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Mock Paper Set 1

Paper 1 · Paper 2 · Paper 4 · Paper 5, with worked solutions and mark schemes

For the Cambridge International AS & A Level Chemistry 9701 syllabus (examinations 2025–2027). Papers 1 and 2: AS content (topics 1–22). Paper 4: A Level content (topics 23–37), drawing on AS knowledge. Paper 5: planning, analysis and evaluation.

What is inside this set

Paper	Format	Time	Marks
Paper 1 · Multiple Choice AS	40 four-option questions, one mark each	1 hour 15 minutes	40
Paper 2 · AS Level Structured Questions AS	5 compulsory structured questions; answer in the spaces provided	1 hour 15 minutes	60
Paper 4 · A Level Structured Questions A	9 compulsory structured questions; answer in the spaces provided	2 hours	100
Paper 5 · Planning, Analysis and Evaluation A	2 compulsory questions: planning an investigation and analysing experimental data	1 hour 15 minutes	30
Solutions	MCQ key with an explanation for every question; worked solutions and mark schemes for Papers 2, 4 and 5; topic map; self-check	–	–

Paper 3 (Advanced Practical Skills) is a hands-on laboratory examination with real apparatus, so it is not included in this book. The Data page after this cover has the important values and the Periodic Table for all four papers.

How to use this set

1. Sit each paper in one go, timed, with a calculator, ruler and pencil. No notes. Use only the Data page and any data printed in the question.
2. Write your answers on the paper (Paper 1: on the answer grid at the end of the paper).
3. Mark it yourself with the mark scheme: give a mark only where your answer matches a marking point. Each badge such as B1 is one mark.
4. Read the worked solution for every question you dropped marks on, then use the topic map to go back to the right chapter of the notes.

Mark-scheme labels

B1 independent mark
C1 compensatory (method) mark: awarded automatically when the final answer is correct
M1 method mark that a following A mark depends on
A1 answer mark (correct value with its unit)
grey notes: allow / ignore / do not allow; ecf = error carried forward

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Data page (for all four papers)

Important values, constants and standards

molar gas constant	$R = 8.31\ J\ K^{-1}\ mol^{-1}$
Faraday constant	$F = 9.65 \times 10^{4}\ C\ mol^{-1}$
Avogadro constant	$L = 6.022 \times 10^{23}\ mol^{-1}$
electronic charge	$e = -1.60 \times 10^{-19}\ C$
molar volume of gas	$V_m = 22.4\ dm^3\ mol^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\ dm^3\ mol^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\ mol^2\ dm^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\ kJ\ kg^{-1}\ K^{-1}$ ($4.18\ J\ g^{-1}\ K^{-1}$)

The Periodic Table of Elements

Group

Key: a = atomic (proton) number; X = atomic symbol; b = relative atomic mass (– = not given)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H 1.0																	2 He 4.0
2	3 Li 6.9	4 Be 9.0											5 B 10.8	6 C 12.0	7 N 14.0	8 O 16.0	9 F 19.0	10 Ne 20.2
3	11 Na 23.0	12 Mg 24.3											13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
4	19 K 39.1	20 Ca 40.1	21 Sc 45.0	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.8	27 Co 58.9	28 Ni 58.7	29 Cu 63.5	30 Zn 65.4	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 79.0	35 Br 79.9	36 Kr 83.8
5	37 Rb 85.5	38 Sr 87.6	39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 95.9	43 Tc –	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6	55 Cs 132.9	56 Ba 137.3	57–71 lanthanoids	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po –	85 At –	86 Rn –
7	87 Fr –	88 Ra –	89–103 actinoids	104 Rf –	105 Db –	106 Sg –	107 Bh –	108 Hs –	109 Mt –	110 Ds –	111 Rg –	112 Cn –	113 Nh –	114 Fl –	115 Mc –	116 Lv –	117 Ts –	118 Og –

lanthanoids	57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm –	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.1	71 Lu 175.0
actinoids	89 Ac –	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np –	94 Pu –	95 Am –	96 Cm –	97 Bk –	98 Cf –	99 Es –	100 Fm –	101 Md –	102 No –	103 Lr –

Any other data you need, such as bond energies, electrode potentials or spectroscopic data, is printed in the question that uses it. All values are from the syllabus Data section.

