Topical Past Paper Workbook

AS & A Level Chemistry (9701) Paper 2

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Introduction

Each topical past paper book consists of hundreds of questions and their answer schemes, in the form of worksheets. Questions are assigned to each chapter according to their corresponding topic. Topics, in turn, are based on the items of the latest Cambridge IGCSE or AS/A level syllabus content. This book's specifications are as follows:

Title: AS & A Level Chemistry (9701) Paper 2 Topical Past Paper Workbook
Subtitle: Exam Practice Worksheets With Answer Scheme
Examination board: Cambridge Assessment International Education (CAIE)
Subject code: 9701
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Paper: 2 (Structured Questions)
Number of pages: 586
Number of questions: 177

Note: Chemistry (9701) Paper 2 consists of a variable number of questions of variable mark value. All questions will be based on the AS Level syllabus content.

Contents

Chapter 1

Atoms, molecules and stoichiometry

1.1 Reacting masses and volumes (of solutions and gases)

1. 9701_s17_qp_21 Q: 1

Combustion data can be used to calculate the empirical formula, molecular formula and relative molecular mass of many organic compounds.

(a) Define the term *relative molecular mass*.

....

....

....

.... [2]

(b) **T** is an alcohol, C_xH_yO. A gaseous sample of **T** occupied a volume of 20 cm^3 at 120 °C and 100 kPa.

The sample was completely burned in 200 cm^3 of oxygen (an excess). The final volume, measured under the same conditions as the gaseous sample, was 250 cm^3.

Under these conditions, all water present is vaporised. Removal of the water vapour from the gaseous mixture decreased the volume to 170 cm^3.

Treating the remaining gaseous mixture with concentrated alkali, to absorb carbon dioxide, decreased the volume to 110 cm^3.

The equation for the complete combustion of **T** can be represented as shown.

$$C_xH_yO + zO_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$

(i) Use the data given to calculate the value of *x*.

x = ... [1]

(ii) Use the data given to calculate the value of *y*.

y = ... [1]

If you were unable to calculate values for x and y then use $x = 4$ and $y = 10$ for the remaining parts of this question. These are **not** the correct values.

(iii) Complete the equation for the complete combustion of the alcohol, **T**.

.... + ...O_2 $\rightarrow$ ....CO_2 + ...H_2O

[1]

(iv) Give the skeletal formulae for two possible structures of **T**.

Name each alcohol.

....	....

[2]

(v) Use the general gas equation to calculate the mass of **T** present in the original 20 cm^3 gaseous sample, which was measured at 120 °C and 100 kPa.

Give your answer to **three** significant figures. Show your working.

mass = ... g [3]

[Total: 10]

2. 9701_m16_qp_22 Q: 2

Spathose is an iron ore that contains iron(II) carbonate, $FeCO_3$. The percentage of iron(II) carbonate in spathose can be determined by titration with acidified potassium dichromate(VI) solution using a suitable indicator.

The ionic equation is shown below.

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 6Fe^{3+}(aq) + 7H_2O(l)$$

(a) A 5.00 g sample of spathose was reacted with excess concentrated hydrochloric acid and then filtered.
The filtrate was made up to 250 cm^3 in a volumetric flask with distilled water.

A 25.0 cm^3 sample of the standard solution required 27.30 cm^3 of 0.0200 mol dm^{-3} dichromate(VI) solution for complete reaction.

(i) Calculate the amount, in moles, of dichromate(VI) ions used in the titration.

amount = ... mol [1]

(ii) Use your answer to **(i)** to calculate the amount, in moles, of Fe^{2+} present in the 25.0 cm^3 sample.

amount = ... mol [1]

(iii) Use your answer to **(ii)** to calculate the amount, in moles, of Fe^{2+} present in the 250 cm^3 volumetric flask.

amount = ... mol [1]

(iv) Use your answer to **(iii)** to calculate the mass of iron(II) carbonate present in the sample of spathose.

mass = ... g [2]

(v) Calculate the percentage of iron(II) carbonate in the sample of spathose.

percentage of iron(II) carbonate = ... % [1]

(b) Iron ores containing iron(III) compounds can be analysed using a similar method.

