / cm ³	20.45	40.80	40.45	20.50
1st burette reading / cm ³	0.20	20.50	20.40	0.35
Volume / cm ³	20.25	20.30	20.05	20.15

What should the student record as the result of the titration?

- A 20.10 cm³
- B 20.17 cm³
- C 20.19 cm³
- D 20.28 cm³

Your answer

[1]

More than half of the candidates had the correct answer, excluding the trial and titration 1 from the mean. Other answers just excluded the trial.

Question 26

26 What is the amount (in moles) of a gas that occupies 23 dm³ at 1.0×10^5 Pa and 293 K?

- A 0.94 mol
- B 1.4 mol
- C 14 mol
- D 94 mol

Your answer

[1]

This question was well done; candidates managed the unit conversion correctly in most cases, though there were also some answers where the temperature had been changed to Celsius.

Question 27

27 The solubility product of silver carbonate, Ag_2CO_3 , is $p \text{ mol}^3 \text{ dm}^{-9}$ at 298 K.

The solubility of silver carbonate is $s \text{ mol dm}^{-3}$ at 298 K.

Which equation is correct?

- A $p = 3s$
- B $p = 2s^2$
- C $p = 2s^3$
- D $p = 4s^3$

Your answer

[1]

Solubility product remains a challenging topic; many of the incorrect answers had not squared the 2 as well as s.

Question 29

29 Which statement(s) is/are correct for a Friedel-Crafts alkylation reaction?

- 1 An alkyl group bonds with a benzene ring by an addition reaction.
- 2 AlCl_3 is used as a catalyst.
- 3 A chloroalkane forms a carbocation during the reaction.

- A 1, 2 and 3
- B Only 1 and 2
- C Only 2 and 3
- D Only 1

Your answer

[1]

It was necessary to know that benzene reacts by substitution to get this question correct, which just over half the candidates did.

Question 30

30 Iodine is soluble in hexane.

Which of the following is/are reason(s) that it dissolves?

- 1** Instantaneous dipole – induced dipole bonds of similar strength are broken and made.
 - 2** The I – I covalent bond is weak.
 - 3** Iodine and hexane both have permanent dipole – permanent dipole bonds.
- A** 1, 2 and 3
 - B** Only 1 and 2
 - C** Only 2 and 3
 - D** Only 1

Your answer

[1]

This question proved more challenging; many of the answers included 2 as a correct reason.

Section B overview

Candidates overall showed good recall of chemical information. Their ability to explain chemistry or apply understanding naturally proved more challenging and they should be encouraged to try and structure a logical response that addresses all the aspects of the question. Many candidates laid calculations out clearly aiding the award of marks, although centres should note that this was not universal and requires further practice in preparing candidates to sit the examination, as was the case with identifying and following command words within questions.

It was noticeable that topics that occur early in the course proved more difficult, possibly due to less recent familiarity.

Question 31 (a)

31 This question is about Group 2 elements and their compounds.

- (a) Strontium is one of the elements in Group 2. Compounds of strontium are used in fireworks to give a crimson colour.

Analysis of the mass spectrum of a sample of strontium gives the data shown below.

Relative isotopic mass	Relative abundance / %
84	0.56
86	9.86
87	7.00
88	82.58

Use this data to calculate the relative atomic mass, A_r , of this sample of strontium.

Give your answer to **2** decimal places.

A_r of strontium = [2]

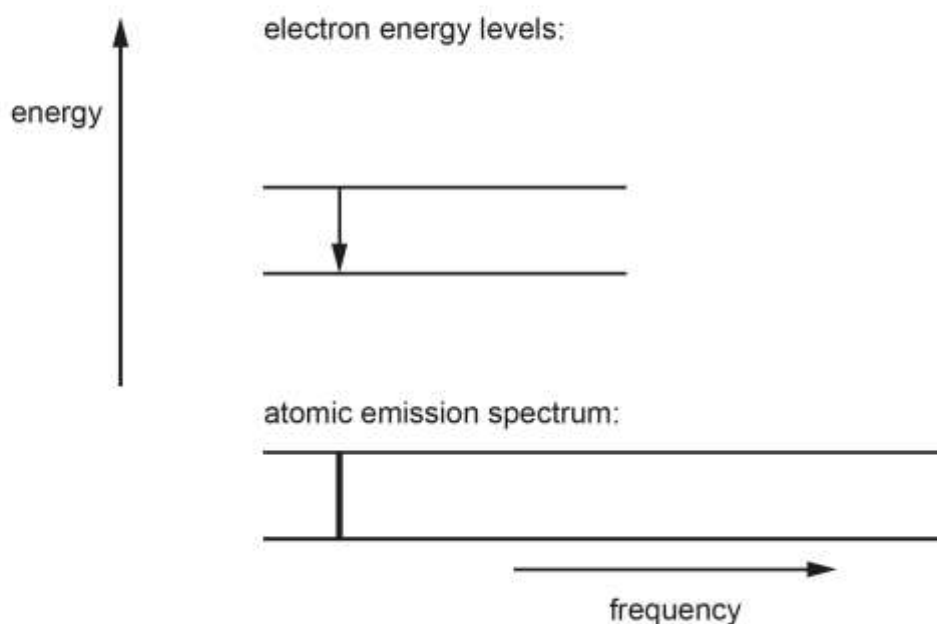
This question was excellently answered with only a very small minority making an arithmetical error or giving the incorrect number of significant figures.

