Atomic Structure Answers

Qu	Part	Sub Part	Marking Guidance	Mark	Comments
8	a		Mass number = number of protons + neutrons (in the nucleus/atom) 7 protons <u>and</u> 7 electrons 8 neutrons	1 1 1	Not in a substance or compound or element
8	b		<u>Average/mean mass of (1) atom(s) (of an element)</u> 1/12 mass of one atom of ^{12}C ***OR*** <u>(Average) mass of one mole of atoms</u> 1/12 mass of one mole of ^{12}C ***OR*** <u>(Weighted) average mass of all the isotopes</u> 1/12 mass of one atom of ^{12}C ***OR*** Average mass of an atom/isotope compared to C-12 on a scale in which an atom of C-12 has a mass of 12 <u>(95.12 x 14) + (4.88 x 15)</u> 100 = 14.05	1 1 1 1	Accept answer in words Can have top line x 12 instead of bottom line ÷12 Allow 95.12 + 4.88 instead of 100 If not to 2 d.p. then lose last mark Not 14.04

8	c		^{15}N is heavier / ^{15}N has a bigger m/z / different m/z values Electromagnet/ electric field/ magnet /accelerating potential or voltage / electric current	1 1	Not different no's of neutrons Not ionisation potential
8	d		No difference Same no of electrons (in outer orbital/shell/sub shell)/ same electron configuration	1 1	 M2 dependent on M1 Not just electrons determine chemical properties Ignore protons

Question	Part	Sub Part	Marking Guidance	Mark	Comments
1	(a)		$2s^2 2p^6 3s^1$	1	$1s^2$ can be rewritten Allow $2s^2 2p_x^2 2p_y^2 2p_z^2 3s^1$ Allow subscripts and capitals
1	(b)	(i)	Energy/enthalpy (needed) to remove one mole of electrons from one mole of atoms/compounds/molecules/elements ***OR*** Energy to form one mole of positive ions from one mole of atoms ***OR*** Energy/enthalpy to remove one electron from one atom In the gaseous state (to form 1 mol of gaseous ions)	1 1	Energy given out loses M1 M2 is dependent on a reasonable attempt at M1 Energy needed for this change $X(g) \rightarrow X^+(g) + e^{(-)}$ = 2 marks This equation alone scores one mark
1	(b)	(ii)	$Mg^+(g) \rightarrow Mg^{2+}(g) + e^{(-)}$ $Mg^+(g) + e^{(-)} \rightarrow Mg^{2+}(g) + 2e^{(-)}$ $Mg^+(g) - e^{(-)} \rightarrow Mg^{2+}(g)$	1	Do not penalise MG Not equation with X
1	(b)	(iii)	Electron being removed from a positive ion (therefore need more energy)/ electron being removed is closer to the nucleus/Mg^+ smaller (than Mg)/Mg^+ more positive than Mg	1	Allow from a + particle/ species Not electron from a higher energy level/or higher sub-level More protons = 0
1	(b)	(iv)	Range from 5000 to 9000 kJ mol^{-1}	1	
1	(c)		Increase Bigger nuclear <u>charge</u> (from Na to Cl)/more <u>protons</u> electron (taken) from same (sub)shell/ similar or same shielding/ electron closer to the nucleus/smaller atomic radius	1 1 1	If decrease CE = 0/3 If blank mark on QWC If no shielding = 0 Smaller ionic radius = 0

Question	Part	Sub Part	Marking Guidance	Mark	Comments
5	(a)		Average/mean mass of (1) atom(s) (of an element) 1/12 mass of one atom of ^{12}C ***OR*** (Average) mass of one mole of atoms 1/12 mass of one mole of ^{12}C ***OR*** (Weighted) average mass of all the isotopes 1/12 mass of one atom of ^{12}C ***OR*** Average mass of an atom/isotope compared to C-12 on a scale in which an atom of C-12 has a mass of 12	1 1 This expression = 2 marks	If moles and atoms mixes Max = 1
5	(b)		d block [Ar] $3d^2 4s^2$ 27	1 1 1	Allow 3d/D Other numbers lose M1 Ignore transition metals Can be written in full Allow subscripts $3d^2$ and $4s^2$ can be in either order