A standard solution of an aqueous iron(III) compound is reacted with aqueous tin(II) chloride. Aqueous tin(IV) chloride and aqueous iron(II) chloride are the products of this reaction.

(i) Write an **ionic** equation for this reaction. Do not include state symbols.

.... [2]

(ii) Any excess tin(II) chloride can be removed by reaction with $HgCl_2(aq)$. A white precipitate of Hg_2Cl_2 is produced.

Complete the equation for this reaction.

..........(.....) + ...$HgCl_2(aq)$ → $SnCl_4$(.....) + Hg_2Cl_2(.....)

[2]

[Total: 10]

3. 9701_w16_qp_21 Q: 1

A 0.17 g sample of a Group 14 chloride, $\mathbf{X}Cl_4$, reacted with water to produce an oxide, $\mathbf{X}O_2$, and HC*l*.

equation 1 $\mathbf{X}Cl_4(s) + 2H_2O(l) \rightarrow \mathbf{X}O_2(s) + 4HCl(aq)$

The HC*l* produced was absorbed in 100 cm^3 of 0.10 mol dm^{-3} sodium hydroxide solution (an excess).

In a titration, the unreacted sodium hydroxide solution required 30.0 cm^3 of 0.20 mol dm^{-3} hydrochloric acid for complete neutralisation.

(a) Calculate the amount, in moles, of hydrochloric acid used in the titration to neutralise the unreacted sodium hydroxide solution.

amount = ... mol [1]

(b) Write the equation for the reaction between hydrochloric acid and sodium hydroxide.

.... [1]

(c) Calculate the amount, in moles, of sodium hydroxide neutralised in the titration.

amount = ... mol [1]

(d) Calculate the amount, in moles, of sodium hydroxide that reacted with the HC*l* produced by the reaction in equation 1.

amount = ... mol [1]

(e) Calculate the amount, in moles, of HC*l* produced by the reaction in equation 1.

amount = ... mol [1]

(f) Calculate the amount, in moles, of **X**Cl_4 in the original 0.17 g sample.

amount = ... mol [1]

(g) Calculate the molecular mass, M_r, of **X**Cl_4.

M_r = ... [1]

(h) Calculate the relative atomic mass, A_r, of **X** and suggest its identity.

A_r of **X** = ...

identity of **X** ....

[2]

[Total: 9]

4. 9701_w16_qp_22 Q: 1

A 0.50 g sample of a Group 2 metal, **M**, was added to 40.0 cm^3 of 1.00 mol dm^{-3} hydrochloric acid (an excess).

equation 1 $\mathbf{M}(s) + 2HCl(aq) \rightarrow \mathbf{M}Cl_2(aq) + H_2(g)$

(a) Calculate the amount, in moles, of hydrochloric acid present in 40.0 cm^3 of 1.00 mol dm^{-3} HCl.

amount = ... mol [1]

(b) When the reaction had finished, the resulting solution was made up to 100 cm^3 in a volumetric flask.

A 10.0 cm^3 sample of the solution from the volumetric flask required 15.0 cm^3 of 0.050 mol dm^{-3} sodium carbonate solution, Na_2CO_3, for complete neutralisation of the remaining hydrochloric acid.

(i) Write the equation for the complete reaction of sodium carbonate with hydrochloric acid.

.... [1]

(ii) Calculate the amount, in moles, of sodium carbonate needed to react with the hydrochloric acid in the 10.0 cm^3 sample from the volumetric flask.

amount = ... mol [1]

(iii) Calculate the amount, in moles, of hydrochloric acid in the 10.0 cm^3 sample.

amount = ... mol [1]

(iv) Calculate the total amount, in moles, of hydrochloric acid remaining after the reaction shown in equation 1.

amount = ... mol [1]

(v) Use your answers to **(a)** and **(b)(iv)** to calculate the amount, in moles, of hydrochloric acid that reacted with the 0.50 g sample of **M**.

amount = ... mol [1]

(vi) Use your answer to **(v)** and equation 1 to calculate the amount, in moles, of **M** in the 0.50 g sample.

amount = ... mol [1]

(vii) Calculate the relative atomic mass, A_r, of **M** and identify **M**.