Question 31 (b)

- (b) The atomic emission spectrum of strontium shows a series of coloured lines against a black background.

The diagram shows the line of shortest frequency in the spectrum and the electron energy change causing it.

Complete the diagram to show the relationship between the next **two** lines in the spectrum and the corresponding energy changes.

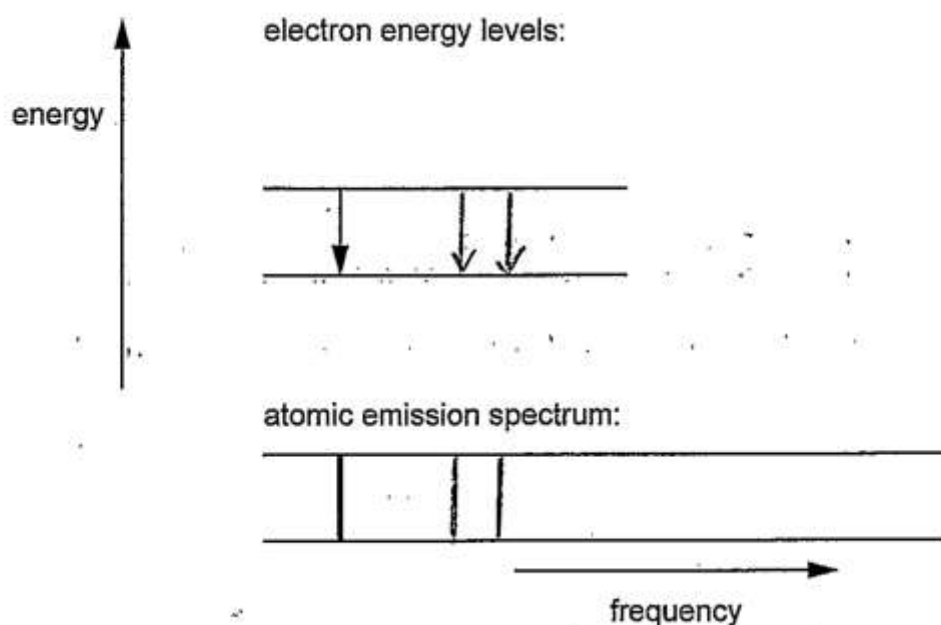


[3]

Key point

Only a small minority of candidates scored the full 3 marks. In general, they did not realise that they should have drawn two more energy levels and shown the transitions from $3 \rightarrow 1$ and $4 \rightarrow 1$ and that both the energy levels drawn and the lines on the spectrum got closer together.

Exemplar 1



This response illustrates that the candidate has got the lines on the spectrum getting closer at higher frequency but has not been able to draw the energy levels and electronic transitions correctly.

Question 31 (c)

(c) A student has three test tubes, each containing the same volume and concentration of a different solution.

- One test tube contains aqueous calcium nitrate.
- One test tube contains aqueous strontium nitrate.
- One test tube contains aqueous barium nitrate.

The student adds an equal volume of aqueous sodium hydroxide to each test tube. A white precipitate forms rapidly in the test tube containing calcium nitrate.

Describe and explain the **trend** in what the student would observe in the other **two** test tubes.

.....

.....

.....

..... [2]

More than half the candidates scored no marks for this question. The trends in solubility of group 2 compounds was not well remembered. Many of the answers were given in terms of reactivity or charge density of the metal ion, or precipitates were given different colours, most commonly cream and yellow as in the silver halides.

Question 31 (d) (i)

(d) Another student uses a roaring Bunsen flame to heat a small sample of calcium carbonate in a test tube. The gas given off is bubbled through lime water.

After about 1 minute the lime water is white and cloudy.

(i) Write an equation for the reaction that occurs when the calcium carbonate is heated.

Include state symbols.

[1]

There was an equal split between 1 or 0 marks in this question. The most common causes for not gaining the mark were incorrect state symbols (aqueous CaO, for example) or including oxygen as a reactant.

Question 31 (d) (ii)

(ii) Carbonates of metals below calcium in Group 2 are heated under the same conditions. The lime water becomes cloudy after different amounts of time.

Describe and explain the **trend** in thermal stabilities of the Group 2 carbonates.

.....

.....

.....

.....

.....

.....

.....

.....

..... [3]

This Group 2 trend was more successfully answered than the solubility of the hydroxides, but there was still some confusion; answers included atomic rather than ionic radius but often redeemed themselves by including charge density as well. Some answers were clear and well structured, but others answered in terms of reactivity.

Question 31 (e)

(e) Barium chloride solution is used as a test for the sulfate ion.

Write an ionic equation for the reaction that occurs when this test is done.

