Q1.

Question Number	Answer	Mark
	C	1

Q2.

Question Number	Answer	Mark
	C	1

Q3.

Question Number	Answer	Mark
	A	1

Q4.

Question Number	Answer	Mark
	B	1

Q5.

Question Number	Answer	Mark
	C	1

Q6.

Question Number	Acceptable answers	Additional guidance	Mark
	Direction out of page (1)	The arrow needs to be parallel to the length of the pipe by eye.	1

Q7.

Question Number	Answer	Mark
	C	1

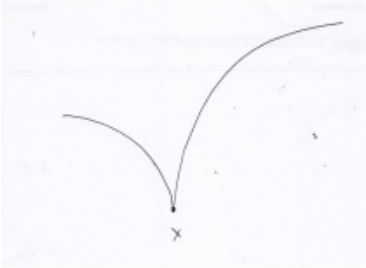
Q8.

Question Number	Answer	Mark
	A	1

Q9.

Question Number	Answer	Mark
	Arrow added to diagram downwards on or near the copper rod (1) An indication that the field is at right angles to the page or copper rod (1) Magnetic field into page (1) (Upward arrow for current →magnetic field out of page. If no arrow on rod MP2 &3 can still be scored)	3
	Total for question	3

Q10.

Question Number	Answer		Mark
	Diagram: Path curves in opposite sense	**(1)**	
	With a greater radius of curvature [For Mp2 drawn line must start at X , upwards at less than 45° to vertical and go above printed line. Look at curvature close to X, do not penalise if later it curves more/less.]	**(1)**	
	 **Explanation: (these marks are independent of the diagram)** (Antihelium) has opposite charge (to proton) **Or** reference to proton +ve **and** antihelium -ve	**(1)**	
	See $r = p/BQ$	**(1)**	
	r is doubled **Or** p/Q is doubled	**(1)**	**5**
	[equation may appear near diagram.]		
	Total for question		**5**

Q11.

Question Number	Answer		Mark
(a)	Only (moving) charged particles are deflected by a magnetic field **Or** Only charged particles can be accelerated to produce a beam	**(1)** **(1)**	**1**
(b)	Into the page	**(1)**	**1**
(c)	Use of $F = mv^2/r$ **Or** use of $r = p/BQ$ Use of $F = Bqv$ **Or** use of $p = mv$ $m = 6.64 \times 10^{-26}$ kg Example of calculation $mv^2/r = Bqv$ $m = Bqr/v = (0.673\ \text{T} \times 1.6 \times 10^{-19}\ \text{C} \times 7.40 \times 10^{-2}\ \text{m}) / 1.20 \times 10^{5}\ \text{m s}^{-1}$ $m = 6.64 \times 10^{-26}$ kg	**(1)** **(1)** **(1)**	**3**
(d)	Semicircle drawn starting from same initial point and a smaller radius	**(1)**	**1**
	Total for question		**6**

Q12.

<table>
<tr><th>Question Number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr>
<td>*</td>
<td>This question assesses a student's ability to show a coherent and logical structured answer with linkage and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.
The following table shows how the marks should be awarded for indicative content.
<table>
<tr><th>Number of indicative points seen in answer</th><th>Number of marks awarded for indicative points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
Indicative content

There is an alternating p.d./E-field
P.d./E-field accelerates protons between dees
Magnetic field perpendicular to plane of dees
Proton path curved by magnetic field
As velocity of protons increases radius of path in dees increases
The time for which a proton is in a dee remains constant
Or the frequency of p.d./E-field is constant

</td>
<td>Guidance on how the mark scheme should be applied: The mark for The following table shows how the marks should be awarded for structure and lines of reasoning
<table>
<tr><th></th><th>Number of marks awarded for structure and lines of reasoning</th></tr>
<tr><td>Answer shows a coherent and logical structure with linkage and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkage between points and is unstructured</td><td>0</td></tr>
</table>
<table>
<tr><th>Number of IC points</th><th>Possible linkage marks</th></tr>
<tr><td>0, 1</td><td>0</td></tr>
<tr><td>2, 3</td><td>1</td></tr>
<tr><td>4, 5, 6</td><td>2</td></tr>
</table>
IC2 accept 'in the gap' for between dees. Accept increases E_k for accelerates

IC3 accept vertical or upwards for perpendicular to plane.