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CHEMISTRY — 9701 · Mock Set 1

Paper 1 Multiple Choice — *1 hour 15 minutes*

Name	Centre no.	Candidate no.

You will need: the answer grid at the end of this paper · soft pencil (type B or HB) · soft clean eraser · calculator

INSTRUCTIONS

- There are forty questions on this paper. Answer all questions.
- For each question there are four possible answers A, B, C and D. Choose the one you consider correct and record your choice in soft pencil on the answer grid.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.
- Important values and the Periodic Table are on the Data page at the front of this set.

1. Arsenic-75 forms the ion $^{75}As^{3-}$ in some of its compounds.
   Which row gives the numbers of subatomic particles in this ion?

	protons	neutrons	electrons
A	33	42	30
B	33	42	36
C	33	75	36
D	36	39	33

2. A sample of antimony has a relative atomic mass of 121.8. It contains only two isotopes, of relative isotopic masses 121.0 and 123.0.
   What percentage of the atoms have a relative isotopic mass of 121.0?

   A 40% B 50% C 60% D 80%

3. The first four ionisation energies of element X, in kJ mol^{-1}, are 577, 1820, 2740 and 11 600.
   What is the most likely formula of the oxide of X?

   A X_2O_3 B XO C XO_2 D X_2O

4. 10 cm³ of a gaseous hydrocarbon is sparked with 80 cm³ of oxygen, which is an excess. After cooling to room temperature, 60 cm³ of gas remains. Shaking this gas with aqueous sodium hydroxide leaves 20 cm³ of oxygen. All volumes are at one temperature and pressure.
   What is the molecular formula of the hydrocarbon?

   A C_4H_6 B C_4H_8 C C_4H_{10} D C_5H_8

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CHEMISTRY — 9701 · Mock Set 1

Paper 2 AS Level Structured Questions — *1 hour 15 minutes*

Name	Centre no.	Candidate no.

INSTRUCTIONS

- Answer all questions, in the spaces provided.
- You may use a calculator. Show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [ ].
- Important values and the Periodic Table are on the Data page at the front of this set.

Question 1

Barium carbonate, $BaCO_3$, is used in some ceramic glazes. When the glaze is fired in a kiln, the carbonate decomposes.

(a) (i) State the type of orbital (s, p or d) and the principal quantum number of the highest-energy occupied orbital in a barium atom in its ground state.

.....

[1]

(ii) A sample of barium contains the four isotopes shown in Table 1.1 and no others.

relative isotopic mass	134.9	135.9	136.9	137.9
abundance / %	9.0	8.0	11.0	72.0

Table 1.1

Calculate the relative atomic mass of barium in this sample. Give your answer to one decimal place.

A_r = ...

[2]

(iii) Explain why the isotopes of barium have the same chemical properties.

.....

[1]

(b) The first ionisation energy of barium is 502 kJ mol^{-1}. The first ionisation energy of magnesium is 736 kJ mol^{-1}.

Explain why the value for barium is lower.

.....

.....

[2]

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(c) (i) Give the equation, with state symbols, for the change when barium carbonate is heated strongly.

[1]

(ii) 3.95 g of pure barium carbonate is heated until it has fully decomposed. Calculate the volume of carbon dioxide formed, measured at room conditions.

volume = ... cm^3 [3]

(iii) State whether magnesium carbonate decomposes at a higher or a lower temperature than barium carbonate.

[1]

(d) (i) The solid product of (c)(i) is added to water and the mixture is stirred. Write an equation for the reaction, and suggest the pH of the solution formed.

[2]

(ii) Lumps of barium carbonate are added to dilute sulfuric acid. Bubbles form at first, but the reaction soon stops, even though both reactants are still present. Suggest why.