Include state symbols.

[2]

Some answers were perfectly correct, but a significant number were not ionic equations and many had incorrect charges or formulae for the ions, so did not score any marks.

Question 32 (a)

32 The impact of climate change is driving the development of replacements for fossil fuels. Crude oil currently remains a source of hydrocarbons, some of which can be used as fuels.

(a) Octane, C_8H_{18} , is one of the alkane hydrocarbons present in petrol.

For maximum fuel efficiency, petrol should burn completely. However, some incomplete combustion usually takes place.

Write an equation for the incomplete combustion of octane that forms carbon monoxide as the only carbon compound.

[1]

This question was very well done despite it not being a common equation requested. Almost three quarters of the answers were correct, with the vast majority giving 8.5 moles of oxygen, rather than doubling all the coefficients.

Question 32 (b)

(b) 2,2,3-trimethylpentane is a structural isomer of octane.

Draw the **skeletal** formula for 2,2,3-trimethylpentane.

[1]

This question was excellently done. There were very few instances of structures including an incorrect number of carbon atoms.

Question 32 (c) (i)

(c) Ethanol is often added to petrol to improve combustion.

A student wishes to measure the enthalpy change of combustion of ethanol.

The student carries out a simple method.

- Step 1** Some water is measured into a copper can.
Step 2 The initial temperature of the water in the can is measured.
Step 3 The initial mass of a spirit burner containing ethanol is measured.
Step 4 The spirit burner is placed under the can which is held above it using a clamp.
Step 5 The wick of the spirit burner is lit.
Step 6 After heating the water in the can, the flame is blown out.
Step 7 The final temperature of the water is measured.
Step 8 The final mass of the spirit burner is measured.

The results are recorded in **Table 32.1**.

Table 32.1

Mass of water used / g	250
Mass of ethanol burned / g	2.73
Initial temperature of water / °C	16.5
Final temperature of water / °C	52.0

- (i) Use the results in **Table 32.1** to calculate a value for the enthalpy change of combustion, $\Delta_c H$, of ethanol, C_2H_5OH , in kJ mol^{-1} .

$\Delta_c H$ of ethanol = kJ mol^{-1} [3]

This question was well done with the vast majority of candidates performing the calculation correctly, although some omitted the sign and lost a mark as a consequence. Other less frequent errors included using the temperature change + 273, or an incorrect formula mass for ethanol.

Question 32 (c) (ii)

- (ii) The student found that the value of $\Delta_c H$ obtained using this method was considerably less exothermic than that in a data book.

State **two** sources of error in the student's method.

Describe a correction for each.

Error 1

.....

Correction 1

.....

Error 2

.....

Correction 2

.....

[4]

The majority of candidates scored 2 of the 4 marks on this question. In some cases, the two errors were both some form of heat loss so could only score once. Heat loss was the most common error cited, often in terms of loss from the copper can or the surface of the water. Other correct responses seen were uneven distribution of heat due to not stirring, and evaporation of ethanol from the wick of the spirit burner. There were also rarer examples suggesting the heat capacity of the can should be determined and included in the calculation. Vague comments about the distance between the wick and the base of the can or incorrect measurements of the volume of water or temperature were not creditworthy. Using polystyrene insulation around the can was acceptable but the use of a polystyrene beaker instead of the copper can was not.

Question 32 (d) (i)

- (d) A value for the enthalpy change of combustion of ethanol can also be calculated using the average bond enthalpy values given in **Table 32.2**.

Table 32.2

Bond	Average bond enthalpy / kJ mol ⁻¹
C–C	+347
C–O	+358
C–H	
O–H	+464
C=O	+805
O=O	+498

- (i) Why are the bond enthalpies in **Table 32.2** described as average values?

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

Many candidates found it difficult to explain this and answers were in terms of averaging different repeats or experimental data. Even if the idea that it was the average enthalpy of that bond in different molecules was apparent, it was not always expressed clearly enough to score.

Question 32 (d) (ii)

- (ii) The larger bond enthalpy of C=O compared with C–O implies that the C=O bond is shorter.

Explain why double bonds are shorter than single bonds between the same atoms.

.....

.....

.....

..... [2]

A high majority of candidates scored no marks on this question; the explanations were unclear and missed the key point of the shared electrons pulling the atoms together.

Misconception



Candidates were not clear about what binds atoms together in a covalent bond; many answers focused on sigma and pi bonds. Those that had the correct idea of shared electrons did not specify the number in each type of bond.

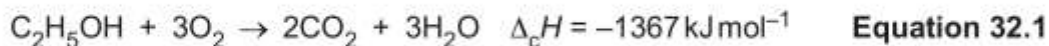
Exemplar 2

in double bonds more electrons are shared
between the elements so the elements are more
attracted to each others nucleuses, so the elements
are closer together and the bond is shorter. [2]

This response illustrates that the number of shared electrons has not been specified for MP1, and the lack of clarity prevents MP2 being given too.

