Question Number	Answer		Mark
1(a)(i)	Outward spiral from centre in either direction, minimum of two complete loops	**(1)**	**1**
1(a)(ii)	Direction consistent with diagram: Clockwise path, field out of page Anticlockwise path, field into page	**(1)**	**1**
1(a)(iii)	Electric field/p.d. between dees causes (resultant) force/acceleration Proton makes half a revolution in half a cycle of the a.c. **Or** facing dee (always) negative when proton reaches gap. **Or** whenever the proton gets to a gap, the p.d. has reversed k.e./speed (only)increases each time the proton crosses the gap **Or** work done by the field in the gap increases the k.e.	**(1)** **(1)** **(1)**	**3**
1(a)(iv)	$Bev=mv^2/r$ **Or** $r=p/Be$ $v=2\pi r/T$ $T=1/f$ (seeing $f=v/(2\pi r)$ scores MP2 & 3) **Or** $Bev=mr\omega^2$ $v=r\omega$ $\omega=2\pi f$ (seeing $v/r=2\pi f$ scores MP2 & 3)	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
1(a)(v)	Use of $B=2\pi fm/e$ with mass of proton $f=1.8\times10^4$ Hz <u>Example of calculation</u> $f=eB/2\pi m$ $f=(1.6\times10^{-19}\text{ C}\times1.2\times10^{-3}\text{ T})/(2\pi\times1.67\times10^{-27}\text{kg})$ $f=1.8\times10^4$ Hz	**(1)** **(1)**	**2**
1(b)	At **X** the idea that 2 particles are produced One is uncharged/neutral so no track charged particle has same charge as incident particle to conserve charge **Or** path of (new) charged particle changes to conserve momentum At **Y** Neutral particle decays into two charged particles. Tracks curve in opposite directions as particles oppositely charged. **Or** particles have (equal and) opposite charge to conserve charge **Or** particles have equal (magnitude of) momenta since their (radius of) curvature is the same.	**(1)** **(1)** **(1)** **(1)** **(1)**	**5**
	Total for question		**15**

Question Number	Answer		Mark
2	(QWC- Work must be clear and organised in a logical manner using technical wording where appropriate **Max 4** Uniform electric field (between plates) **(1)** Force due to E **or** idea of attraction/repulsion **(1)** (Ball has an) acceleration (**not** an increasing velocity) **(1)** Which is constant/uniform (can be with reference to increasing velocity) **(1)** Vertical line/ + and – values shows change in direction **(1)** Inelastic collision/less energy after impact **(1)**		**4**
	Total for question		**4**

Question Number	Answer	Mark
3	Use of *W=mg* **(1)** Use of *F=BIL* **(1)** B = 0.04 T **(1)**	
	Total for question	**3**

Question Number	Answer	Mark
4(a)(i)	measured thickness of lead 4-5 mm **(1)** measured radius 32 - 38 mm **(1)** Value between 38 – 57 mm **(1)** Eg actual radius = 35 mm x 6 mm/4.5 mm	**3**
4(a)(ii)	Use of $p = Bqr$ [any two values sub] **(1)** Answer range 9.1×10^{-21} - 1.4×10^{-20} N s or kg m s^{-1} [allow ecf]**(1)**	**2**
4(b)	Track gets more curved above lead / r smaller above lead **(1)** Must be slowing down / less momentum / loses energy **(1)** Up [dependent on either answer above] **(1)**	**3**
4(c)	Into page **(1)** [ecf out of page if down in b]	**1**
4(d)(i)	Division by 9.11×10^{-31} kg **(1)** Answer range 1.0 – 1.6 x 10^{10} m s^{-1} **(1)**	**2**
4(d)(ii)	greater than speed of light **(1)** (impossible) so mass must have increased **(1)**	**2**
	Total for question	**13**

Question Number	Answer		Mark
5(a)	The <u>magnetic</u> field (must be) at right angles to the current	**(1)**	
5(b)	All three units for force, length and current clearly identified (The unit of force is kg m s^{-2} **, t**he unit of current is A, the unit of length is m) T = kg A^{-1} s^{-2}	**(1)** **(1)**	**2**
5(c)	*Use* of $\rho = m/V$ Use of $mg = BIl$ B = 0.53 (T) (no u.e. as given in question for part (b)) <u>Example of calculation</u> $m = 2.7 \times 10^3$ kg $m^{-3} \times 10 \times 10^{-3}$ m $\times 10 \times 10^{-3}$ m $\times l$ $m = 0.27 \times l$ $B = (0.27 \times l \times 9.81$ m $s^{-2})/ (5$ A $\times l)$ B = 0.53 T	**(1)** **(1)** **(1)**	**3**
5(d)	(Magnetic field is) into paper/page	**(1)**	
	Total for question		**7**