[1]

[Total: 14]

Question 2

Liquid household bleach contains sodium chlorate(I), NaClO, made from chlorine and cold aqueous sodium hydroxide.

(a) (i) Give the equation for the change when chlorine meets cold aqueous sodium hydroxide.

[1]

(ii) Use oxidation numbers to explain why this reaction is described as disproportionation.

[1]

(b) Chlorine is also added to drinking water. Give the equation for the change as it dissolves, forming a species that kills bacteria.

[1]

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Worked solutions and mark schemes

Mark your papers first, then read the explanations. Totals: Paper 1 = 40, Paper 2 = 60, Paper 4 = 100, Paper 5 = 30.

Paper 1 Multiple Choice: answer key

1 B	2 C	3 A	4 B	5 C	6 D	7 D	8 A	9 C	10 C
11 B	12 D	13 B	14 C	15 A	16 B	17 D	18 A	19 A	20 C
21 A	22 D	23 D	24 C	25 B	26 A	27 D	28 C	29 B	30 B
31 A	32 D	33 C	34 A	35 B	36 D	37 A	38 B	39 D	40 C

Key balance: A 10 · B 10 · C 10 · D 10. One mark for each correct answer.

Paper 1: worked solutions

1 **B**

Arsenic has proton number 33 (Periodic Table). Neutrons = 75 − 33 = 42. A 3− ion has three more electrons than protons: 33 + 3 = 36. A takes electrons away as if the ion were positive; C gives the mass number as the neutron number.

2 **C**

Let the abundance of the 121.0 isotope be y%. Then 121.0y + 123.0(100 − y) = 121.8 × 100, so 2y = 120 and y = 60%. A (40%) is the abundance of the heavier isotope. As a check, 121.8 is closer to 121.0 than to 123.0, so the lighter isotope must be the more abundant.

3 **A**

The big jump comes between the 3rd and 4th ionisation energies (2740 to 11 600), so X has three outer electrons, is in Group 13 and forms X^{3+}. With O^{2-} the formula is $\mathrm{X_2O_3}$. C would need four outer electrons; D would need the jump after the first ionisation energy.

4 **B**

Oxygen left = 20 cm³, so oxygen used = 80 − 20 = 60 cm³. Sodium hydroxide absorbs the carbon dioxide: 60 − 20 = 40 cm³ of $\mathrm{CO_2}$. For $\mathrm{C}_x\mathrm{H}_y + (\mathrm{x} + \frac{y}{4})\mathrm{O_2} \longrightarrow x\,\mathrm{CO_2} + (\frac{y}{2})\mathrm{H_2O}$, 10 cm³ gives 40 cm³ of $\mathrm{CO_2}$, so x = 4. Then x + y/4 = 60/10 = 6, so y = 8. Water is liquid after cooling, so it has no gas volume.

5 **C**

Mass of water lost = 4.93 − 2.41 = 2.52 g = 0.140 mol. $\mathrm{MgSO_4}$: M_r = 120.4, so 2.41 g = 0.0200 mol. Ratio water : salt = 0.140 : 0.0200 = 7. D is the value often remembered for washing soda; it does not fit these data.

6 **D**

HCl at the start = 0.0500 × 0.500 = 0.0250 mol. HCl left over = 0.0120 × 0.500 = 0.00600 mol. HCl used = 0.0190 mol. $\mathrm{CaCO_3 + 2\,HCl}$, so $\mathrm{CaCO_3}$ = 0.00950 mol = 0.00950 × 100.1 = 0.951 g, which is 79.2% of 1.20 g. A works from the HCl left over instead of the HCl used. B and C use the A_r of calcium, 40.1, instead of the M_r of calcium carbonate (C also misses the 1 : 2 ratio).

7 **D**

In NH_4Cl, NH_4^+ and Cl^- are held by ionic bonds; N–H bonds are covalent, and one of them forms when the lone pair of NH_3 is donated to H^+ (coordinate). A has ionic and covalent bonds only; $MgCl_2$ is treated as ionic; CH_3NH_2 is covalent with an unused lone pair.