Question 32 (d) (iii)

(iii) The equation for the combustion of ethanol is shown below:



Use the data in **Table 32.2** and the value of $\Delta_c H$ from **Equation 32.1**, to calculate a value for the average bond enthalpy for the C–H bond in kJ mol^{-1} .

average bond enthalpy for C–H bond = kJ mol^{-1} [3]

This question shows the need for clearly set out working as arithmetical errors are easy to make, as well as not including all the bonds to be broken or made in the correct numbers. About a third of candidates scored 3 marks, but where the working was clear and easy to follow 1 or 2 marks were given to the majority of candidates.

Question 32 (e)

(e) The ethanol that is mixed with fossil fuels in petrol can be made by fermentation of crops.

A student says that this ethanol is carbon neutral in petrol.

Discuss this statement.

.....

.....

.....

.....

.....

.....

..... [3]

This proved a challenging question. Many candidates had not quite realised what the question was asking and therefore many of the answers were vague and muddled. Some answered in terms of the whole fuel, not just the ethanol. Answers indicating that CO_2 taken in during growth or photosynthesis offset the CO_2 produced in combustion often didn't use key terms such as growth, photosynthesis or combustion so were too vague to score. Other considerations such as fuel burned in transporting or cultivating the ethanol producing CO_2 were, again, often too vague to score.

Question 33 (a) (i)

33 Citric acid is a weak acid that is present in many fruits. The addition of citrate salts to fruit-based products such as jams forms buffer solutions in the products.

(a) A student uses citric acid, $\text{C}_3\text{H}_5\text{O}(\text{COOH})_3$, to prepare a sample of sodium citrate, $\text{C}_3\text{H}_5\text{O}(\text{COONa})_3$ as shown in **Equation 33.1**.



The M_r of citric acid is 192.

The student uses 4.80 g of citric acid and obtains 5.18 g of sodium citrate.

(i) Calculate the percentage yield in this salt preparation.

percentage yield = % **[2]**

This question was very well done; nearly three quarters of candidates scored full marks. A minority scored 1 mark as they had miscalculated the M_r of sodium citrate but scored MP2 by using an incorrectly determined M_r in the correct subsequent step.

Question 33 (a) (ii)

(ii) The pH of the sodium hydroxide solution used in this salt preparation is 13.46 at 25°C.

Calculate the concentration of the sodium hydroxide solution.

concentration of sodium hydroxide = mol dm^{-3} **[2]**

This question was well done with half the candidates scoring full marks. If the calculation was clearly set out it was possible to credit the correct $[\text{H}^+]$ determined from the pH even if the second step was not attempted.

Question 33 (b) (i)

- (b) Buffer solutions are also important in living systems. For example, human blood needs to be maintained at a pH between 7.35 and 7.45.

The buffering action in blood involves the equilibrium as represented by **Equation 33.2**.



- (i) Identify the Brønsted-Lowry acid and conjugate base in **Equation 33.2**.

Brønsted-Lowry acid

Conjugate base

[1]

The majority of candidates scored here. Some used H^+ for the acid which was an unfortunate error.

Question 33 (b) (ii)

- (ii) Using **Equation 33.2**, explain how this buffer solution maintains its pH when small amounts of acid and alkali are added.

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

There were some general/unspecific answers, but most candidates scored for equilibrium shifting left and right (MP1 & 3). Some responses made general reference to large amounts of acid and/or salt, for example, which were not specifically linked to this equilibrium so did not score MP2.

Question 33 (b) (iii)

(iii) At body temperature, healthy blood at a pH of 7.40 has a concentration ratio

$$\frac{\text{HCO}_3^-}{\text{H}_2\text{CO}_3} = 11.3$$

If the pH falls below 7.35, a condition known as acidosis may develop which can cause shortness of breath and, in extreme cases, death.

Calculate the concentration ratio of $\frac{\text{HCO}_3^-}{\text{H}_2\text{CO}_3}$ in a patient with a blood pH of 7.20.

concentration ratio of $\frac{\text{HCO}_3^-}{\text{H}_2\text{CO}_3} = \dots\dots\dots$ [4]

This was a difficult question but almost a third of candidates scored the full 4 marks. This was another instance where clear working was essential, as those who set things out clearly were able to score for the $[\text{H}^+]$ at each of the two pH values if they wrote it down as part of the working. Many answers then went on to find the ratio of these numbers, rather than finding K_a .

Question 34 (a) (i)

34 Electrode potentials are used to investigate redox reactions.

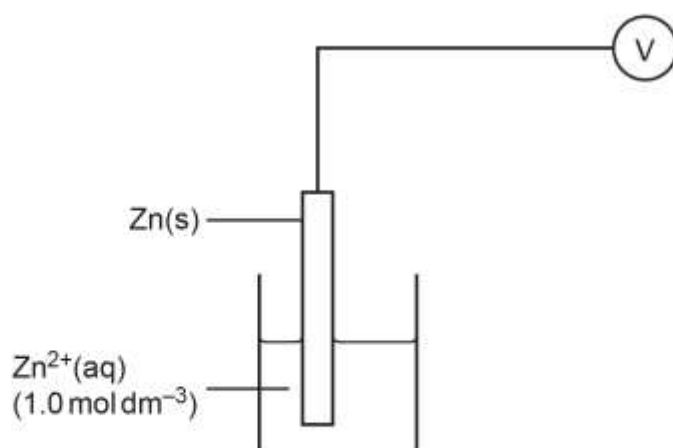
Standard electrode potentials for a range of redox half-cells are shown in **Table 34.1**.

