Candidate evidence

Q1(a) **Maximum mark: 3**

Response 1 **Marks**

$$a = \frac{dv}{dt} = 8 \cdot 4t + 1 \cdot 6.$$

$$24 = 8 \cdot 4t + 1 \cdot 6$$

$$22 \cdot 4 = 8 \cdot 4t$$

$$t = 2 \cdot 67s.$$

Response 2

$$a = \frac{dv}{dt} = 8 \cdot 4t + 1 \cdot 6$$

$$a = 8 \cdot 4t + 1 \cdot 6$$

$$24 = 8 \cdot 4t + 1 \cdot 6$$

$$22 \cdot 4 = 8 \cdot 4t$$

$$t = 2 \cdot 6s$$

Response 3

$$V = 4 \cdot 2t^2 + 16t$$

$$\frac{dv}{dt} = a = 8 \cdot 4t + 16$$

$$24 = 8 \cdot 4t + 16$$

$$8 = 8 \cdot 4t$$

$$t = 0 \cdot 952s$$

Q1(b) **Maximum mark: 3**

Response 1 **Marks**

The candidate's final answer from Q1(a) was 2·67 s.

$S = \int v\,dt = \cancel{k}\ 1.4t^3 + 0.8t^2 + c$

~~use~~ when $t = 0,\ S = 0$

$\therefore\ 0 = c$

so, $S = 1.4t^3 + 0.8t^2$

$= 1.4(2.67)^3 + 0.8(2.67)^2$

$= 32.4\,m$

Response 2

The candidate's final answer from Q1(a) was 2·7 s.

$v = 4.2t^2 + 1.6$

$\int v\,dt = s = 1.4t^3 + 1.6t$

when $t = 2.7$,

$s = 1.4(2.7)^3 + 1.6(2.7)$

$= 31.8762$

$s = 31.9\,m$

.

Response 3

The candidate's final answer from Q1(a) was 2·67 s.

$s = \int_0^{2.67} 4.2t^2 + 1.6t\ \ dt$

$= \left[\frac{4.2t^3}{3} + \frac{1.6t^2}{2}\right]_0^{2.67}$

$= \left(\frac{4.2(2.67)^3}{3} + \frac{1.6(2.67)^2}{2}\right) - (0)$

$= 15.68\,m$

Q2(a)(i) **Maximum mark: 3**

Response 1 **Marks**

$V = r\omega$ $m = 380$ $r = 7.6$ $V = 8.8 \text{ ms}^{-1}$

$8.8 = 7.6 \times \omega$

$\omega = 1.1571\ldots \text{ rad s}^{-1}$

$F = mr\omega^2$

$= 380 \times 7.6 \times 1.1571\ldots$

$= 3344 \text{N}$

Response 2

$$F = \frac{mv^2}{r}$$

$$= \frac{(380)(8.8)^2}{(7.6)}$$

$$= \underline{3870\text{N}}$$

Response 3

$$F = \frac{mv^2}{r}$$

$$= \frac{380 \times 8.8^2}{7.6}$$

$$= 3872$$

Q2(a)(ii) Maximum mark: 1

Response 1 **Marks**

Into the centre of circular path
followed
90° to the velocity

Response 2

Towards the centre of the axel
that is turning the ride.

Response 3

Towards the centre.

Q2(b)(i) **Maximum mark: 2**

Response 1 **Marks**

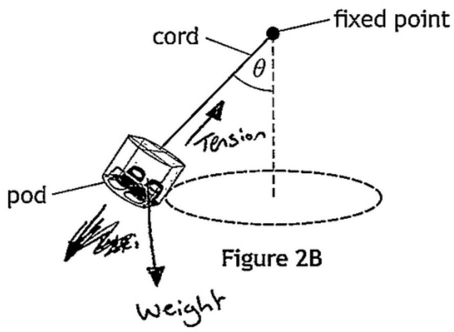


Figure 2B

Response 2

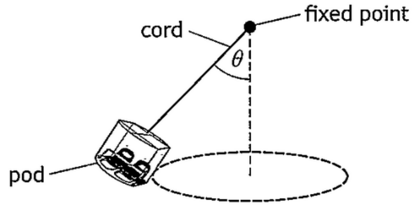
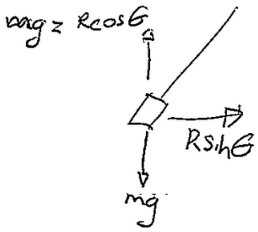


