**Name of the Student**:_____
**Max. Marks : 26 Marks** **Time : 26 Minutes**

Mark Schemes

**Q1.**

| Question Number | Answer | | Mark |
|---|---|---|---|
| *(a) | (QWC – Work must be clear and organised in a logical manner using technical wording where appropriate)<br>**Electric field**<br>Provides a force on the proton/particle<br>Which accelerate the proton/particle **Or** gives energy to the protons/particles<br><br>**Magnetic field**<br>Provides a force on a moving proton **Or** Provides a force at right angles to the direction of motion (of the protons)<br>Acts as a centripetal force **Or** produces circular motion<br><br>**Additional detail about either field**<br>E field across gap only<br>**Or** The idea that the E field is reversed /alternates every half cycle **Or** B field perpendicular to the Dees<br><br>(this mark may be awarded from a diagram) | (1)<br>(1)<br>(1)<br>(1)<br>(1) | 5 |
| (b) | Division by e (ignore powers of 10 error)<br>multiplication by $c^2$<br>Mass = 0.14 ($GeV/c^2$)<br><br>Example of calculation<br>Mass = $(2.5 \times 10^{-28}\ kg \times 9 \times 10^{16}\ m^2\ s^{-2})/1.6 \times 10^{-19}\ C$<br>Mass = $0.14 \times 10^9\ eV/c^2 = 0.14\ GeV/c^2$ | (1)<br>(1)<br>(1) | 3 |
| (c) | 2/3 charge of a proton **Or** 2/3 charge of a positron<br>**Or** 2/3 positive value of the charge on an electron **Or** $2/3e^+$ | (1) | 1 |

| | | | |
|---|---|---|---|
| **(d)(i)** | <table><tr><th>Particle</th><th>Quark combination</th></tr><tr><td>$K^-$</td><td>$\bar{s}u$</td></tr><tr><td>K+</td><td>$\bar{u}s$</td></tr><tr><td>K0</td><td>$\bar{s}d$ or $\bar{d}s$</td></tr></table> | (1)<br>(1)<br>(1) | 3 |
| **(d)(ii)** | Mass-energy is conserved **Or** a comment about $E = mc^2$<br>Appropriate reference to colliding particles having mass and kinetic energy The extra mass comes from the kinetic energy. | (1)<br>(1)<br>(1) | 3 |
| | **Total for question** | | **15** |

**Q2.**

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| **(a)(i)** | • a $\pi^0$ may be $u\bar{u}$ **Or** $d\bar{d}$ (1)<br>• it must be a quark combined with its own antiquark so that overall charge is 0 (1)<br>OR it can only contain up or down quarks (as it is not a strange particle) | Allow $s\bar{s}$ | **(2)** |
| **(a)(ii)** | mesons are made up of quarks, whereas leptons are fundamental particles (1) | | **(1)** |

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| **(b)(i)** | • use of v = s/t (1)<br>• t = 5.05 × $10^{-5}$ s (1) | Example of calculation:<br>$t = \frac{s}{v} = \frac{15\times10^{3}\,\text{m}}{0.99\times3\times10^{8}\,\text{m s}^{-1}} = 5.05\times10^{-5}\,\text{s}$ | **(2)** |
| **(b)(ii)** | • use of $\lambda t_{1/2} = 0.693$ (1)<br>• λ = 3.15 × $10^{5}$ $s^{-1}$ (1)<br>• use of $N = N_0 e^{-\lambda t}$ (1)<br>• $\frac{N}{N_0} = 1.23\times10^{-7}$ (1) | Example of calculation:<br>$\lambda = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{2.2\times10^{-6}\,\text{s}} = 3.15\times10^{5}\,\text{s}^{-1}$<br>$\frac{N}{N_0} = e^{-\lambda t} = e^{-3.15\times10^{5}\,\text{s}^{-1}\times5.05\times10^{-5}\,\text{s}} = 1.23\times10^{-7}$<br>$\frac{N}{N_0} = 1.1\times10^{-7}$ if "show that" value used | **(4)** |
| **(b)(iii)** | • This is much smaller than 10% indicating the muon lifetime is much greater than the expected value (1)<br>• The high speed of the muon has led to relativistic effects (1) | | **(2)** |