Question number	Answer		Mark
18(a)	• Mass equal (to mass of electron) • Charge equal and opposite (to charge of electron) • Lepton number (equal and) opposite (to lepton number of electron)	(1) (1) (1)	**3**
18 (b)	• Curvature more in top half of picture • Particle moving slower after passing through lead plate because energy lost, so moving from lower half to top half • (Applying FLHR,) field into page (mark dependent on an indication of correct direction of positron motion)	(1) (1) (1)	**3**
18 (c) (i)	• Use of conversion factor 1.6×10^{-19} C • Use of $E_k = ½ mv^2$ • Calculated speed = 2.8×10^9 (m s^{-1}), which is greater than the speed of light (so it must be relativistic) Example of calculation $E_k = 23 \times 10^6$ eV $\times 1.6 \times 10^{-19}$ C $= 3.7 \times 10^{-12}$ J 3.7×10^{-12} J $= 0.5 \times 9.11 \times 10^{-31}$ kg $\times v^2$ $v = 2.8 \times 10^9$ m s^{-1}	(1) (1) (1)	**3**
18 (c) (ii)	• Use of $E = pc$ (ecf for E from (c)(i)) • Use of $r = p/Bq$ • $B = 2.1$ T Do not award MP1 if $p = mv$ calculated using v from part (i) Example of calculation 3.7×10^{-12} J $= p \times 3.00 \times 10^8$ m s^{-1} $p = 1.2 \times 10^{-20}$ N s 0.037 m $= 1.2 \times 10^{-20}$ N s / $B \times 1.6 \times 10^{-19}$ C $B = 2.1$ T	(1) (1) (1)	**3**

18 (d)	• Use of $E_k = ½ mv^2$ (1) • Use of $\Delta E = c^2 \Delta m$ (1) • Use of $E = hf$ (1) • $f = 1.2 \times 10^{20}$ Hz (1) Example of calculation $E_k = 2 \times 0.5 \times 9.11 \times 10^{-31}$ kg $\times (1.5 \times 10^7$ m s$^{-1})^2$ $= 2.0 \times 10^{-16}$ J $\Delta E = (3.00 \times 10^8$ m s$^{-1})^2 \times 2 \times 9.11 \times 10^{-31}$ kg $= 1.64 \times 10^{-13}$ J Total energy = 1.64×10^{-13} J + 2.0×10^{-16} J = 1.64×10^{-13} J Energy for one gamma photon = 8.2×10^{-14} J 8.2×10^{-12} J = 6.63×10^{-34} J s $\times f$ $f = 1.2 \times 10^{20}$ Hz		**4**
	Total for question 18		**16**