Table 34.1

redox half-cell	half-equation	E°/V
1	$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Zn}(\text{s})$	-0.76
2	$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Fe}(\text{s})$	-0.44
3	$\text{Sn}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Sn}(\text{s})$	-0.14
4	$2\text{H}^+(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{H}_2(\text{g})$	0.00
5	$\frac{1}{2}\text{O}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightleftharpoons 2\text{OH}^-(\text{aq})$	+0.40
6	$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightleftharpoons \text{Fe}^{2+}(\text{aq})$	+0.77
7	$\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14\text{H}^+(\text{aq}) + 6\text{e}^- \rightleftharpoons 2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O}(\text{l})$	+1.33
8	$\text{Cl}_2(\text{aq}) + 2\text{e}^- \rightleftharpoons 2\text{Cl}^-(\text{aq})$	+1.36
9	$\text{MnO}_4^-(\text{aq}) + 8\text{H}^+(\text{aq}) + 5\text{e}^- \rightleftharpoons \text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}(\text{l})$	+1.51

(a) A student sets up an electrochemical cell in the laboratory based on redox half-cells 1 and 6.

(i) Complete the labelled diagram to show the student's cell.



[3]

The most frequently seen score in this question was 3 marks. Those scoring fewer marks had iron or graphite electrodes, did not have both Fe^{2+} and Fe^{3+} ions in the solution, or in some rare instances, did not have the salt bridge dipping into the solutions.

Question 34 (a) (ii)

- (ii) Use the data in **Table 34.1** to calculate $E^{\ominus}_{\text{cell}}$ for the student's electrochemical cell.

$$E^{\ominus}_{\text{cell}} = \dots\dots\dots \text{V} \text{ [1]}$$

The vast majority of answers given were correct for this question. There were however a minority of answers giving 0.01, having not taken the effect of the polarity of the cells on the signs of the half cells into account. Some answers also used the Fe^{2+}/Fe electrode potential instead of the $\text{Fe}^{3+}/\text{Fe}^{2+}$.

Question 34 (a) (iii)

- (iii) State the **types** of particle that cause the transfer of charge through the wire and the solutions.

The wire

The solutions

[2]

This was a high scoring question, although there were some instances of protons conducting in the solutions!

Question 34 (b)

- (b) Standard electrode potentials can be used to explain how some metals protect iron from rusting.

A thin coating of zinc on the surface of iron will provide protection from rusting even when the zinc coating becomes scratched. However, a scratched thin coating of tin will not protect the surface.

Use the data in **Table 34.1** to explain these observations.

.....

.....

.....

.....

.....

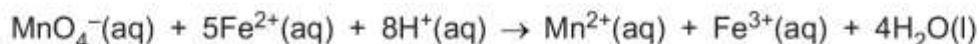
.....

..... [3]

Responses to this question were often vague or illogical. In some instances, the electrode potentials of zinc and tin were compared with $\text{Fe}^{3+}/\text{Fe}^{2+}$ or were compared with each other without reference to iron at all. Some answers were in terms of reactivity, rather than tendency to lose electrons. This idea needs to be practised more.

Question 34 (c)*

(c)* The analysis of iron(II) compounds can be carried out using manganate(VII) redox titrations.



- 5.88 g of an alloy containing iron are dissolved in dilute sulfuric acid.
- The resulting Fe^{2+} solution is completely transferred into a 0.250 dm^3 volumetric flask and made up to the mark.
- 25.0 cm^3 of the Fe^{2+} solution requires a mean titre of 20.80 cm^3 of $0.0200\text{ mol dm}^{-3}$ potassium manganate(VII).

Describe, giving practical details, how the titration is carried out and use the information to calculate the percentage by mass of iron in the alloy, giving your answer to an **appropriate** number of significant figures.

.....

.....

.....

.....

.....

.....

.....

..... [6]

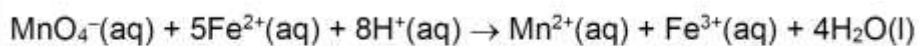
This question was well done. Common reasons for being limited to Level 2 were incomplete practical details, incorrect colour changes or use of an indicator. The calculation was progressed well in most cases, significant figures were sometimes incorrect or the fact that 25 cm^3 was taken out of a total volume of 250 cm^3 was sometimes overlooked. In some cases, a detailed description of how to prepare the alloy solution was given, which has been asked for in the past but was not needed here.

Erratum Notice

Instructions to candidates:

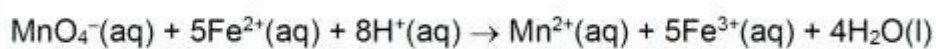
Turn to **page 26** of the **question paper** and look at **question 34(c)***.