8 **A**

H_3O^+ has three bond pairs and one lone pair around oxygen, so it is pyramidal, like NH_3. NO_3^-, SO_3 and BCl_3 each have three bonding regions and no lone pair on the central atom, so they are trigonal planar. The tempting error is to treat every "XY_3" species as pyramidal.

9 **C**

Propane is non-polar and has only instantaneous dipole–induced dipole forces. Ethanal is polar, so it has permanent dipole–permanent dipole forces as well. Ethanol has hydrogen bonds, the strongest of these forces. With similar numbers of electrons, the order is propane, ethanal, ethanol.

10 **C**

$M_r = \dfrac{mRT}{pV}$ with SI units: T = 127 + 273 = 400 K, p = 110 × 10^3 Pa, V = 260 × 10^{-6} m^3. M_r = 0.500 × 8.31 × 400 ÷ (110 × 10^3 × 260 × 10^{-6}) = 58.1. A uses the temperature in °C. B and D are half and double the correct value.

11 **B**

Iodine is a simple molecular lattice of I_2 molecules. When it sublimes the molecules separate, so only the weak instantaneous dipole–induced dipole forces are overcome; the covalent I–I bonds stay intact. C is the classic mistake of breaking covalent bonds in a physical change.

12 **D**

q = mcΔT = 150 × 4.18 × 22.0 = 13 794 J = 13.8 kJ. n = 0.600/60.0 = 0.0100 mol. ΔH = −13.8/0.0100 = −1380 kJ mol^{-1}. A is q itself, not per mole. C leaves out the specific heat capacity. (The accepted value is much more exothermic, because heat is lost in the real experiment.)

13 **B**

Bonds broken: C=C 610 and Br–Br 193 (total 803). Bonds formed: C–C 350 and two C–Br 560 (total 910). ΔH = 803 − 910 = −107 kJ mol^{-1}. The other C–H bonds cancel. C is "formed minus broken". D leaves out the new C–C bond. A leaves out the C=C to C–C change altogether.

14 **C**

Both the elements and the propene burn to the same products, so $\Delta H_f = \Sigma \Delta H_c$(reactants) − ΔH_c(product) = 3(−394) + 3(−286) − (−2058) = +18 kJ mol^{-1}. The equation is $3\,C + 3\,H_2 \longrightarrow C_3H_6$. A adds instead of subtracting the last term; D forgets the factors of 3.

15 **A**

N in NH_3 is −3; N in N_2O is +1: a rise of 4. In the others: $NO_2 \longrightarrow NO_3^-$ is +4 to +5 (rise of 1); $NH_3 \longrightarrow N_2$ is −3 to 0 (rise of 3); $N_2O \longrightarrow NO_2$ is +1 to +4 (rise of 3).

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Paper 2: worked solutions and mark scheme

1(a)(i)

Barium is in Period 6 and Group 2, so the outer electrons are in the 6s orbital.

Mark scheme · s orbital, principal quantum number 6 (allow 6s) B1

1(a)(ii)

A_r = (134.9 × 9.0 + 135.9 × 8.0 + 136.9 × 11.0 + 137.9 × 72.0) ÷ 100 = 13 736 ÷ 100 = 137.4.

Mark scheme · sum of (isotopic mass × abundance) divided by 100 C1

· 137.4 A1

1(a)(iii)

Chemical properties depend on the electrons, and isotopes have the same electronic configuration.

Mark scheme · same number of electrons / same electronic configuration (ignore "same protons" alone) B1

1(b)

Barium's outer electron is much further from the nucleus and is more shielded by inner shells, so it is held less strongly, although the nuclear charge is greater.

Mark scheme · the outer electron of Ba is further from the nucleus / in a higher shell (allow greater atomic radius) B1

· more shielding, which outweighs the greater nuclear charge, so less attraction for the outer electron B1

1(c)(i)

$\mathrm{BaCO_3\,(s) \longrightarrow BaO\,(s) + CO_2\,(g)}$

Mark scheme · correct equation with state symbols B1

1(c)(ii)

M_r of $\mathrm{BaCO_3}$ = 137.3 + 12.0 + 48.0 = 197.3. n = 3.95 ÷ 197.3 = 0.0200 mol. 1 mol gives 1 mol of $\mathrm{CO_2}$, so V = 0.0200 × 24.0 = 0.480 $\mathrm{dm^3}$ = 480 $\mathrm{cm^3}$.