Figure 2B



Response 3

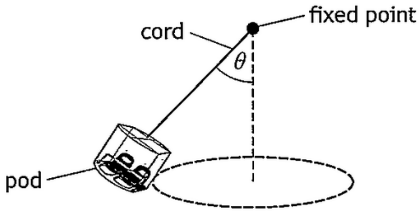
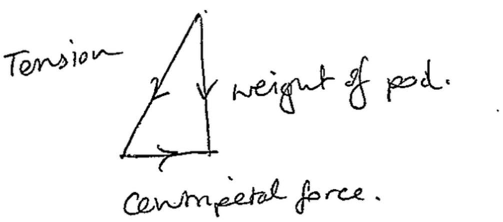


Figure 2B



Q2(b)(ii) Maximum mark: 2

Response 1

Marks

θ will decrease because there is ~~a~~ smaller centripetal force acting on the pod ~~[illegible]~~.

Response 2

angle θ decreases as the force of tension decreases so the centripedal force can pull the pod closer to the centre.

Response 3

angle θ decreases.

Q3(a) **Maximum mark: 2**

Response 1 **Marks**

$M = 63$

$I = \frac{1}{3} mL^2$ $L = 2.1$

$I = \frac{1}{3} \times 63 \times (2.1)^2$

$= 92.61\ \mathrm{Kgm^2}$

Response 2

$I = \frac{1}{3} mr^2$

$I = \frac{1}{3} \times 63 \times 2.1^2$

$I = 92.61\ \mathrm{kgm^2}$

$I \approx 93\ \mathrm{kgm^2}$

Response 3

$I = \frac{1}{3} ml^2$

$= \frac{1}{3} \times 63 \times 2.1^2$

$= 93\ \mathrm{kgm}$ as reqd.

Q3(b)(i) Maximum mark: 1

Response 1 **Marks**

The total length of the gymnast has decreased which results in a smaller moment of inertia.

Response 2

The mass is more evenly distributed and is closer to the bar, meaning it resists movement less.

Response 3

The distribution of her mass about the axis of rotation has changed

Q3(b)(ii) Maximum mark: 3

Response 1

Marks

Before

~~te~~

$L = I\omega$

$L = 93 \times 7.9$

$L = 734.7 \text{ kgm}^2 \text{ rad s}^{-1}$

After

$L = I\omega$

$734.7 = 62 \times \omega$

$\omega = 11.85 \text{ rad s}^{-1}$

$\rightarrow 11.9 \text{ rad s}^{-1}$

Response 2

$I\omega = I\omega$

$93 \times 7.9 = 62 \times \omega$

$= \cancel{11.85 \text{ rad s}^{-1}}$

$= 12 \text{ rad s}^{-1}$

Response 3

$I\omega_0 = \omega(I + I_{pike})$

$(93 \times 7.9) = \omega(93 + 62)$

$734.7 = 155\omega$

$\omega = 1.5 \text{ rad s}^{-1}$

Q5(a) **Maximum mark: 1**

Response 1 **Marks**

A gravitational potential of $-1.70 \times 10^9 J kg^{-1}$ means that -1.70×10^9 of energy is required to move one unit mass. ~~to~~

Response 2

Means that $-1.70 \times 10^9 J$ of work has to be done to move unit mass (1kg) from infinitely far away to that point.

Response 3

$1.7 \times 10^9 J$ of energy is needed to move a kilogram mass from infinity to point A.