The equation in the question reads:



Please cross out ' $\text{Fe}^{3+}(\text{aq})$ ' and replace with ' $5\text{Fe}^{3+}(\text{aq})$ '.

The equation should now read:



Question 34 (d)

Table 34.1 is repeated below:

Table 34.1

redox half-cell	half-equation	E°/V
1	$Zn^{2+}(aq) + 2e^{-} \rightleftharpoons Zn(s)$	-0.76
2	$Fe^{2+}(aq) + 2e^{-} \rightleftharpoons Fe(s)$	-0.44
3	$Sn^{2+}(aq) + 2e^{-} \rightleftharpoons Sn(s)$	-0.14
4	$2H^{+}(aq) + 2e^{-} \rightleftharpoons H_2(g)$	0.00
5	$\frac{1}{2}O_2(g) + H_2O(l) + 2e^{-} \rightleftharpoons 2OH^{-}(aq)$	+0.40
6	$Fe^{3+}(aq) + e^{-} \rightleftharpoons Fe^{2+}(aq)$	+0.77
7	$Cr_2O_7^{2-}(aq) + 14H^{+}(aq) + 6e^{-} \rightleftharpoons 2Cr^{3+}(aq) + 7H_2O(l)$	+1.33
8	$Cl_2(aq) + 2e^{-} \rightleftharpoons 2Cl^{-}(aq)$	+1.36
9	$MnO_4^{-}(aq) + 8H^{+}(aq) + 5e^{-} \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$	+1.51

(d) A student carries out the analysis described in **part (c)** but uses hydrochloric acid instead of sulfuric acid to dissolve the sample of the alloy.

Using the data in **Table 34.1**, predict and explain the effect of this change of acid on the titre of potassium manganate(VII).

.....

 [2]

This question was very challenging with only a small number of candidates scoring any marks at all. The electrode potential table had been reprinted here again suggesting that electrode potentials were the key to the answer. Most answers focused on the fact that there were fewer H^{+} ions in hydrochloric acid. If electrode potentials were used, the Cl_2/Cl^{-} electrode potential was compared with iron not MnO_4^{-}/Mn^{2+} .

Question 35 (a)

35 When developing vaccines against viruses, scientists need to understand the chemistry of the virus spike protein. One type of vaccine contains the messenger RNA so that cells can produce the spike proteins themselves and develop immune reactions to them.

- (a) One section of mRNA contains the sequenceGGUGCC.... that codes for glycine and alanine.

Explain how this mRNA sequence enables these two amino acids to form the correct primary structure in a protein.

.....

.....

.....

..... [2]

This was a challenging question; fewer than half the candidates scored any marks. The concept of translation was not well understood. Many candidates seemed to think that either t-RNA or m-RNA synthesised amino acids and many struggled to appreciate the difference between a codon on m-RNA and an anti-codon on t-RNA.

Question 35 (b) (i)

- (b) All amino acids apart from glycine, $\text{H}_2\text{NCH}_2\text{COOH}$, show optical isomerism.

- (i) Describe the feature of the amino acid structure that allows optical isomerism to occur.

.....

..... [1]

This question was generally well answered. The idea of 4 different groups around a carbon was needed.

Question 35 (b) (ii)

- (ii) Draw two diagrams that show the 3-D relationship between the optical isomers of alanine, $\text{H}_2\text{NCH}(\text{CH}_3)\text{COOH}$.



[2]

The majority of candidates scored 2 marks here. If fewer marks were scored, it was due to the 3D diagram being incorrect; the in-plane bonds being at 180° or the incorrect atom being connected to the bond, H in the NH_2 group, for example. In each case the second mark could score. Very few answers did not attempt 3D diagrams.

Question 35 (c)

- (c) The primary structure of a protein is the order in which the amino acid residues are bonded together.

Draw a structural formula to show a dipeptide that can be formed when alanine, $\text{H}_2\text{NCH}(\text{CH}_3)\text{COOH}$, and serine, $\text{H}_2\text{NCH}(\text{CH}_2\text{OH})\text{COOH}$, bond together.

Draw a circle around the peptide link.

[2]

This question was generally well done. Not including the whole C=O NH in the circle or having 'end bonds' was the cause of some lost marks.

Question 35 (d) (ii)

- (ii) Write equations for the reactions that occur in the two beakers.

Equation for reaction with acid (H_3O^+).

Equation for reaction with alkali (OH^-).