A_r of **M** = ...

identity of **M** = ...
[2]

[Total: 9]

Chapter 2

Atomic structure

2.1 Particles in the atom

5. 9701_s17_qp_22 Q: 1

The composition of atoms and ions can be determined from knowledge of atomic number, nucleon number and charge.

(a) Complete the table.

atomic number	nucleon number	number of electrons	number of protons	number of neutrons	symbol
3		2			$^{6}_{3}Li^{+}$
		23	26	32	

[2]

(b) Boron occurs naturally as a mixture of two stable isotopes, ^{10}B and ^{11}B. The relative isotopic masses and percentage abundances are shown.

isotope	relative isotopic mass	abundance / %
^{10}B	10.0129	19.78
^{11}B	to be calculated	80.22

(i) Define the term *relative isotopic mass*.

....

.... [2]

(ii) Calculate the relative isotopic mass of ^{11}B.

Give your answer to **six** significant figures. Show your working.

[2]

[Total: 6]

2.2 Electrons: energy levels, orbitals, ionisation, electron affinity

6. 9701_s20_qp_23 Q: 2

(a) Explain what is meant by the term *relative isotopic mass*.

....

....

.... [2]

(b) A sample of copper contains two isotopes, ^{63}Cu and ^{65}Cu. The relative atomic mass of the copper in this sample is 63.55.

Calculate the percentage abundance of each of these isotopes. Show your working.

percentage abundance of ^{63}Cu = ... %

percentage abundance of ^{65}Cu = ... %
[2]

(c) **(i)** Name the type of bonding within a sample of solid copper.

.... [1]

(ii) Draw a labelled diagram to show the bonding within a sample of solid copper.

[2]

(iii) State the electronic configuration of a copper atom.

$1s^2$ .... [1]

(d) A student is provided with a sample of hydrated copper(II) sulfate, $CuSO_4 \cdot xH_2O$, and is asked to determine the value of x.
The student dissolves a sample of the hydrated copper(II) sulfate in water and adds it to an excess of aqueous potassium iodide to make a total volume of 250.0 cm^3 of solution.

$$2CuSO_4 + 4KI \rightarrow 2CuI + I_2 + K_2SO_4$$

The amount of iodine produced during this reaction is found by titrating a sample of this solution with sodium thiosulfate solution.

25.0 cm^3 of the iodine-containing solution requires 20.0 cm^3 of 0.10 mol dm^{-3} sodium thiosulfate solution.

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

(i) Calculate the amount, in mol, of copper(II) sulfate present in the original sample of hydrated copper(II) sulfate.

Show your working.

amount of copper(II) sulfate = ... mol [2]

(ii) A total of 7.98 g of $CuSO_4$ is present in 10.68 g of $CuSO_4 \cdot xH_2O$.

Complete each row of the table to calculate the value of x, where x is an integer.

[M_r: $CuSO_4$,159.6]

amount of $CuSO_4$ in 10.68 g of $CuSO_4 \cdot xH_2O$	.... mol
amount of H_2O in 10.68 g of $CuSO_4 \cdot xH_2O$	.... mol
value of x	x = ...

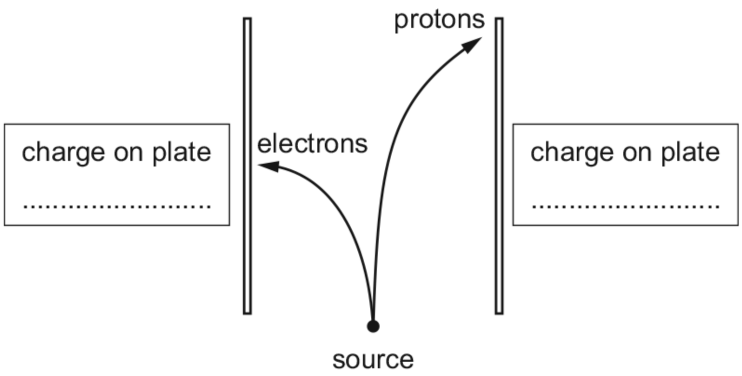
[3]

[Total: 13]

7. 9701_w20_qp_22 Q: 1

Atoms contain the subatomic particles electrons, protons and neutrons. Protons and electrons were discovered by observations of their behaviours in electric fields.