Q5(b) **Maximum mark: 3**

Response 1 **Marks**

$$E_p = -\frac{Gm\cancel{m}}{r}$$

$$= \frac{-6.67\times10^{-11} \times 1.9\times10^{27}}{1.69\times10^{8}}$$

$$= -7.49\times10^{8}\ \mathrm{J\,kg^{-1}}$$

Response 2

$$V = -\frac{GM}{r}$$

$$= \frac{-6.67\times10^{-11} \times 1.9\times10^{27}}{1.69\times10^{8}}$$

$$= -7.50\times10^{8}\ \mathrm{J}$$

Response 3

$$V = \frac{-GM}{r}$$

$$= \frac{6.67\times10^{-11} \times 1.9\times10^{27}}{(1.69\times10^{8})}$$

$$= 749.9\times10^{6}\ \mathrm{J\,kg^{-1}}$$

Q5(c) **Maximum mark: 4**

Response 1 **Marks**

The candidate's answer from Q5(b) was 749·9 × 10^6 Jkg^{-1}.

A/ $E_p = Vm$

$= 1{\cdot}70 \times 10^9 \times 1{\cdot}6 \times 10^3$

$= 2{\cdot}72 \times 10^{12}$ J

B/ $E_p = Vm$

$= 749{\cdot}9 \times 10^6 \times 1{\cdot}6 \times 10^3$

$= 1{\cdot}2 \times 10^{12}$ J

$E_p(A) - E_p(B)$

$2{\cdot}72 \times 10^{12} - 1{\cdot}2 \times 10^{12}$

$= 1{\cdot}5 \times 10^{12}$ J

Response 2

The candidate's answer from Q5(b) was −7·5 × 10^8 Jkg^{-1}.

$E_{pA} = V_A m = -1{\cdot}7 \times 10^9 \times 1{\cdot}6 \times 10^3 = -2{\cdot}72 \times 10^{12}$

$E_{pB} = V_B m = -7{\cdot}5 \times 10^8 \times 1{\cdot}6 \times 10^3 = -1{\cdot}2 \times 10^{12}$

$E_{pA} - E_{pB} = -2{\cdot}72 \times 10^{12} - (-1{\cdot}2 \times 10^{12})$

$= \underline{-1{\cdot}52 \times 10^{12}\,J}$

Response 3

The candidate's answer from Q5(b) was $-0{\cdot}75 \times 10^9$ Jkg^{-1}.

$\Delta V = -1{\cdot}7 \times 10^9 - (-0{\cdot}75 \times 10^9)$

$= -0{\cdot}95 \times 10^9 \text{ J kg}^{-1}$

$E_p = \Delta V \times m$

$= -0{\cdot}95 \times 10^9 \times 1{\cdot}6 \times 10^3$

$= \underline{-1{\cdot}52 \times 10^{12} \text{ J}}$

Response 4

The candidate's answer from Q5(b) was $-7{\cdot}5 \times 10^8$ Jkg^{-1}

$E_p = Vm$

$E_p = -1{\cdot}7 \times 10^9 \times 1{\cdot}6 \times 10^3$

$E_p = -2{\cdot}72 \times 10^{12}$ J at A

$E_p = Vm$

$E_p = -7{\cdot}5 \times 10^8 \times 1{\cdot}6 \times 10^3$

$E_p = -1{\cdot}2 \times 10^{12}$ J

Change $= -1{\cdot}2 \times 10^{12} - (-2{\cdot}72 \times 10^{12})$

$= \underline{1{\cdot}52 \times 10^{12} \text{ J}}$

Q6(a) **Maximum mark: 1**

Response 1 **Marks**

No observer can determine by experiment whether they are in a gravitational field or an accelerating frame of reference.

Response 2

The ~~[illegible]~~ equivalence principle means that the effects of acceleration ~~[illegible]~~ due to a gravitational field are the same as the effects of acceleration through empty space.