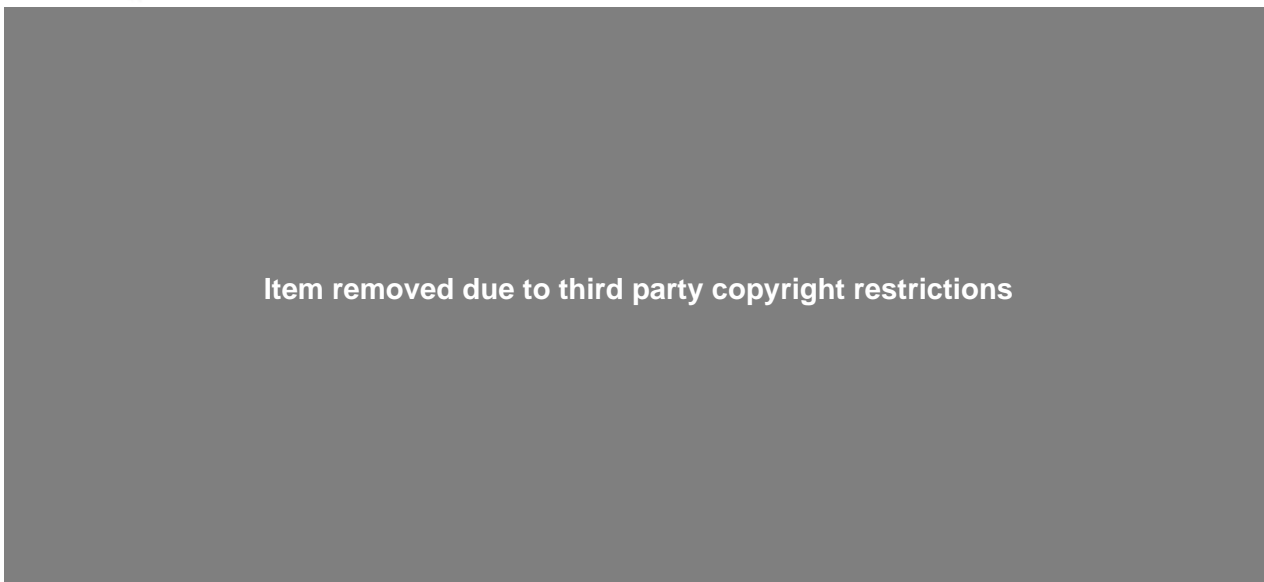
[2]

Candidates had the correct idea here; those not scoring fully did not start with the stated zwitterion, choosing instead the amino acid structure. Nonetheless they showed good appreciation of the impact of the acid/alkali species on the structure. Some candidates forgot to include the water produced or used NaOH and HCl instead of H_3O^+ and OH^- .

Question 35 (e)

(e) The secondary structure of a protein is held together by hydrogen bonds.

Fig. 35.1, shows hydrogen bonding between neighbouring peptide chains in a sheet-type secondary structure.



Item removed due to third party copyright restrictions

.....

.....

.....

.....

.....

.....

.....

[3]

More than half the candidates scored 0 on this question, despite having some of the correct ideas, as answers were not clearly and logically expressed. The answer needed to relate to the structure given in the diagram.

MP1 is for explaining why the O in the C=O is δ^- in terms of O being more electronegative than C.

MP2 is for explaining why H is δ^+ in terms of N being more electronegative than H.

MP3, the most frequently scored, was for $H^{\delta+}$ being attracted to the lone pair on O on the neighbouring chain.

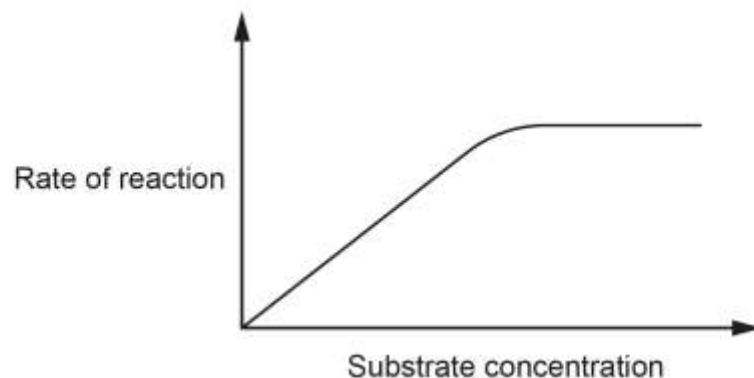
Answers were rather general, many candidates citing the difference in electronegativity between O and H as causing a dipole and therefore giving rise to H-bonding.

Question 35 (f)*

- (f)* Enzymes are proteins that catalyse certain reactions. They can be used by viruses to infect cells.

The rates of enzyme-catalysed reactions typically vary with substrate concentration as shown in the graph in **Fig. 35.2**.

Fig. 35.2



The mechanism of an enzyme-catalysed reaction can be written:



State the meaning of the symbols used in the mechanism and explain how this mechanism accounts for the shape of the curve in **Fig. 35.2**. [6]


This was an idea well understood by candidates. The majority of marks were in the middle of the range, however, as the orders of reaction may have been given for one or both the stages, but not the rate determining step.