(a) The diagram shows the behaviour of separate beams of electrons and protons in an electric field.



(i) Complete the diagram with the relative charge of each of the electrically charged plates. [1]

(ii) On the diagram, draw a line to show how a separate beam of neutrons from the same source behaves in the same electric field. [1]

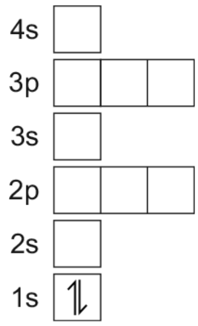
(b) Electrons in atoms up to $_{36}$Kr are distributed in s, p and d orbitals.

(i) State the number of occupied orbitals in an isolated atom of $_{36}$Kr.

type of orbital	s	p	d
number of orbitals			

[3]

(ii) Complete the diagram to show the number and relative energies of the electrons in an isolated atom of $_{14}Si$.



[2]

(iii) The diagram shows a type of orbital.

State the total number of electrons that exist in all orbitals of this type in an atom of $_{9}F$.

.... [1]

(iv) The first ionisation energies of elements in the first row of the d block ($_{21}Sc$ to $_{29}Cu$) are very similar. For all these elements, it is a 4s electron that is lost during the first ionisation.

Suggest why the first ionisation energies of these elements are very similar.

....

....

....

.... [3]

(c) *Hydron* is a general term used to represent the ions $^{1}_{1}H^{+}$, $^{2}_{1}H^{+}$ and $^{3}_{1}H^{+}$.

State, in terms of subatomic particles in the nucleus, what is the same about each of these ions and what is different.

same ....

different ....

[1]

[Total: 12]

8. 9701_s19_qp_23 Q: 1

(a) A sample contains three different types of atom: $^{40}_{18}Ar$, $^{40}_{19}K$ and $^{40}_{20}Ca$.

(i) State fully, in terms of the numbers of subatomic particles, what these three atoms have in common.

....

.... [1]

(ii) State fully, in terms of the numbers of **all** subatomic particles, how these three atoms **differ** from each other.

....

.... [1]

(b) A sample of sulfur contains only two isotopes, ^{32}S and ^{34}S. The relative atomic mass of this sample is 32.09.

isotope	isotopic mass
^{32}S	32.0
^{34}S	34.0

Calculate the percentage abundance of the isotopes present in this sample.

% abundance ^{32}S = ...

% abundance ^{34}S = ...
[3]

(c) The electronic configuration of a sulfur atom is $1s^2 2s^2 2p^6 3s^2 3p^4$.

(i) Identify which orbital in a sulfur atom has the lowest energy.

.... [1]

(ii) Sketch the shape of a p orbital.

[1]

(iii) During the process of ionisation a sulfur atom loses an electron.

$$S(g) \rightarrow S^+(g) + e^- \qquad \Delta H = 1000\,kJ\,mol^{-1}$$

Identify the orbital from which this electron is removed. Explain your answer.

orbital ....

explanation ....

....
[2]

(d) (i) Complete the diagram to show the arrangement of electrons within the third shell of a phosphorus atom.

3s		3p	
☐	☐	☐	☐

[1]

(ii) Explain why the first ionisation energy of sulfur is less than that of phosphorus.

....

....

....

.... [2]

[Total: 12]

9. 9701_s16_qp_21 Q: 1

(a) Complete the table to show the composition and identity of some atoms and ions.

