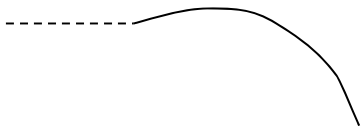
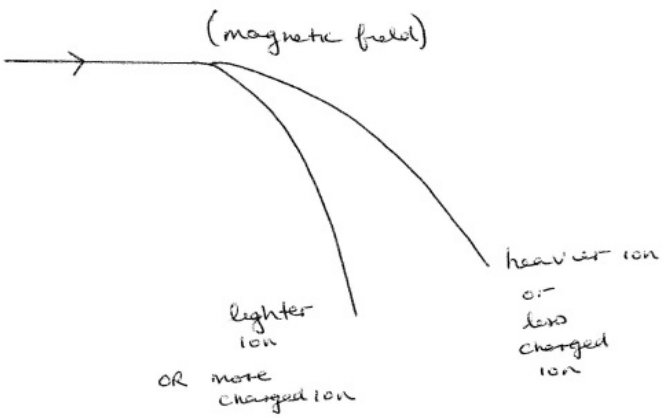
Question Number	Acceptable Answers	Reject	Mark
1a(i)	Any two of O^+, O^{2+}, O_2^+, O_2^{2+} (1) for each correct ion ALLOW $^{16}O^+$, $^{16}O^{2+}$, $(^{16}O)_2^+$, $(^{16}O)_2^{2+}$ $^{16}O_2^+$, $^{16}O_2^{2+}$ $O=O^+$/ $O=O^{2+}$ for O_2 ions Added mass numbers which describe a diatomic ion eg $^{32}O_2^+$ Added round or square brackets	O^- O^{2-} Ions of O_3 Incorrect mass numbers eg $^{32}O^+$ Added incorrect atomic numbers Eg $^{16}_{9}O^+$	**(2)**

Question Number	Acceptable Answers	Reject	Mark
1a(ii)	The magnetic field/ electromagnet/ electromagnetic field OR Deflection by magnetic field ALLOW Deflection and magnetic field	Gravitational field Just deflector/deflection Electric field Vacuum and magnetic field Detector/ detection	**(1)**

Question Number	Acceptable Answers	Reject	Mark
1 **a(iii)**	**curved** lines going towards the detector region with at least one hitting the detector ALLOW Section of straight line before curve starts if magnetic field position is not shown Line may go up very slightly before it curves down, probably to keep it clear of lower line.  (1) Labelling of paths depends on ions chosen: **Heavier ion** shown as **less deflected** OR O^{2+} more deflected than O_2^+ OR Ion with **lower charge** shown as **less deflected** ALLOW Ions with negative charges (as already penalised in (i)) (1) If chosen ions are O^+ and O_2^{2+} they will not be separated – answer must make this clear  	Straight lines Curvature away from detector/ concave curvature Line turning back upwards Species which are not ions of oxygen	**(2)**

Question Number	Acceptable Answers	Reject	Mark
1(b)	**Look at final answer** **16. 004 scores (2)** **16.00445 scores (1)** Correct expression with incorrect final answer scores (1) (16x99.759 + 17x0.037 + 18x0.204)/100 OR (16x0.99759 + 17x0.00037 + 18x0.00204) (1) =16.00445 =16.004 (1) Ignore units	 16.005	**(2)**

Question Number	Acceptable Answers	Reject	Mark
1(c)	Isotopic composition of oxygen in air varies ALLOW The abundance of the isotopes of oxygen varies OR Oxygen standard was introduced before existence of oxygen isotopes was known OR Some scientists used a standard based on one isotope while others used a value based on mixture in natural abundance OR The answer is inaccurate unless a specified isotope is used OR 12C standard used because there are many 12C compounds which can be used to calibrate the mass spectrometer ALLOW It was difficult to obtain pure oxygen from air.	Air contains other gases Air contains many isotopes Oxygen has many isotopes Just '12C standard is better' 12C standard gives a whole number	**(1)**

Question Number	Acceptable Answers	Reject	Mark
1(d)	No difference as both isotopes have the same number of protons (and electrons)/ the same nuclear charge IGNORE Same electronic configuration OR No difference as **only** number of neutrons is different		**(1)**

(Total for Question = 9 marks)

Question Number	Acceptable Answers	Reject	Mark
2(a)	(Atoms/elements/isotopes with) the same number of protons (and electrons) **and** different numbers of neutrons ALLOW answers in terms of bromine isotopes, 35 protons **and** 44 or 46 neutrons. IGNORE different number of nucleons IGNORE same atomic number but different mass number		1

Question Number	Acceptable Answers	Reject	Mark
2(b)(i)	(High energy) **electrons** are 'fired' at/ **Electrons** bombard/Use of an '**electron** gun' (1) (result in) loss of electron/electrons (thus forming an ion) This can be shown in an equation $X + e \rightarrow X^+ + 2e$ OR $X \rightarrow X^+ + e$ (1) Stand alone marks	Magnetic field (0) Forms an anion	2