IC5 accept reference to $r = p/BQ$</td>
<td>6</td>
</tr>
</table>

Q13.

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>(i)</td>
<td>

Electric field vertically downwards (from top plate to bottom plate) (1)
Magnetic field into paper (1)

</td>
<td></td>
<td>2</td>
</tr>
</table>

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	• Use of $E = \frac{V}{d}$ (1) • Use of $F_E = EQ$ (1) • Use of $F_M = BQv$ (1) • Show that these forces are equal (if v is 2.2 x 10^5 m s^{-1}) and hence state that B is suitable (1)	Do not award MP4 if incorrect ion charge used Example of calculation: $E = \frac{V}{d} = \frac{135\,\text{V}}{2.5\times10^{-2}\,\text{m}} = 5400\,\text{V m}^{-1}$ $F = EQ = 5400\,\text{V m}^{-1} \times 1.6\times10^{-19}\,\text{C} = 8.6\times10^{-16}\,\text{N}$ $F = BQv = 24.5\times10^{-3}\,\text{T}\times1.6\times10^{-19}\,\text{C}\times2.2\times10^{5}\,\text{ms}^{-1}$ $= 8.6\times10^{-16}\,\text{N}$	4

Q14.

Question Number	Answer	Mark
(a)	The idea that electron(s) have been removed/added from an atom/molecule/particle. (1)	1
(b)	Flemings left hand (rule) **Or** FLHR (1)	1
(c)	**Max 5** Only charged particles leave a trail so photon is neutral (1) **Or** the two particles produced are charged because they leave a track Particles are oppositely charged because they curve/spiral in opposite directions (1) **Or** Particles are oppositely charged to conserve charge (1) (Applying FLHR) , top particle is positive and bottom one negative. (1) Because they have the same curvature/radius on the spirals **Or** because the paths have identical shape (1) Particles have the same momentum (1) The photon enters from the left because the (resultant) momentum afterwards is to the right.	5
	Total for question	7

Q15.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• The ions experience a force perpendicular to their velocity (and the magnetic field) (1) • The (resultant) force on the ions causes an acceleration at right angles to their velocity (1) **Or** There is a magnetic force acting towards the centre of the path	For velocity accept direction of motion or direction of travel	2

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	• Use of $r = \frac{mv}{BQ}$ (1) • $r = 0.23$ m (1)	Example of calculation: $r = \frac{mv}{BQ}$ $= \frac{(34.97 \times 1.66 \times 10^{-27})\text{kg} \times 2.2 \times 10^{5}\,\text{m s}^{-1}}{0.35\,\text{T} \times 1.6 \times 10^{-19}\,\text{C}} = 0.228\,\text{m}$	2

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii) 1	• path drawn with less curvature (less overall deflection) (1)	MP1 awarded for path in the magnetic field	1

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii) 2	• ions are more massive (1) • ions have the same charge so the radius of the path would be greater (1)		2

Q16.

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

Q17.

Question Number	Answer		Mark
(i)	Outward spiral from centre in either direction, minimum of two complete loops	(1)	1
(ii)	Direction consistent with diagram: Clockwise path, field out of page Anticlockwise path, field into page	(1)	1
(iii)	Electric field/p.d. between dees causes (resultant) force/acceleration	(1)	
	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	(1)	
	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)	3
(iv)	$Bev=mv^2/r$ **Or** $r=p/Be$	(1)	
	$v=2\pi r/T$	(1)	
	$T=1/f$ (seeing $f=v/(2\pi r)$ scores MP2 & 3)	(1)	
	Or		
	$Bev = mr\omega^2$	(1)	
	$v = r\omega$	(1)	
	$\omega = 2\pi f$ (seeing $v/r = 2\pi f$ scores MP2 & 3)	(1)	3
(v)	Use of $B= 2\pi fm/e$ with mass of proton	(1)	
	$f=1.8 \times 10^4$ Hz	(1)	2
	<u>Example of calculation</u> $f = eB/ 2\pi m$ $f = (1.6 \times 10^{-19}\ C \times 1.2 \times 10^{-3}\ T)/ (2\pi \times 1.67 \times 10^{-27} kg)$ $f=1.8 \times 10^4$ Hz		