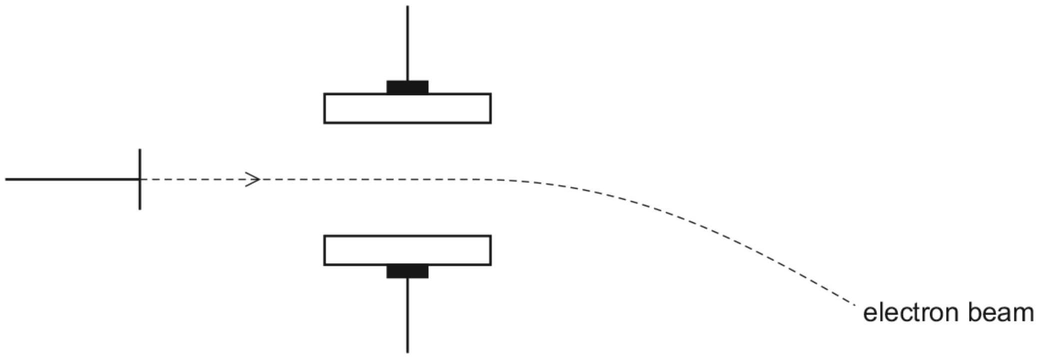
name of element	nucleon number	atomic number	number of protons	number of neutrons	number of electrons	overall charge
lithium	6	3	....	....	....	+1
oxygen	....	....	....	9	10	....
....	54	26	26	....	24	....
....	....	....	17	18	....	0

[4]

(b) Beams of protons, neutrons and electrons behave differently in an electric field due to their differing properties.

The diagram shows the path of a beam of electrons in an electric field.

Add and label lines to represent the paths of beams of protons and neutrons in the same field.



[3]

(c) The fifth to eighth ionisation energies of three elements in the third period of the Periodic Table are given. The symbols used for reference are **not** the actual symbols of the elements.

	ionisation energies, $kJ\,mol^{-1}$			
	fifth	sixth	seventh	eighth
X	6274	21269	25398	29855
Y	7012	8496	27107	31671
Z	6542	9362	11018	33606

(i) State and explain the group number of element **Y**.

group number ....

explanation ....

....

[1]

(ii) State and explain the general trend in **first** ionisation energies across the third period.

....

....

.... [2]

(iii) Explain why the **first** ionisation energy of element **Y** is less than that of element **X**.

....

....

....

.... [2]

(iv) Complete the electronic configuration of element **Z**.

$1s^2$ .... [1]

(d) A sample of strontium exists as a mixture of four isotopes. Information about three of these isotopes is given in the table.

mass number	86	87	88
abundance	9.86%	7.00%	82.58%

(i) Calculate the abundance of the fourth isotope.

abundance = ... % [1]

(ii) The relative atomic mass of this sample of strontium is 87.71.

Calculate the mass number of the fourth isotope.

mass number = ... [2]

[Total: 16]

10. 9701_s16_qp_22 Q: 1

(a) Complete the table to show the composition and identity of some atoms and ions.

name of element	nucleon number	atomic number	number of protons	number of neutrons	number of electrons	overall charge
boron	10	5	....	....	....	0
nitrogen	....	....	....	8	10	....
....	208	82	82	....	80	....
....	....	....	3	3	....	+1

[4]

(b) The fifth to eighth ionisation energies of three elements in the third period of the Periodic Table are given. The symbols used for reference are **not** the actual symbols of the elements.

	ionisation energies, $kJ\,mol^{-1}$			
	fifth	sixth	seventh	eighth
X	7012	8496	27 107	31 671
Y	6542	9362	11 018	33 606
Z	7238	8781	11 996	13 842

(i) State and explain the group number of element **Y**.

group number ....

explanation ....

.... [1]

(ii) State and explain the general trend in **first** ionisation energies across the third period.

....

....

.... [2]

(iii) Complete the electronic configuration of element **X**.

$1s^2$ .... [1]

(c) A sample of oxygen exists as a mixture of three isotopes. Information about two of these isotopes is given in the table.

mass number	16	17
abundance	99.76%	0.04%

(i) Calculate the abundance of the third isotope.

abundance = ... % [1]

(ii) The relative atomic mass of this sample of oxygen is 16.0044.

