Question Number	Acceptable Answers	Reject	Mark
1 (a)	Atoms (of an element) with the same number of protons **(1)** But with different number of neutrons **(1)** Same atomic number but different mass number only = **(1)** Element(s) with same number of protons but different number of neutrons = **(1)** max Ignore comments on electrons unless incorrect in which case award max 1		**2**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(i)	(Electric field) **accelerates** ions		**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b) (ii)	(Magnetic field) **deflects** / changes direction of / bends the beam of ions if the term 'ions' is missing or an incorrect term is used e.g. 'atoms', penalise only once in parts b (i) and b (ii)	just bends ions	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (c)	% abundance = (135 x 9.01 + 136 x 10.81 + 137 x 12.32 + 138 x 67.86) /100 **(1)** = 137.4 **(1)** ignore units Allow TE for one slip in transfer of data from question Correct answer scores **(2)**	Just 137 as final answer 137.39 137.3903 137.390	**2**

Question Number	Acceptable Answers	Reject	Mark
1 (d)	three peaks (caused by Br_2^+ ions) **(1)** because ions (^{79}Br-^{79}Br)$^{(+)}$ and (^{81}Br-^{79}Br)$^{(+)}$ / (^{79}Br-^{81}Br)$^{(+)}$ and (^{81}Br-^{81}Br)$^{(+)}$ **(1)** Mark independently		**2**

Question Number	Acceptable Answers	Reject	Mark
1 (e)	Any one analysis of material from space / drug testing in sport / identify breakdown products from drugs in body / quality control in pharmaceutical industry / identify molecules from sample with potential biological activity / radioactive dating with context e.g determine age of fossils / human remains The uses above must have a context / determining M_r of a molecule / evidence for structure from fragmentation pattern		**1**

Question Number	Acceptable Answers	Reject	Mark
2(a)(i)	**The mark is for the idea of impact by high energy electrons** **Any ONE of:** High-energy electrons Bombard with electrons Fast electrons (fired at sample) Accelerated electrons (fired at sample) (High-energy) electrons fired (at sample) (Sample) blasted with electrons Electron gun ALLOW "beam of electrons" IGNORE any comments (correct or incorrect) re subsequent ionization of the sample	High-**density** electrons	**1**

Question Number	Acceptable Answers	Reject	Mark
2(a)(ii)	Electric field /electrostatic field / charged plates /voltage plates	**Positively-charged** plates /electronic field /electric current /(electro) magnetic field / electric coil	**1**

Question Number	Acceptable Answers	Reject	Mark
2(a)(iii)	Magnetic field/magnet / electromagnet /magnetic plates/ electromagnetic field	**"Negative** magnetic field"/ negatively-charged magnet	**1**

Question Number	Acceptable Answers	Reject	Mark
2(b)	(Molecular mass of a substance is) that of the molecular ion/parent ion OR (m/e value for) peak/ion of largest mass OR (m/e value for) peak/ion furthest to the right ALLOW “last peak”/“peak at the end”	Highest peak/ tallest peak/ comments about determination of relative atomic mass	**1**