Mark scheme · M_r = 197.3 C1

· n = 0.0200 mol C1

· 480 $\mathrm{cm^3}$ (ecf from the amount) A1

1(c)(iii)

Thermal stability increases down Group 2, so magnesium carbonate decomposes more easily.

Mark scheme · lower B1

1(d)(i)

$\mathrm{BaO\,(s) + H_2O\,(l) \longrightarrow Ba(OH)_2\,(aq)}$. Barium hydroxide is quite soluble and is a strong base.

Mark scheme · correct equation (state symbols not needed) B1

· pH 12–14 B1

1(d)(ii)

Barium sulfate is insoluble. It forms a layer on the lumps and stops the acid reaching the carbonate.

Mark scheme · insoluble barium sulfate coats the carbonate / prevents further contact with the acid B1

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2(a)(i)

$Cl_2 + 2\,NaOH \longrightarrow NaCl + NaClO + H_2O$

Mark scheme · correct equation (allow an ionic equation) B1

2(a)(ii)

Chlorine starts at 0. One Cl atom goes to −1 in NaCl (reduced) and the other to +1 in NaClO (oxidised).

Mark scheme · Cl from 0 to −1 and from 0 to +1: the same element is both oxidised and reduced B1

2(b)

$Cl_2 + H_2O \rightleftharpoons HOCl + HCl$. HOCl (and the ClO^- it forms) kills the bacteria.

Mark scheme · correct equation forming HOCl and HCl (allow → and ⇌) B1

2(c)(i)

$n(S_2O_3^{2-})$ = 0.01440 × 0.100 = 1.44 × 10^{-3} mol. Ratio I_2 : $S_2O_3^{2-}$ = 1 : 2, so $n(I_2)$ = 7.20 × 10^{-4} mol. Ratio ClO^- : I_2 = 1 : 1, so $n(ClO^-)$ = 7.20 × 10^{-4} mol.

Mark scheme · n(thiosulfate) = 1.44 × 10^{-3} mol C1
· $n(ClO^-)$ = 7.20 × 10^{-4} mol A1

2(c)(ii)

Concentration of B = 7.20 × 10^{-4} ÷ 0.0250 = 0.0288 mol dm^{-3}. The bleach was diluted by a factor of 250/10 = 25, so its concentration = 0.720 mol dm^{-3}. M_r of NaClO = 74.5, so 0.720 × 74.5 = 53.6 g dm^{-3}.

Mark scheme · 0.720 mol dm^{-3} in the original bleach (× 25 seen) C1
· 53.6 g dm^{-3} (ecf from (c)(i)) A1

2(d)(i)

Iodide ions are larger, so the outer electrons are further from the nucleus and more shielded. They are lost more easily.

Mark scheme · I^- is larger / has more shielding, so its outer electron is lost more easily B1

2(d)(ii)

Silver nitrate gives a white precipitate of AgCl and a cream precipitate of AgBr. AgCl dissolves in dilute ammonia; AgBr dissolves only in concentrated ammonia.

Mark scheme · NaCl: white precipitate; NaBr: cream precipitate B1
· the white precipitate dissolves in dilute ammonia; the cream one needs concentrated ammonia B1

3(a)

The carbonyl carbon has three bonding regions and no lone pair, so they spread out equally in a plane.

Mark scheme · trigonal planar B1
· 120° (allow 118–122°) B1

3(b)

Propan-2-ol has an O–H group and can form hydrogen bonds. Propanone molecules can only form weaker permanent dipole–permanent dipole forces with each other.

Mark scheme · propan-2-ol has hydrogen bonds, stronger than the permanent dipole forces in propanone B1