Response 3

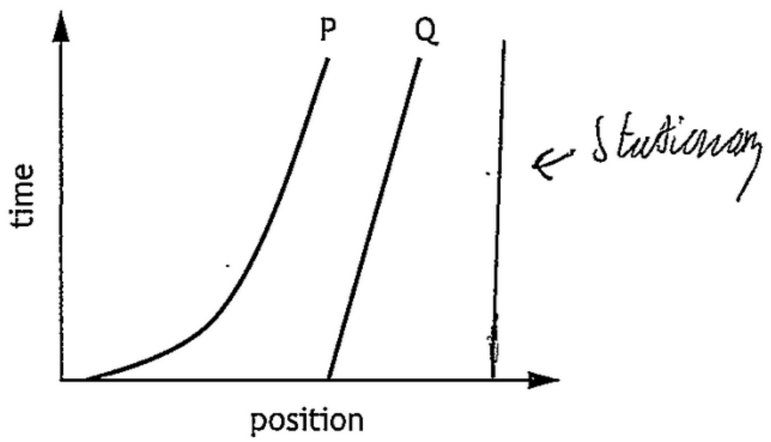
gravitation and acceleration are equivalent due to a curvature in spacetime.

Response 4

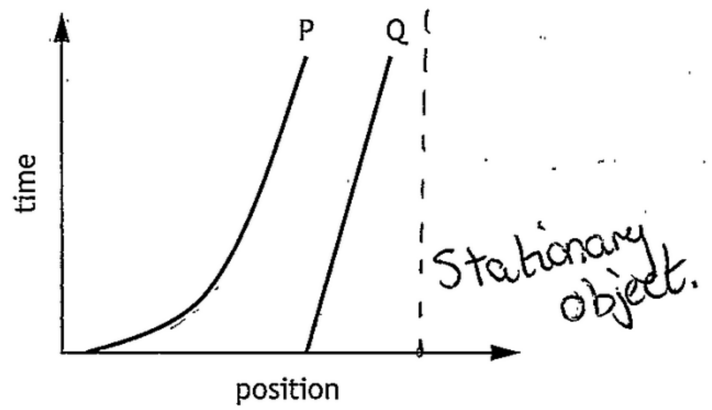
That there is no way to experimentally determine if you are in an accelerating point of reference or a gravitational field.

Q6(b)(ii) Maximum mark: 1

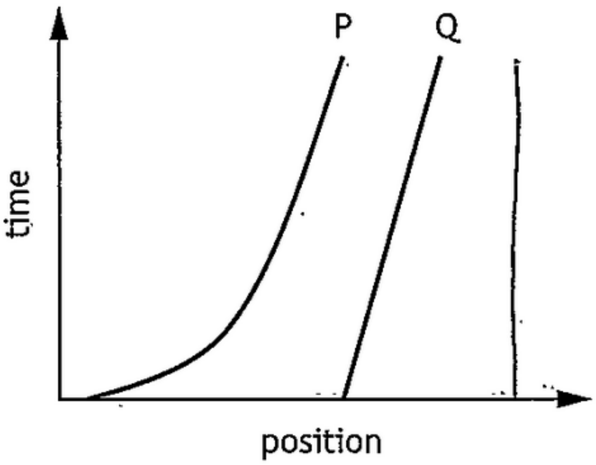
Response 1 **Marks**



Response 2



Response 3



Q6(c)(i) Maximum mark: 2

Response 1 **Marks**

$$0.0487 = \frac{4 \times 6.67 \times 10^{-11} \times M}{1.54 \times 10^{6} \times (3 \times 10^{8})^2}$$

$$6.74 \times 10^{21} = 4 \times 6.67 \times 10^{-11} \times M$$

$$M = 2.53 \times 10^{31}\ kg$$

Response 2

$$\theta = \frac{4GM}{rc^2}$$

$$0.0487 = \frac{4 \times 6.67 \times 10^{-11} \times M}{1.54 \times 10^{6} \times (3 \times 10^{8})^2}$$

$$0.0487 = \frac{4 \times 6.67 \times 10^{-11} \times M}{1.386 \times 10^{23}}$$

$$M = \frac{0.0487 \times 1.386 \times 10^{23}}{4 \times 6.67 \times 10^{-11}}$$

$$M = \underline{\underline{2.53 \times 10^{31}\ kg}}$$

Response 3

$\theta = 0.0487$

$r = 1.54 \times 10^{6}$

$c = 3 \times 10^{8}$

$G = 6.67 \times 10^{-11}$

$$\theta = \frac{4GM}{rc^2}$$

$$\theta rc^2 = 4GM$$

$$M = \frac{\theta rc^2}{4G}$$

$$= \frac{0.0487 \times 1.54 \times 10^{6} \times 3 \times 10^{8\,2}}{4 \times 667 \times 10^{-11}}$$

$$= \underline{2.53 \times 10^{31}\ kg.}$$

Q6(c)(ii)A **Maximum Mark: 2**

Response 1 **Marks**

$r = 6.955 \times 10^8$

$\theta = \dfrac{2 \times 3 \times 10^3}{6.955 \times 10^8}$

~~= 8.63 rad~~

$= 8.63 \times 10^{-6}$ rad.

