

Question Number	Answer	Mark
1(a)	$\bar{u}d$ (allow $\bar{c}d \ \bar{c}s \ \bar{u}s$)	(1) 1
1(b)	π^0	(1) 1
1(c)	Use of $v = s/t$ $t = 2.6 \times 10^{-8} \text{ s}$ <u>Example of answer</u> $t = 5.9 \text{ m} / 2.3 \times 10^8 \text{ m s}^{-1}$ $t = 2.57 \times 10^{-8} \text{ s}$	(1) (1) 2
*1(d)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Max 6 Pions are charged so leave a track Pion interacts with a stationary charged particle 2 neutral particles produced Because there are gaps in the trail Or no tracks produced Tracks are in different directions so that momentum is conserved Both particles decay into two charged particles At each decay particles have opposite charges Because charge is conserved Or particles move in opposite curvature. At each decay momentum is conserved	(1) (1) (1) (1) (1) (1) (1) (1) (1) 6
1(e)(i)	Antiproton Same mass as proton and opposite charge	(1) (1) 2
1(e)(ii)	It will annihilate with a proton/particle	(1) 1
	Total for question	13

Question Number	Answer	Mark	
2(a)(i)	Three quarks Or three antiquarks (accept the letter q to represent quarks)	(1)	
2(a)(ii)	Quark and an antiquark (accept the letter q to represent quarks)	(1)	
2(b)	Similarity: they have the same mass Or same magnitude of charge Difference: opposite charge	(1) (1)	2
2(c)(i)	Up and antistrange (in words or symbols, and can be in either order)	(1)	
2(c)(ii)	μ^- + μ $K^- \rightarrow \mu^- + \mu$	(1) (1)	2
2(c)(iii)	Energy = 2×494 MeV eV to J conversion Energy = 1.58×10^{-10} (J) (division by c^2 and subsequent multiplication by c^2 is not penalised) <u>Example of calculation</u>	(1) (1) (1)	3
	Energy = $2 \times 494 \times 10^6$ eV $\times 1.6 \times 10^{-19}$ J eV ⁻¹ Energy = 1.58×10^{-10} J		
	Total for question		10

Question Number	Answer	Mark
3(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 = $35 \text{ mm} \times 6 \text{ mm} / 4.5 \text{ mm}$	3
3(a)(ii)	Use of $p = Bqr$ [any two values sub] (1) Answer range $9.1 \times 10^{-21} - 1.4 \times 10^{-20} \text{ N s}$ or kg m s^{-1} [allow ecf](1)	2
3(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
3(c)	Into page (1) [ecf out of page if down in b]	1
3(d)(i)	Division by $9.11 \times 10^{-31} \text{ kg}$ (1) Answer range $1.0 - 1.6 \times 10^{10} \text{ m s}^{-1}$ (1)	2
3(d)(ii)	greater than speed of light (1) (impossible) so mass must have increased (1)	2
Total for question		13