5	(c)		$\frac{(90x9) + (91x2) + (92x3) + (94x3)}{17}$ (= 1550) (or ∑ their abundances)	1 1	If one graph reading error lose M1 and allow consequential M2 and M3. If 2 GR errors penalise M1 and M2 but allow consequential M3 If not 17 or ∑ their abundances lose M2 and M3
			=91.2	1	91.2 = 3 marks provided working shown.
			Zr/ Zirconium	1	M4 -allow nearest consequential element from M3 accept Zr in any circumstance
5	(d)		High energy electrons/bombarded or hit with electrons	1	accept electron gun
			knocks out electron(s) (to form ions)	1	
			Z^+ = 90 deflected most	1	If not 90 lose M3 and M4 If charge is wrong on 90 isotope lose M3 only Accept any symbol in place of Z
			since lowest mass/lowest m/z	1	Allow lightest
5	(e)		(ions hit detector and) cause current/(ions) accept electrons/cause electron flow	1	QWC
			bigger current = more of that isotope/current proportional to abundance	1	Implication that current depends on the number of ions

Question	Marking Guidance	Mark	Comments
1(a)(i)	Different number / amount of neutrons	1	Not different neutrons Ignore same protons and/or electrons CE incorrect statement relating to protons / electrons
1(a)(ii)	Same electron configuration / same number of electrons (in the outer shell)	1	Ignore same no of protons Ignore electrons determine chemical properties CE if wrong statement relating to protons / neutrons
1(b)	<u>Average mass of 1 atom (of an element)</u> 1/12 mass atom of ^{12}C OR <u>Average/mean mass of atoms of an element</u> 1/12 mass of one atom of ^{12}C OR <u>(Average) mass of one mole of atoms</u> 1/12 mass of one mole of ^{12}C OR <u>(Weighted) average mass of all the isotopes</u> 1/12 mass of one atom of ^{12}C OR Average mass of an atom/isotope compared to C-12 on a scale in which an atom of C-12 has a mass of 12	1 1	If moles and atoms mixes Max = 1 Mark top and bottom line independently 1/12 on bottom line can be represented as x 12 on top line This expression = 2 marks

1 (c) (i)	$\frac{(64 \times 12) + (66 \times 8) + (67 \times 1) + (68 \times 6)}{27}$ ($= \frac{1771}{27}$) $= \underline{65.6}$	1 1 1	If not 27 max 1 mark (for top line) Mark is for dividing by 27 or string If **evidence** of arithmetic or transcription error seen in M1 or M2 allow consequential M3 and consequential 1(c)(ii) 65.6 = 3 marks
1(c)(ii)	$^{64}Zn^{+}$	1 1	M1 for identifying Zn / zinc M2 is for the + sign and the 64 M2 is dependent on M1
1(d)	Size of the charge (on the ion) / different charges / different *m/z*	1	Allow forms 2+ ions QWC
1(e)	(ions hit detector and) cause current/(ions) accept electrons/cause electron flow/electric pulse caused bigger current = more of that isotope/current proportional to abundance	1 1	 Implication that current depends on the number of ions M2 dependent on M1

Question	Marking Guidance	Mark	Comments
2(a)	$\underline{4d^{10}\,5s^2\,5p^1}$ in any order	1	Allow subscripts for numbers Allow capitals
2(b)(i)	Using an electron gun / (beam of) high energy/fast moving electrons	1	Ignore 'knocks out an electron'
2(b)(ii)	$In(g) + e^- \rightarrow In^+(g) + 2e^-$ ***OR*** $In(g) \rightarrow In^+(g) + e^-$ $In(g) - e^- \rightarrow In^+(g)$	1	The state symbols need not be present for the electron- but if they are they must be (g) No need to show charge on electron If I CE = 0 Ignore any equations using M
2(b)(iii)	So no more than 1 electron is knocked out/ so only one electron is knocked out/ prevent further ionisation	1	Allow stop 2+ and 3+/other ions being formed Not to get wrong m/z
2(b)(iv)	Any two processes from • Accelerate (owtte) • Deflect (owtte) • Detect (owtte)	2 max	Ignore wrong causes of process

2(c)(i)	<u>Average/mean mass of (1) atom(s) (of an element)</u> 1/12 mass of one atom of ^{12}C ***OR*** <u>(Average) mass of one mole of atoms</u> 1/12 mass of one mole of ^{12}C ***OR*** <u>(Weighted) average mass of all the isotopes</u> 1/12 mass of one atom of ^{12}C ***OR*** Average mass of an atom/isotope compared to C-12 on a scale in which an atom of C-12 has a mass of 12	1 1	Not average mass of 1 molecule Allow the wording Average mass of 1 atom of an element compared to 1/12 mass atom of ^{12}C (or mass 1/12 atom of ^{12}C) Allow if moles of atoms on both lines Accept answer in words Can have top line x 12 instead of bottom line ÷12 If atoms/moles mixed, max = 1
2(c)(ii)	$\frac{113x + 115y}{x + y} = 114.5$ ratio (113:115) = 1:3 **OR** 25:75 **OR** 0.5:1.5 etc	1 1	Allow idea that there are 4 x 0.5 divisions between 113 and 115 Correct answer scores M1 and M2 If 1:3 for In(115): In(113), max = 1
2(d)	None Same no of electrons (in the outer shell)/same electron configuration	1 1	 Ignore electrons determine chemical properties/ ignore protons M2 dependent on M1 being correct

