Name of the Student:_____
Max. Marks : 21 Marks **Time : 21 Minutes**

Mark Schemes

Q1.

Question Number	Acceptable answers	Additional guidance	Mark
(i)	• units eV (energy) base units: kg m^2 s^{-2} **Or** base units of momentum: kg m s^{-1} **(1)** • divide energy by units of speed (c) m s^{-1} gives kg m s^{-1} which are units of momentum Or multiply units of momentum by speed (c) m s^{-1} to give units of energy kg m^2 s^{-2} **(1)**		**2**
(ii)	• resolves a y-component or x-component of electron momentum **(1)** • applies momentum conservation in x-direction or y-direction **(1)** • comparison of total momentum after **Or** momentum of proton after plus comment **(1)** Alternative: • draws a vector triangle	Example of calculation $p_y = 9.1\ (\text{GeV/c})\sin 20 = 3.1\ \text{GeV/c}$ $p_x = 9.1\ (\text{GeV/c})\cos 20 = 8.55\ \text{GeV/c}$ p_x of proton = 20 (GeV/c) - 8.55 (GeV/c) = 11.45 G $p_{\text{proton}} = \sqrt{3.1^2 + 11.45^2}$ $= 11.86\ \text{GeV/c}$ Alternative: p_y = 9.1 (GeV/c)sin20 = 3.1 GeV/c=11.9($\emptyset = 15.2$ So total p after = 11.9 GeV/c cos 15.2 + 9.1 (GeV/c)cos20	**3**
	• Uses cosine rule • Calculates angle from three sides = 20.4°	= 11.5 + 8.55 = 20.05 GeV/c	
(iii)	• (total) kinetic energy not conserved **(1)**		**1**

Q2.

<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>

Q3.

<table>
<tr><th>Question Number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr>
<td></td>
<td>• Energy of cosmic ray could be turned into matter/mass (1)

• According to $\Delta E = c^2\Delta m$ (1)</td>
<td></td>
<td>2</td>
</tr>
</table>

Q4.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)	An explanation that makes reference to the following: • due to the large mass and speed <u>OR</u> large momentum <u>OR</u> large energy (1) • the alpha particle would have a large <u>change</u> in momentum when deflected through large angles which requires a large force (1)		**(2)**

Question Number	Acceptable Answer	Additional guidance	Mark
(b)	• use of $F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$ (1) • charge of alpha $= 2 \times 1.6 \times 10^{-19}$ (C) (1) • r = 1.3×10^{-13} (m) (1) • comparison of the two distances (1) • conclusion that the alpha particle must reach a closer distance to give a larger force and relates this to the model (1)	Accept calculating a force for $r = 1.4 \times 10^{-10}$ and comparing forces <u>Example of calculation:</u> $r = \sqrt{8.99 \times 10^9 \text{ N m}^2\text{C}^{-2} \times \frac{(79 \times 2)(1.6 \times 10^{-19} \text{ C})^2}{2}}$ $r = 1.3 \times 10^{-13}$ m	**(5)**