Question Number	Acceptable Answers	Reject	Mark
2(b)(ii)	Magnet/Magnetic field/Electromagnet	Electric field Magnetic shield Magnetic radiation	1

Question Number	Acceptable Answers	Reject	Mark
2(b)(iii)	Particles (of gas/air) will interfere with the movement of the **ions**/collide with the **ions**/deflect **ions** OR Additional peaks will be detected/peaks at incorrect m/e IGNORE references to chemical reactions	Atoms for ions	1

Question Number	Acceptable Answers	Reject	Mark
2(c)	**arking point 1** Twin peaks of about the same height at 79 and 81 (1) **Marking point 2** Twin peaks of about the same height at 158 and 162 (1) **Marking point 3** Peak at 160 (1) **Marking point 4** Peak at 160 approximately twice the height of the peaks at 158 and 162 (1) IGNORE **Small** peak at 80 which could be due to Br_2^{2+} (79-81) In MPs 1 and 2 penalise height difference once only		4

Question Number	Acceptable Answers	Reject	Mark
2(d)	$\left(\frac{47 \times 79) + (53 \times 81)}{100}\right) = 80.06$ (1) (answer =) 80.1 (1) Correct final answer without working scores (2) No TE on incorrect expression	Incorrect units of mass/%	2

Question Number	Acceptable Answers	Reject	Mark
2(e)	The (m/e) value would be **halved**	Peak half as high	1

Question Number	Acceptable Answers	Reject	Mark
2(f)(i)	Any two from: Sample kept sealed/ tamper-proof (1) Sample stored and labelled clearly (1) Sample stored in preservative/sample tested immediately after being taken (1) Sample kept under temperature control (1) Monitor sample is being taken from named competitor (1) Check that other non-banned substances do not give similar mass spectrometry result (1) Analysis repeated (to confirm result)/ Multiple samples taken/ Sample divided into two and tested at different times/ locations (1) Container/equipment sterile/cleaned (1) Run a control sample/ compare to a sample without drugs (1) Sampling to take place immediately after event (1) Precautions need to be **actions / activities** that are carried out and not just a statement that something must or must not happen but **how** this is ensured or prevented There will likely be other suggestions in addition to those given above which can be given credit if they are reasonable actions	References to medication being taken Just 'no contamination'	2

Question Number	Acceptable Answers	Reject	Mark
2(f)(ii)	Health concerns/depression/bursts of anger/ acts of violence/heart attack/strokes/liver damage/masculine features in women/ harmful side effects Allow any suitable health concern	Just 'Fear of being banned/prosecuted' Just 'side effects'	1

Question Number	Acceptable Answers	Reject	Mark
2(g)	Any suitable use such as: RAM/RMM calculations/Relative isotopic mass calculations/Space probes/ Pharmaceutical purity/testing of new pharmaceuticals/Age of rocks from Helium content/ Identification of unknown substances/ Carbon dating/Radioactive dating	Alcohol testing C-12 dating	1

TOTAL FOR QUESTION = 16 MARKS

Question Number	Acceptable Answers	Reject	Mark
3(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 about ionization of the sample whether correct or incorrect IGNORE descriptions of vaporisation	High-**density** electrons	**1**

Question Number	Acceptable Answers	Reject	Mark
3(a)(ii)	Electric field / (negatively) charged plates ALLOW voltage plates electrostatic field electrical field pushed by positively (charged) plate/ anode	**Positively** charged plates alone / electronic field / electric current / electricity / electrical charge / (electro) magnetic field / electric coil	**1**

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

Question Number	Acceptable Answers	Reject	Mark
3(b)	(194 x 32.8) + (195 x 30.6) + (196 x 25.4) + (198 x 11.2)) ÷ 100 **(1)** = 195.262 = 195.3 **(1 d.p.)** **(1)** Method **(1)** Answer must be to **1 d.p.** IGNORE g , g mol^{-1} or amu but other wrong units lose a mark Correct answer with no working **(2)** ALLOW TE for second mark if 1 numerical slip in transferring data from the table and answer to 1 d.p		**2**

Question Number	Acceptable Answers	Reject	Mark
3(c)	d(-block) ALLOW D(-block) IGNORE Transition element(s) / transition metal(s)		**1**

Question Number	Acceptable Answers	Reject	Mark
3(d)(i)	**(Na):** ✓ and ✓ **(1)** **(Na_2O):** **X** and ✓ **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
***3 (d) (**	**Na:** conducts when **both** solid and molten due to (delocalized)**free / mobile electrons** **(1)** **Na_2O:** does not conduct when solid as no mobile **ions** / **ions** unable to move / **ions** in fixed position **(1)** **Na_2O:** conducts when molten as has mobile **ions** **(1)**	Ions with reference to either form of sodium metal electrons electrons	**3**

Total for Question = 11 marks