2(e)	29.0% /29% O $\frac{69.2}{114.8/114.5}$ $\frac{1.8}{1}$ $\frac{29.0}{16}$ or 0.603 1.8 1.81 1 3 3 EF = In H_3O_3	1 1 1	If no O calculated, allow M2 if In and H divided by the correct A_r Allow $In(OH)_3$ Do not allow last mark just for ratio 1:3:3 If InO_3H_3 given with no working then allow 3 marks If I not In, lose M3

Question	Marking Guidance	Mark	Comments
1(a)	37 48	1 1	These answers only. Allow answers in words. Ignore any sum(s) shown to work out the answers.
1(b)(i)	Electron gun / high speed/high energy electrons Knock out electron(s)	1 1	Not just electrons. Not highly charged electrons. Remove an electron.
1(b)(ii)	$Rb(g) \rightarrow Rb^{+}(g) + e^{(-)}$ ***OR*** $Rb(g) + e^{(-)} \rightarrow Rb^{+}(g) + 2e^{(-)}$ ***OR*** $Rb(g) - e^{(-)} \rightarrow Rb^{+}(g)$	1	Ignore state symbols for electron.
1(c)	Rb is a bigger (atom) / e further from nucleus / electron lost from a higher energy level/ More shielding in Rb / less attraction of nucleus in Rb for outer electron / more shells	1	Answer should refer to Rb not Rb molecule. If converse stated it must be obvious it refers to Na Answer should be comparative.
1(d)(i)	s / block s / group s	1	Only
1(d)(ii)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^1$	1	Allow $3d^{10}$ before $4s^2$ Allow in any order.

1(e)	$\frac{(85 \times 2.5) + 87 \times 1}{3.5}$ = 85.6 ***OR*** $\frac{(85 \times 5) + 87 \times 2}{7}$ = 85.6	1 1 1 1 1 1	M1 is for top line Only ***OR*** M1 ^{85}Rb 71.4% and ^{87}Rb 28.6% M2 divide by 100 M3 = 85.6
1(f)	Detector Current / digital pulses / electrical signal related to abundance	1 1	Mark independently. Allow detection (plate). Not electrical charge.
1(g)	Smaller Bigger nuclear charge / more protons in Sr Similar/same shielding	1 1 1	Chemical error if not smaller, CE = 0/3 If blank mark on. Not bigger nucleus. QWC (Outer) electron entering same shell/sub shell/orbital/same number of shells. Do not allow incorrect orbital.

Question	Marking Guidance	Mark	Comments
7(a)	$\frac{(82 \times 2) + (83 \times 2) + (84 \times 10) + (86 \times 3)}{17}$ $\left(\frac{1428}{17}\right)$	1 1	M1 for the top line M2 is for division by 17
	= 84.0	1	Not 84 No consequential marking from M1 or M2 Ignore units
	The A_r in the Periodic table takes account of the other isotopes / different amounts of isotopes (or words to that effect regarding isotopes)	1	Award independently Comparison implied Isotope(s) alone, M4 = 0
7(b)	(Beam of electrons from) an electron gun / high speed / high energy electrons	1	
	Knocks out electron(s) (to form a positive ion)	1	
	$Kr(g) + e^- \rightarrow Kr^+(g) + 2e(^-)$	1	State symbols must clearly be (g)
	OR		
	$Kr(g) \rightarrow Kr^+(g) + e(^-)$ / $Kr(g) - e(^-) \rightarrow Kr^+(g)$		
	The ^{84}Kr isotope	1	One mark for identifying the 84 isotope
	Has 2 electrons knocked out / gets a 2+ charge	1	One mark for the idea of losing 2 electrons (from this isotope)

Question	Marking Guidance	Mark	Comments
1(a)	Average/mean mass of 1 atom (of an element) 1/12 mass of one atom of ^{12}C ***OR*** Average/mean mass of atoms of an element 1/12 mass of one atom of ^{12}C ***OR*** Average/mean mass of atoms of an element x12 mass of one atom of ^{12}C ***OR*** (Average) mass of one mole of atoms 1/12 mass of one mole of ^{12}C ***OR*** (Weighted) average mass of all the isotopes 1/12 mass of one atom of ^{12}C ***OR*** Average mass of an atom/isotope (compared to C-12) on a scale in which an atom of C-12 has a mass of 12	1 1	If moles and atoms mixed, max = 1 Mark top and bottom line independently. All key terms must be present for each mark. This expression = 2 marks.
1(b)	$\frac{(70x3) + (72x4) + 73 + (74x5)}{13} = \frac{941}{13}$ $= 72.4$	1 1 1	72.4 only.
1(c)	$^{(72)}Ge^{+}$ or germanium^{+}	1	Must show '+' sign. Penalise wrong mass number.