Calculate the mass number of the third isotope. You **must** show your working.

mass number = ... [2]

[Total: 11]

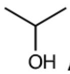
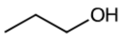
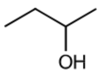
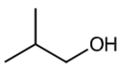
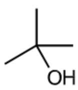
Chapter 3

Chemical bonding

Appendix A

Answers

1. 9701_s17_ms_21 Q: 1

(a)	The mass of a molecule OR the (weighted) average / (weighted) mean mass of the molecules	1
	Relative / compared to $\frac{1}{12}$ (the mass) of <u>an atom</u> of carbon–12 OR on a scale in which a carbon–12 atom / isotope has a mass of (exactly) 12 (units)	1
(b)(i)	**3**	1
(b)(ii)	**8**	1
(b)(iii)	$C_3H_8O + 4½O_2 \rightarrow 3CO_2 + 4H_2O$	1
(b)(iv)	 **AND** propan–2–ol / 2–propanol	1
	 **AND** propan–1–ol / 1–propanol	1
	Alternative answers (any two):  **AND** butan–1–ol / 1–butanol  **AND** butan–2–ol / 2–butanol  **AND** (2–)methylpropan–1–ol / (2–)methyl–1–propanol  **AND** (2–)methylpropan–2–ol / (2–)methyl–2–propanol	
(b)(v)	correct conversions of data to SI/consistent units p = 100 000 ; V = 20×10^{-6} ; T = 393	1
	calculation of *n (= pV/RT)* from M1 values $n = \frac{100 \times 10^3 \times 20 \times 10^{-6}}{8.31 \times 393}$	1
	calculation of mass *m (= n × Mr)* **AND** answer correct to **3sf** $m = 6.12 \times 10^{-4} \times 60 = 0.0367$ (g) Alternative answer for using $C_4H_{10}O$: $m = 6.12 \times 10^{-4} \times 74 = 0.0453$ (g)	1
	Total:	**10**

2. 9701_m16_ms_22 Q: 2

(a) (i)	$\frac{27.30}{1000} \times 0.020 = \mathbf{5.46 \times 10^{-4}}$ (mol)	[1]
(ii)	**(i)** × 6 = **3.28×10^{-3}** (mol)	[1]
(iii)	**(ii)** × $\frac{250}{25.00}$ = **3.28×10^{-2}** (mol)	[1]
(iv)	M_r of $FeCO_3$ = 55.8 + 12.0 + 3(16.0) = **115.8** **(iii)** × $M_r(FeCO_3)$ = **3.79** g	[1] [1]
(v)	$\frac{\text{(iv)}}{5.00} \times 100\%$ = **75.9%**	[1]
(b) (i)	$2Fe^{3+} + Sn^{2+} \rightarrow 2Fe^{2+} + Sn^{4+}$ species balancing	 [1] [1]
(ii)	**$SnCl_2$(aq)** + **2**$HgCl_2$(aq) → $SnCl_4$(**aq**) + Hg_2Cl_2(**s**) $SnCl_2$ AND 2 state symbols	 [1] [1]

3. 9701_w16_ms_21 Q: 1

(a)	6×10^{-3} (mol)	1	**1**
(b)	$NaOH + HCl \rightarrow NaCl + H_2O$	1	**1**
(c)	6×10^{-3} (mol)	1	**1**
(d)	4×10^{-3} (mol)	1	**1**
(e)	4×10^{-3} (mol)	1	**1**
(f)	1×10^{-3} (mol)	1	**1**
(g)	170	1	**1**
(h)	28(.0) Si/silicon	1 1	**2**
	Total:		**9**

4. 9701_w16_ms_22 Q: 1

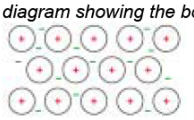
(a)	0.04 **OR** 4×10^{-2}	**1**
(b)(i)	$Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$	**1**
(b)(ii)	0.00075 **OR** 7.5×10^{-4}	**1**
(b)(iii)	0.0015 **OR** 1.5×10^{-3}	**1**
(b)(iv)	0.015 **OR** 1.5×10^{-2}	**1**
(b)(v)	0.025 **OR** 2.5×10^{-2}	**1**
(b)(vi)	0.0125 **OR** 1.25×10^{-2} **OR** 0.013 **OR** 1.3×10^{-2}	**1**
(b)(vii)	40 Ca / calcium	**1** **1**
	Total:	**9**

