Charged Particles in Fields - Mark Scheme

Q1.

Question Number	Answer	Mark
	The only correct answer is D A *is not correct because there are no nuclei to decay* B *is not correct because metal wires consist of ions and free electrons* C *is not correct because no light is being directed to filament*	**1**

Q2.

Question Number	Answer		Mark
(a)(i)	(Thermionic) emission of electrons from heated filament **Or** Thermionic emission of electrons from (heated) filament	**(1)**	
	Electrons accelerated by field (between anode and filament) **Or** the electrons gain kinetic energy due to work done by the field	**(1)**	**2**
(a)(ii)	Use of $qV = ½ mv^2$ $v = 6.9 \times 10^6$ m s^{-1} Example of calculation 1.60×10^{-19} C $\times$ 135 V $= ½ \times 9.11 \times 10^{-31}$ kg $\times v^2$ $v = 6.89 \times 10^6$ m s^{-1}	**(1)** **(1)**	**2**
(b)(i)	Equates $F = mv^2/r$ and $F = BQv$ Algebra including use of $p = mv$ for conclusion Example of derivation $F = mv^2/r$ and $F = BQv$ $mv^2/r = BQv$ $mv/r = BQ$ $r = mv/BQ$ $p = mv$ so $r = p/BQ$	**(1)** **(1)**	**2**
(b)(ii)	Use of $r=p/BQ$ $B = 1.1 \times 10^{-3}$ T (Allow ecf of v from (a)(ii)) Example of calculation 0.073 m / 2 $= 9.11 \times 10^{-31}$ kg $\times 6.89 \times 10^6$ m s^{-1} / $B \times 1.60 \times 10^{-19}$ C $B = 1.1 \times 10^{-3}$ T	**(1)** **(1)**	**2**
(c)	**Max 2** Camera allows magnification **or** camera avoids unsteadiness of hand But as the scale isn't against the object being measured there will be parallax errors **or** as camera cannot 'line up' with both sides at the same time there will be parallax errors difficult to align ruler with maximum distance between sides of circle **or** thickness of path makes it difficult to measure diameter resolution of metre rule is small relative to the measurement **Or** percentage uncertainty in measured value is low		**2**
(d)	Electron collisions decreases E_K / speed / momentum of electrons, reducing radius/diameter **Or** (accelerating) electrons emit (synchrotron) radiation, reducing the E_K / speed / momentum of the electrons, reducing radius/diameter	**(1)**	
	Electrons scattered/absorbed by helium so intensity of beam decreases **Or** There are fewer electrons in the beam so the intensity decreases	**(1)**	**2**
	Total for question		**12**

Q3.

Question Number	Answer	Mark
*(a)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) P.d./E-field accelerates protons between dees (1) This is an alternating p.d./E-field **Or** the p.d./ E-field reverses when the proton is in the dees (1) Magnetic field perpendicular to (plane of) dees/proton motion (1) Proton path curved by magnetic field **Or** magnetic field exerts centripetal force (1) As momentum/velocity/speed/$E_{kinetic}$ of protons increases radius of path in dees increases (1) The time for which a proton is in a dee remains constant **Or** the frequency of p.d./E-field is constant (1)	(6)

Question Number	Answer	Mark
(b)(i)	$^{1}_{1}p + {}^{18}_{8}O \rightarrow {}^{18}_{9}O + {}^{1}_{0}n$ Left hand side correct (1) Right hand side correct (1) Neutron produced (dependent an equation) (1)	(3)
b(ii)	Use of $F = \frac{kQ_1Q_2}{r^2}$ (1) with $e \times 8e$ (1) $F = 180$ N (1) <u>Example of calculation</u> $F = \frac{8.99 \times 10^{9}\text{Nm}^2\text{C}^{-2} \times 1.6 \times 10^{-19}\text{C} \times 8 \times 1.6 \times 10^{-19}\text{C}}{(3.2 \times 10^{-15}\ \text{m})^2}$ $F = 179.8$ N	(3)
	Total for question 14	**12**

Q4.

Question Number	Answer	Mark
	B	1

Q5.

Question Number	Answer	Mark
	B – into the page	**1**
	Incorrect Answers: A – treats direction of electron travel as direction of current C – not perpendicular to page D – not perpendicular to page	

Q6.

Question Number	Answer	Mark
	D	**1**

Q7.

Question Number	Answer		Mark
(a)	Photon causes no ionisation	(1)	**1**
(b)	Track A by (Fleming's) left hand rule	(1)	**1**
* **(c)**	(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate) Charges are opposite so spiral in opposite directions Both particles have same mass/charge so same curvature/radius Circular motion is due to magnetic field/force being at right angles to (direction of) motion They have decreasing E_k/speed/momentum Uses $Bqv=mv^2/r$ or $r=mv/Bq$ to justify decreasing radius	(1) (1) (1) (1) (1)	**5**
	Total for question		**7**

Q8.

Question Number	Answer		Mark
(a)	See energy = QV **Or** $W=QV$ **Or** $E=QV$ **Or** $F=EQ$ **and** $E=V/d$	(1)	
	Equate QV and $\frac{1}{2}mv^2$		
	Or equate QV and $\frac{p^2}{2m}$	(1)	**2**
* (b)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate)		
	the (magnetic) field acts at a right angle to the direction of motion **Or** the velocity of the ion is perpendicular to the (magnetic) field	(1)	
	the force is perpendicular to the direction of motion.	(1)	
	the force acts as a centripetal force **Or** this is the condition for circular motion	(1)	**3**
(c)	See mass of ion = $80 \times 1.66 \times 10^{-27}$ (kg) in velocity/p calculation **Or** 1.328×10^{-25} (kg) in velocity/p calculation	(1)	
	Use of $m/Q = 2V/v^2$ with $Q = (-)\ 1.6\text{x}10^{-19}$ (C)	(1)	
	Use of $BQv = \frac{mv^2}{r}$ **Or** use of $r = \frac{p}{BQ}$ **and** $p = mv$ (do not award this mark if speed of light is used)	(1)	
	$r = 0.47$ m	(1)	**4**
	Example of calculation $m/Q = 2V/v^2$ $v = \sqrt{(2VQ/m)}$ $v = \sqrt{\frac{2 \times 3000\ \text{V} \times 1.6 \times 10^{-19}\ \text{C}}{80 \times 1.66 \times 10^{-27}\text{kg}}}$ $v = 8.5 \times 10^4$ (ms^{-1}) $r = mv/BQ$ $r = \frac{80 \times 1.66 \times 10^{-27}\text{kg} \times 8.5 \times 10^4\text{m s}^{-1}}{0.15\ \text{T} \times 1.6 \times 10^{-19}\text{C}}$ $r = 4.7 \times 10^{-1}$ m		
	Total for question		**9**