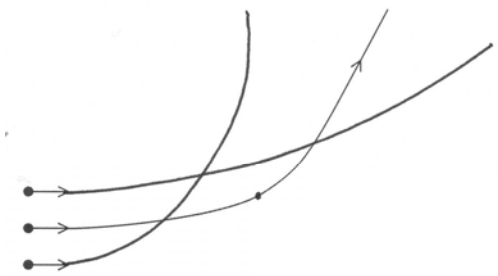
Question Number	Answer		Mark
1(a)	Radial lines (at least 4) most touching nucleus but not going through it (straight by eye) Equispaced Arrow pointing away from circle	**(1)** **(1)** **(1)**	**3**
1(b)(i)	$F = Q_1 Q_2 / 4\pi\varepsilon r^2$ or $F = k Q_1 Q_2 / r^2$ Charges are $79 \times 1.6 \times 10^{-19}$ and $2 \times 1.6 \times 10^{-19}$ (values are 1.23×10^{-17} and 3.2×10^{-19})	**(1)** **(1)**	**2**
1(b)(ii)	Marks can be scored for use of symbols, cell annotation or values $F = \Delta p/(\Delta)t$ $(\Delta)v = (\Delta)p/m$ $(D5) = D4 + \frac{(-)B5 \times C5}{6.64 \times 10^{-27}}$ $(D5) = 1.24 \times 10^{7} + \frac{(-)20.2 \times 1 \times 10^{-21}}{6.64 \times 10^{-27}}$ $F/m = (-)\ 3.04 \times 10^{27}$ **OR** $a = F/m$ $v = (u) + at$ $(D5) = D4 + \frac{(-)B5 \times C5)}{6.64 \times 10^{-27}}$ $(D5) = 1.24 \times 10^{7} + \frac{(-)20.2 \times 1 \times 10^{-21}}{6.64 \times 10^{-27}}$ $F/m = (-)\ 3.04 \times 10^{27}$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
1(b)(iii)	$s = ½ (u+v) t$ accept $s = vt$ (with either D5 or D6) **Or** $s = ut + ½ at^2$ (s) = ½ (D5 + D6)*C6 or value or other correct equations	**(1)** **(1)**	**2**
1(b)(iv)	Value in range 2.00 - 2.49($\times 10^{-14}$ m)	**(1)**	**1**
***1(c)**	(QWC- Work must be clear and organised in a logical manner using technical wording where appropriate.) Atom mainly <u>empty</u> space Charge is concentrated in the centre/in a nucleus/nucleus is charged Mass is concentrated (at the centre) **Or** Dense/massive nucleus	**(1)** **(1)** **(1)**	**3**
	Total for question		**14**

Question Number	Answer		Mark
2(a)	(Magnetic) force acts at right angles to ion motion/current Force is the centripetal force **or** causing centripetal acceleration **or** direction of acceleration/force is to centre (of circle)	**(1)** **(1)**	**2**
2(b)	See $F = BQv$ **or** $r = p/BQ$ $F = mv^2/r$ **or** $p = mv$ $f = v/2\pi r$ **or** $f = \omega/2\pi$ **or** $T = 2\pi r/v$ **or** $T = 2\pi/\omega$	**(1)** **(1)** **(1)**	**3**
2(c)(i)	Identifies positive (field) above **and** below (the ion) which repels the ion	**(1)** **(1)**	**2**
2(c)(ii)	$3 \times 32.0645 / 10 \times (10^6)$ $= 0.0000096$(u)	**(1)** **(1)**	**2**
2(c)(iii)	Convert MeV to J Convert J to kg Convert kg to u Mass loss = 0.0024(u) (and this is more than 0.00001u) <u>Example of calculation</u> mass loss = 2.2 MeV x 1.6×10^{-13} J J to kg $3.52 \times 10^{-13} / 9 \times 10^{16}$ kg kg to u $3.91 \times 10^{-30} / 1.66 \times 10^{-27}$ u	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question		**13**