5. 9701_s17_ms_22 Q: 1

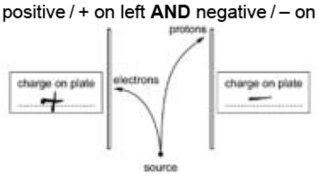
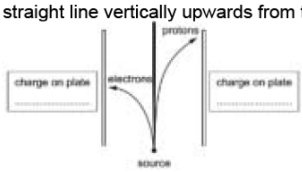
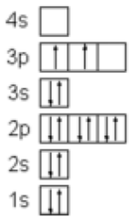
(a)	atomic number	nucleon number	number of electrons	number of protons	number of neutrons	symbol		2
		6		3	3		1	
						$^{58}_{26}Fe^{3+}$	1	

(b)(i)	EITHER mass of an atom / isotope relative / compared to 1/12 (the mass) of (an atom of) C-12 OR on a scale in which a C-12 (atom / isotope) has (a mass of exactly) 12 (units) OR mass of one mol (of atoms) of an isotope relative / compared to 1/12 (the mass) of 1 mol of C-12 OR on a scale in which one mol C-12 (atom / isotope) has a mass of (exactly) 12 g	 1 1	2
(b)(ii)	$\frac{(10.0129 \times 19.78) + (80.22x)}{100} = 10.8$		1
	x = 10.9941		1
	Total:		6

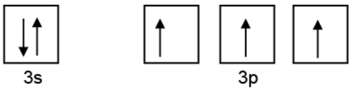
6. 9701_s20_ms_23 Q: 2

(a)	**EITHER** **M1** mass of an atom / isotope **M2** relative / compared to 1/12 (the mass) of (an atom of) C-12 OR on a scale in which a C-12 (atom / isotope) has (a mass of exactly) 12 (units) **OR** **M1** mass of one mol (of atoms) of an isotope **M2** relative / compared to 1/12 (the mass) of 1 mol of C-12 OR in which one mol C-12 (atom / isotope) has a mass of (exactly) 12 g	2
(b)	% abundance of ^{63}Cu = 72.5% % abundance of ^{65}Cu = 27.5% **M1** *correct algebraic expression AND correct calculation of x for one isotope* % ab of ^{63}Cu = x (x/100 × 63) + ((1- x)/100 × 65) = 63.55 so x =72.5 OR % ab of ^{65}Cu = x (1- x)/100 × 63) + x/100 × 65) = 63.55 so x = *27.5* **M2** *calculation of abundance of other isotope by 100- x*	2
(c)(i)	metallic	1
(c)(ii)	*diagram showing the bonding in a sample of copper*  **M1** diagram shows regular arrangement of spheres labelled as positively charged ions / +2 or +1 / cations **M2** diagram shows surrounded by electrons and clearly labelled as 'delocalised electrons'	3
(c)(iii)	($1s^2$) $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^{10}$ $4s^1$ **OR** ($1s^2$) $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^1$ $3d^{10}$	1
(d)(i)	**M1** *calculate the number mol $S_2O_3^{2-}$ added* 20/1000 x 0.10 = 2×10^{-3} = 0.002 (mol $S_2O_3^{2-}$) **M2** *calculate number mol $CuSO_4$ in 250cm^3* (1mol $S_2O_3^{2-}$: 1 mol $CuSO_4$) = 0.002 mol $CuSO_4$ in 25cm^3 so 0.02 mol $CuSO_4$ in 250cm^3	2
(d)(ii)	**M1** amount of $CuSO_4$ in 10.68 g of $CuSO_4 \cdot xH_2O$: 7.98 / (159.6) = <u>0.05</u> (mol) **M2** amount of H_2O in 10.68 g of $CuSO_4 \cdot xH_2O$: (10.68 – 7.98) / 18 = 2.7 / 18 =) <u>0.15</u> (mol) **M3** value of **x**: (mol H_2O ÷ mol $CuSO_4$ =) 3	3

7. 9701_w20_ms_22 Q: 1

<table>
<tr><td>(a)(i)</td><td>positive / + on left AND negative / – on right

</td><td>1</td></tr>
<tr><td>(a)(ii)</td><td>straight line vertically upwards from the source