Exemplar 3

State the meaning of the symbols used in the mechanism and explain how this mechanism accounts for the shape of the curve in Fig. 35.2. (EP is enzyme and products) [6]

E is used for the enzyme with available active site, S means substrate. ES is enzyme-substrate complex and P is the product (made from substrate). When substrate concentration is low, it is the limiting reagent and first order wrt. the reaction. Therefore rate and $[S]$ are proportionate at start when $[S]$ is low; $E + S \rightarrow ES$ is the rate determining step (RDS). However when $[S]$ is higher, rate plateaus as $E + S \rightarrow ES$ is no longer the RDS as all the E active sites are occupied by S at any one time. $EP \rightarrow E + P$ is now the RDS and $[S] \therefore$ becomes 0 order wrt. the reaction. The release of the ~~empty~~ unoccupied enzyme is the step that now determines the ROR. and so the rate first increases proportionally when $[S]$ is low as $E + S \rightarrow ES$ is the RDS, however when $[S]$ reaches certain value, it becomes 0 order and rate does not increase when $[S]$ increases.

Additional answer space if required

therefore  shape graph.

This response shows all the aspects can be covered very concisely. The orders of reaction and rate determining steps have been related clearly to the shape of the graph and the answer is logically structured.

Supporting you

Teach Cambridge

Make sure you visit our secure website [Teach Cambridge](#) to find the full range of resources and support for the subjects you teach. This includes secure materials such as set assignments and exemplars, online and on-demand training.

Don't have access? If your school or college teaches any OCR qualifications, please contact your exams officer. You can [forward them this link](#) to help get you started.

Reviews of marking

If any of your students' results are not as expected, you may wish to consider one of our post-results services. For full information about the options available visit the [OCR website](#).

Access to Scripts

For the June 2023 series, Exams Officers will be able to download copies of your candidates' completed papers or 'scripts' for all of our General Qualifications including Entry Level, GCSE and AS/A Level. Your centre can use these scripts to decide whether to request a review of marking and to support teaching and learning.

Our free, on-demand service, Access to Scripts is available via our single sign-on service, My Cambridge. Step-by-step instructions are on our [website](#).

Keep up-to-date

We send a monthly bulletin to tell you about important updates. You can also sign up for your subject specific updates. If you haven't already, [sign up here](#).

OCR Professional Development

Attend one of our popular CPD courses to hear directly from a senior assessor or drop in to a Q&A session. Most of our courses are delivered live via an online platform, so you can attend from any location.

Please find details for all our courses for your subject on **Teach Cambridge**. You'll also find links to our online courses on NEA marking and support.

Signed up for ExamBuilder?

ExamBuilder is the question builder platform for a range of our GCSE, A Level, Cambridge Nationals and Cambridge Technicals qualifications. [Find out more](#).

ExamBuilder is **free for all OCR centres** with an Interchange account and gives you unlimited users per centre. We need an [Interchange](#) username to validate the identity of your centre's first user account for ExamBuilder.

If you do not have an Interchange account please contact your centre administrator (usually the Exams Officer) to request a username, or nominate an existing Interchange user in your department.

Active Results

Review students' exam performance with our free online results analysis tool. It is available for all GCSEs, AS and A Levels and Cambridge Nationals.

[Find out more](#).

Need to get in touch?

If you ever have any questions about OCR qualifications or services (including administration, logistics and teaching) please feel free to get in touch with our customer support centre.

Call us on
01223 553998

Alternatively, you can email us on
support@ocr.org.uk

For more information visit

 **ocr.org.uk/qualifications/resource-finder**

 **ocr.org.uk**

 **facebook.com/ocrexams**

 **twitter.com/ocrexams**

 **instagram.com/ocrexaminations**

 **linkedin.com/company/ocr**

 **youtube.com/ocrexams**

We really value your feedback

Click to send us an autogenerated email about this resource. Add comments if you want to. Let us know how we can improve this resource or what else you need. Your email address will not be used or shared for any marketing purposes.



I like this



I dislike this



OCR is part of Cambridge University Press & Assessment, a department of the University of Cambridge.

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored. © OCR 2023 Oxford Cambridge and RSA Examinations is a Company Limited by Guarantee. Registered in England. Registered office The Triangle Building, Shaftesbury Road, Cambridge, CB2 8EA. Registered company number 3484466. OCR is an exempt charity.

OCR operates academic and vocational qualifications regulated by Ofqual, Qualifications Wales and CCEA as listed in their qualifications registers including A Levels, GCSEs, Cambridge Technicals and Cambridge Nationals.

OCR provides resources to help you deliver our qualifications. These resources do not represent any particular teaching method we expect you to use. We update our resources regularly and aim to make sure content is accurate but please check the OCR website so that you have the most up to date version. OCR cannot be held responsible for any errors or omissions in these resources.

Though we make every effort to check our resources, there may be contradictions between published support and the specification, so it is important that you always use information in the latest specification. We indicate any specification changes within the document itself, change the version number and provide a summary of the changes. If you do notice a discrepancy between the specification and a resource, please [contact us](#).

You can copy and distribute this resource freely if you keep the OCR logo and this small print intact and you acknowledge OCR as the originator of the resource.

OCR acknowledges the use of the following content: N/A

Whether you already offer OCR qualifications, are new to OCR or are thinking about switching, you can request more information using our [Expression of Interest form](#).

Please [get in touch](#) if you want to discuss the accessibility of resources we offer to support you in delivering our qualifications.