1(d)	70 Lowest mass / lowest m/z	1 1	If M1 incorrect or blank CE = 0/2 Ignore symbols and charge even if wrong. Accept lightest. Accept fewest neutrons.
1(e)	Electron(s) transferred / flow (at the detector) (From detector / plate) to the (+) ion	1 1	M1 must refer to electron flow at the detector. If M1 incorrect CE = 0/2 Do not allow from a charged plate.
1(f)	They do not have the same electron configuration / they have different number of electrons (in the outer shell)	1	Ignore electrons determine the properties of an atom. Ignore they are different elements or different number of protons.

Question	Marking Guidance	Mark	Comments
1(a)(i)	1.6734×10^{-24} (g) 1.6734×10^{-27} kg	1	Only. Not 1.67×10^{-24} (g)
1(a)(ii)	**B**	1	
1(b)(i)	$\frac{10x + 11y}{x + y} = 10.8$ **OR** ratio 10:11 = 1:4 **OR** 20:80 etc abundance of ^{10}B is 20(%) **OR** $\frac{10x}{100} + \frac{11(100-x)}{100} = 10.8$ $10x + 1100 - 11x = 1080$ $\therefore x = 1100 - 1080 = 20\%$	1 1	Allow idea that there are 5 × 0.2 divisions between 10 and 11 Correct answer scores M1 and M2
1(b)(ii)	Same number of electrons (in outer shell or orbital) Same electronic configuration / arrangement	1	Ignore electrons determine chemical properties. Ignore protons unless wrong.

1(c)	Range between 3500 and 10 000 kJ mol^{-1}	1	
1(d)	$B^{+}(g) \longrightarrow B^{2+}(g) + e^{(-)}$ $B^{+}(g) - e^{(-)} \longrightarrow B^{2+}(g)$ $B^{+}(g) + e^{(-)} \longrightarrow B^{2+}(g) + 2e^{(-)}$	1	Ignore state symbol on electron even if wrong.
1(e)	Electron being removed from a positive ion (therefore need more energy) / electron being removed is closer to the nucleus	1	Must imply removal of an electron. Allow electron removed from a + particle/ species or from a 2+ ion. Not electron removed from a higher/lower energy level / shell. Not electron removed from a higher energy sub-level / orbital. Ignore electron removed from a lower energy sub-level / orbital. Ignore 'more protons than electrons'. Not 'greater nuclear charge'. Ignore 'greater effective nuclear charge'. Ignore shielding.

Question	Marking Guidance	Mark	Comments
2(a)	$5s^2\ 4d^{10}\ 5p^4$ / $4d^{10}\ 5s^2\ 5p^4$	1	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^4$ or $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p^4$ Allow any order but must finish with $5p^4$
2(b)(i)	$\frac{(124 \times 2) + (126 \times 4) + (128 \times 7) + (130 \times 6)}{19}$ or $\frac{2428}{19}$ 127.8 Or $\frac{(124 \times 10.5) + (126 \times 21.1) + (128 \times 36.8) + (130 \times 31.6)}{100}$ 127.8	1 1 1 Or 1 1 1	M1 for top line M2 for correct denominator 127.8 with no working shown scores 3 marks Mark for 100 dependent on top line correct
2(b)(ii)	Other isotopes present/some isotopes absent /different abundances of isotopes	1	
2(c)	$Te^+ + e^{(-)} \rightarrow Te$	1	Ignore state symbols Allow $Te^{2+} + 2e^{(-)} \rightarrow Te$

2(d)	128 Most abundant ion (QoL – superlative)	1 1	Only M2 dependent on correct M1
2(e)	2+ ion formed / 2 electrons removed From ^{128} (Te)	1 1	Due to $^{128}Te^{2+}$ = 2 marks Mark independently

2(f)	Same (Each isotope has the) same number of protons/same nuclear charge <u>and</u> same number of electrons / electronic configuration	1 1	If not same CE = 0/2 Ignore more neutrons in ^{130}Te