</td><td>1</td></tr>
<tr><td>(b)(i)</td><td><table><tr><td>type of orbital</td><td>s</td><td>p</td><td>d</td></tr><tr><td>number of orbitals</td><td>4</td><td>9</td><td>5</td></tr></table></td><td>3</td></tr>
<tr><td>(b)(ii)</td><td>
</td><td>2</td></tr>
<tr><td>(b)(iii)</td><td>5</td><td>1</td></tr>
<tr><td>(b)(iv)</td><td>Award one mark for each correct bullet point – max 3 marks
• nuclear charge increases
• extra electron(s) in inner shell / n=3 /d-subshell / d- orbital
• increased shielding (of 4s electrons by electrons in n=3 / 3rd shell / 3d)
• (overall) similar nuclear attraction (for outer electron)</td><td>3</td></tr>
<tr><td>(c)</td><td>answer in terms of subatomic particles in the nucleus
same (number of) protons
AND
different (number of) neutrons</td><td>1</td></tr>
</table>

8. 9701_s19_ms_23 Q: 1

(a)(i)	All have the same nucleon number OR same sum / **total** number of protons + neutrons	**1**
(a)(ii)	(different) number of protons, neutrons **and** electrons	**1**
(b)	**M1** *x* / 100 □ 32 + (100–*x* / 100 □ 34) = 32.09 **M2** (32*x* + 3400 – 34*x*) = 3209 so *x* = 95.5 **M3** S^{32} 95.5% **AND** S^{34} 4.5%	**3**
(c)(i)	1s	**1**
(c)(ii)	 OR 	**1**
(c)(iii)	**M1** 3p **M2** It is less attracted to the nucleus (so takes less energy to lose) OR It is the highest energy orbital (which is occupied) / it is in the highest energy orbital	**2**
(d)(i)		**1**
(d)(ii)	**M1** (in S, the electron is removed from the) 2 electrons in (3)**p** orbital OR a pair of electrons in (3)**p** (orbital / sub-shell) **M2** (paired electrons) repel	**2**

9. 9701_s16_ms_21 Q: 1

(a)

name of element	nucleon no.	atomic no.	no. of protons	no. of neutrons	no. of electrons	overall charge	
lithium	6	3	3	3	2	+1	[1]
oxygen	17	8	8	9	10	–2	[1]
iron	54	26	26	28	24	+2	[1]
chlorine	35	17	17	18	17	0	[1]

(b)	line straight on labelled 'neutrons' line (curving) up labelled 'protons' proton line clearly shows less (overall) deflection than electron curve	[1] [1] [1]
(c) (i)	Group 16 / 6 / VI AND Big (owtte) increase / big difference / big gap / big jump / jump in increase / jump in difference after 6th IE	[1]
(ii)	increases (across period) due to increasing attraction (of nucleus for electrons) due to increasing nuclear charge / atomic / proton number AND constant/similar shielding / same (outer / number of) shell / energy level	[1] [1]
(iii)	electron (pair) repulsion (**Y** has a) pair of electrons in a (3)<u>p orbital</u> / a (3)<u>p orbital</u> is full ORA	[1] [1]
(iv)	$(1s^2)2s^22p^63s^23p^5$	[1]
(d) (i)	0.56(%)	[1]
(ii)	$\frac{(A\times0.56)+(86\times9.86)+(87\times7.00)+(88\times82.58)}{100}=87.71$ *A* = 84	[1] [1]

10. 9701_s16_ms_22 Q: 1

(a)	see table below	[1] [1] [1] [1]
(b) (i)	Group 17 / VII / 7 AND big (owtte) increase / big difference / big gap / big jump / jump in increase / jump in difference after 7th IE	[1]
(ii)	increases across period due to increasing attraction (of nucleus for electrons) due to increasing nuclear charge / atomic / proton number AND constant / similar shielding / same (outer) shell / energy level	[1] [1]
(iii)	$1s^2 2s^2 2p^6 3s^2 3p^4$	[1]
(c) (i)	(100 – 99.76 – 0.04=) 0.2	[1]
(ii)	$\frac{0.2x + (99.76 \times 16) + (0.04 \times 17)}{100} = 16.0044$ x = 18	[1] [1]

(a)

name of element	nucleon number	atomic number	number of protons	number of neutrons	number of electrons	overall charge	
boron	10	5	5	5	5	0	[1]
nitrogen	15	7	7	8	10	–3	[1]
lead	208	82	82	126	80	+2	[1]
lithium	6	3	3	3	2	+1	[1]