Question Number	Answer		Mark
3(a)	To prevent interaction/deflection/collision of the alpha particle with the air. [do not accept: 'don't get in the way' , 'cause ionisation', 'interfere with'. Looking for a definite interaction between the alpha and the air molecules. Accept air particles]	**(1)**	**1**
3(b)	**TWO** Nucleus (very) much smaller than separation of nuclei **Or** nucleus (very) much smaller than the atom Nucleus is charged (don't penalise if candidate says positively charged) Nucleus is (very) dense **Or** nucleus is massive **Or** nucleus contains most of the mass (no credit for candidates referring to the atoms and not the nucleus.)	**(1)** **(1)** **(1)**	**2**
3(c)	**Particle** Path curves up with less deflection than for particle shown and must cross the printed line. **Or** a straight path. **Bottom Particle** Path curves up with more deflection than for particle shown Greatest curvature before greatest curvature of particle shown. (dependent mark) <u>Example</u> 	**(1)** **(1)** **(1)**	**3**
	Total for question		**6**

Question Number	Answer		Mark
4(a) (i)	Use of $\lambda = h/p$ and $p = mv$ **Or** $v = h/m\lambda$ Use of $m = 9.11 \times 10^{-31}$ kg $v = 7.28 \times 10^{6}$ m s^{-1} Example of calculation $\lambda = h/mv$ $v = 6.63 \times 10^{-34}$ J s /(9.11×10^{-31} kg $\times$ 1.0×10^{-10} m) $v = 7.28 \times 10^{6}$ m s^{-1}	**(1)** **(1)** **(1)**	**3**
4(a) (ii)	Use of $E_k = ½ mv^2$ **Or** $E_k = p^2/2m$ **Or** see $E_k = 2.41 \times 10^{-17}$ J Divided by 1.60×10^{-19} $E_k = 151$ eV (accept values in range 150 – 152 eV) (ecf value of v from (a)) Example of calculation $E_k = ½ (9.11 \times 10^{-31}$ kg)(7.28×10^{6} m s$^{-1})^2$ / (1.60×10^{-19} J eV^{-1}) $E_k = 151$ eV	**(1)** **(1)** **(1)**	**3**
4(b)	The wavelength is similar in size to the nucleus The wavelength /nucleus is (much) smaller / 10^{-15}m / 10^{-14} m (if value is not given, 'wavelength is small' or 'wavelength is very small' is not sufficient)	**(1)** **(1)**	**2**
	Total for question		**8**

Question Number	Answer		Mark
***5**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Max 5** **Observations:** Most alpha went straight through Some deflected Very few came straight back **Or** very few had a deflection > 90^{o} **Or** 1 in 8000 came straight back (Do not credit responses in terms of 'bounced' or 'reflected'.) **Conclusions:** Atom mainly empty (space) Charge is concentrated in the centre/in a nucleus/nucleus is charged Mass is concentrated (at the centre) Or dense/massive nucleus	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**Max 5**
	Total for question		**5**

Question Number	Answer	Mark
6(a)	Observations: Most alpha went straight through / undeflected (1) [Do not credit just "alphas go through"] Some / few deflected [not "reflected] (1) Very few / < 1 in 1000 came straight back / were deflected through very large angles (>90°) / were reflected (1)	**3**
6(b)(i)	Any mention of tubes (1) Alternating p.d. / a.c. p.d. /alternating electric field (1) Length of tubes increases (1)	**3**
6(b)(ii)	Use of $p = E/c$ with $c = 3 \times 10^8$ (1) (Use of de Broglie) $\lambda = h/p$ with $h = 6.6 \times 10^{-34}$ (1) wavelength = 6.2×10^{-17} m (1) Example of answer $p = 20 \times 1.6 \times 10^{-10}$ J / 3×10^8 m s^{-1} = 1.1×10^{-17} N s Correct sub of h and p i.e. $\lambda = 6.6 \times 10^{-34} / 1.1 \times 10^{-17}$ N s	**3**
6(b)(iii)	Wavelengths need to be smaller than nuclei [allow same as / similar to – must be comparative] (1)	**1**
6(b)(iv)	Proton is not uniform / has space (1) Contains quarks (1) [ignore any reference to charge]	**2**
6(b)(v)	Kinetic energy is not conserved (1) [K.E. and momentum not conserved – do not credit]	**1**
	Total for question	**13**

7(i)	B
7(ii)	C