Response 2

$\theta = \dfrac{2r_{sch}}{r}$

$= \dfrac{2 \times 3 \times 10^3}{6.955 \times 10^8}$

$= 8.63 \times 10^{-6}$

Response 3

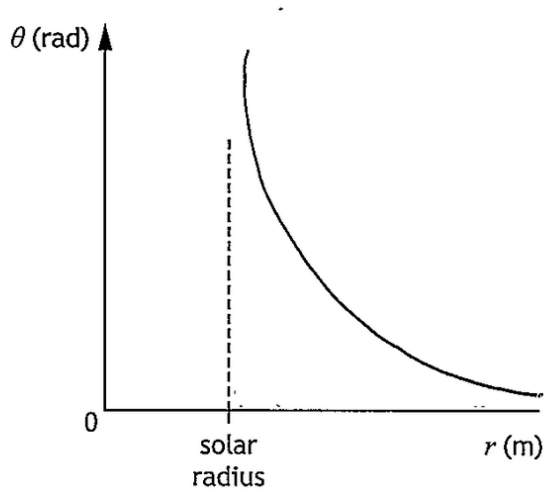
$\theta = \dfrac{2 \times 3 \times 10^3}{6.955 \times 10^8}$

$= 8.63^\circ$

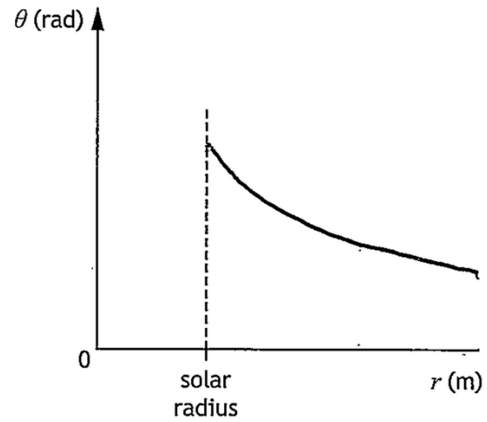
Q6(c) (ii)(B)

Maximum mark: 2

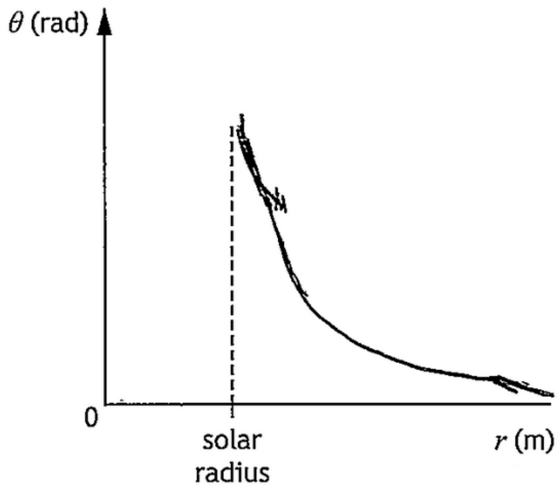
Response 1 **Marks**



Response 2



Response 3



Q7(a) (ii)(A)

Maximum mark: 1

Response 1 **Marks**

Most of the hydrogen fusion will have stopped.

Response 2

hydrogen to helium fusion will stop
helium will fuse to carbon

Response 3

Hydrogen will have burnt out and stopped fusing to form Helium

Q7(a)(ii)(B) **Maximum mark: 1**

Response 1 **Marks**

Thermal pressure will be greater than gravitational forces.