Question Number	Acceptable Answers	Reject	Mark
2(c)	**Mark independently:** **First mark:** Any mention of (determination of) amount /mass/abundance of ^{14}**C** (in cloth) ALLOW Any mention of (determination of) concentration/content/percentage of ^{14}**C** (in cloth) **OR** find proportion of ^{12}**C : **^{14}**C** (in cloth) **(1)** **Second mark:** Any mention of any one of the following:- (Use) half-life of ^{14}**C** / mention that amount of ^{14}**C** (in cloth) decreases (over time) / ^{14}**C** decays over time / comparison of amount of ^{14}**C** in living systems / comparison of amount of ^{14}**C** in modern materials / compare with ^{12}**C : **^{14}**C** in living systems **(1)**	amount of ^{14}**C** (in cloth) increases (over time)	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a)	<u>**Average/mean mass** of an atom/isotopes **(1)**</u> (1/12 mass of an atom of) carbon–12 **(1)** **First mark:** mention of mean or average mass of either an atom/isotope**s** *IGNORE* "weighted" before average or mean *IGNORE* any mention of "moles" in definition **Second mark: any mention** of carbon-12 *IGNORE* any reference to "moles" or "1 mole" at any stage *IGNORE* 12 g with reference to carbon-12 **Mark the two points independently**	"weight" instead of mass mean or average mass **of an element**… without prior mention of either an atom or isotopes	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (b) (i)	(Rubidium/it has) two **isotopes** *ALLOW* (Rubidium/it has) "different **isotopes**" *ALLOW* abbreviations such as formulae of rubidium atoms or cations with isotopic masses		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (b) (ii)	$\frac{85 \times 72 + 87 \times 28}{100}$ **(1)** = 85.56 or 85.6 **(1)** Correct answer with no working **(2)** **NOTE**: Rounding error giving answer 85.5 scores **(1)** *IGNORE* **any** units (for example, g/g mol^{-1}/%) **NOTE:** If 71% abundance used for ^{85}Rb and 29% for ^{87}Rb, answer = 85.58 or 85.6 scores **(1)** Second mark awarded if answer CQ correct on wrong abundances and /or wrong isotopic masses.	Calculation of simple arithmetic mean of 85 + 87 = 86 scores zero	**2**

Question Number	Acceptable Answers	Reject	Mark
4 (a)	Q: O-H ALLOW OH – O – H **(1)** R: C=O ALLOW – C = O | – C = O **(1)** IGNORE names ACCEPT answers written on spectrum	Just 'alcohol' — OH Just 'carbonyl' - C O | C-O	**2**

Question Number	Acceptable Answers	Reject	Mark
4 (b) (i)	Y = methanol / CH_3OH **(1)** Any two of the following: Molecular ion / M^+ / M_r / CH_3OH^+ / methanol = 32 CH_3^+ = 15 CH_3O^+ / CH_2OH^+ = 31 $CHOH^+$/ CH_2O^+ =30 COH^+ = 29 CO^+ = 28 **(1)** Charges not required TE in second mark for two correct possible peaks from an incorrect compound.		**2**

Question Number	Acceptable Answers	Reject	Mark
4 (b) (ii)	Two **(1)** This mark may be scored if two shifts are given. Any two shifts correctly identified: -O**H** at 2.0-4.0 / any value in this range **H**-C-O at 3.0- 4.2 / any value in this range **H** in CH_3 OH at 3.39 (ppm) **(1)** Allow TE for ethanol with three peaks **(1)** and three correct shift values: -O**H** at 2.0-4.0 / any value in this range **H**-C-O at 3.0- 4.2 / any value in this range CH in an alkane at 0.1–1.9 **(1)**	CH in an alkane at 0.1–1.9 Just CH_3 OH at 3.39	**2**

Question Number	Acceptable Answers	Reject	Mark
4 (c) (i)	Z contains two –OH/ one alcohol + one acid ALLOW two alcohol groups / is a diol		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (c) (ii)	Z is an acid / contains –COOH / contains –CO_2H/ contains a carboxylic acid group / contains H^+		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (c) (iii)	Z is a secondary alcohol/ a ketone is **formed** from **Z** / Z contains $-\overset{\mid}{\underset{\underset{H}{\mid}}{C}}-OH$ **(1)**	**Z** is a ketone	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (c) (iv)	(Iodoform produced) so **Z** contains CH_3 CH(OH)- TE if **Z** is identified as a ketone in (iii): **Z** contains CH_3 C=O / **Z** is a methyl ketone		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (d)	Answers will be based on several pieces of information (molecular formula, products of ester hydrolysis, answers to (c)) which may be contradictory if errors have been made. ALLOW TE marks for formulae which are chemically possible (ie no 5 bonded carbons etc) and based on most of the deductions but **not necessarily all**. **Z** is $CH_3CH(OH)CH_2COOH$ **(1)** Stand alone mark ALLOW TE for an **acid** with OH in wrong position in **Z** if oxidation product identified as aldehyde TE for **Z** = CH_3COCH_2COOH if identified as ketone in (iii) **X** is $CH_3CH(OH)CH_2COOCH_3$ **(1)** Stand alone mark TE for a methyl ester of **Z**		**2**