Response 2

The thermal pressure will increase and the gravitational force will decrease meaning the matter of the planet will not be as held together and spread out, increasing the diameter

Response 3

Fusion of elements heavier than hydrogen create more ~~t~~ thermal pressure, but the gravitational force is constant so the star is now pushing against the same gravitational force with a greater force causing the star to expand

Q7(b)(i) Maximum mark: 3

Response 1

Marks

$L = b4\pi r^2$

$= 1.6\times10^{-7}\times 4\pi\times(6.1\times10^{18})^2$

$= 7.5\times10^{31}$ W.

Response 2

$\cancel{L = 4\pi r^2 \sigma T^4}$

$1.67\times10^{-7} = \frac{L}{4.68\times10^{38}}$

$L = 7.81\times10^{31}$ W

$b = \frac{L}{4\pi r^2}$

$1.6\times10^{-7} = \frac{L}{4\pi\times 6.1\times10^{18^2}}$

$\cancel{1.8\times10^{-7} = \frac{L}{7.67\times10^{19}}}$

Response 3

$b = \frac{L}{4\pi r^2}$.

$L = b4\pi r^2$.

$= 1.6\times10^{-7}\times 4\times\pi\times 6.1\times10^{18^2}$

$= 7.48\times10^{31}$ W.

Q7(b)(ii) Maximum mark: 3

Response 1 **Marks**

The candidate's final answer for Q7(b)(i) was 7·48 × 10^{31} W.

$L = 4\pi r^2 \sigma T^4$

$7.48\times10^{31} = 4\times\pi\times 8.3\times10^{11^2} \times 5.67\times10^{-8}\, T^4$

$T^4 = 1.52\times10^{14}$

$T = 3511\ K$.

Response 2

The candidate's final answer for Q7(b)(i) was 1·2 × 10^{13} W.

$L = 4\pi r^2 \sigma T^4$

$1.2\times10^{13} = 4\pi \times (8.3\times10^{11} + 6.1\times10^{18})$

$5.67\times10^{-8} \times T^4$

$T^4 = 2.76$

$T = 1.3\ K$

Response 3

The candidate's final answer for Q7(b)(i) was 7·5 × 10^{31} W.

$L = 7.5\times10^{31}$

$\sigma = 5.67\times10^{-8}$

$T = ?$

$r = 8.3\times10^{11}$

$L = 4\pi r^2 \sigma T^4$

$7.5\times10^{31} = 4\pi\times(8.3\times10^{11})^2 \times 5.67\times10^{-8} \times T^4$

$T^4 = \cancel{4.91\times10^{17}}\ \dfrac{7.5\times10^{31}}{4.91\times10^{17}}$

$T = \underline{3500k}$

Q7(c) **Maximum mark: 1**

Response 1 **Marks**

How massive it is.

Response 2

The mass.

Q8(a) **Maximum mark: 3**

Response 1 **Marks**

$$\Delta E \Delta t \geq \frac{h}{4\pi}$$

$$\Delta E_{min} \geq \frac{h}{4\pi \Delta t}$$

$$\Delta E_{min} \geq \frac{6.63 \times 10^{-34}}{4\pi \times 8.5 \times 10^{-6}}$$

$$\Delta E_{min} \geq 6.2 \times 10^{-30}\ \text{J}.$$

Response 2

$$\Delta E \Delta t \geq \frac{h}{4\pi}$$

$$\Delta E \geq \frac{6.63 \times 10^{-34}}{4\pi \times 8.5 \times 10^{-6}}$$

$$\Delta E = \pm 6.21 \times 10^{-30}\ \text{eV}$$

Response 3

$$\Delta E \Delta t \geq \frac{h}{4\pi}$$

$$\Delta E \times (8.5 \times 10^{-6}) = \frac{6.63 \times 10^{-34}}{4\pi}$$

$$\Delta E = \pm 6.2 \times 10^{-30}\ \text{J}$$

Q8(b) **Maximum mark: 3**

Response 1 **Marks**

$4.1\times10^9\ eV = 4.1\times10^9 \times 1.6\times10^{-19}$
$= 6.56\times10^{-10}\ J$

10000 in 1 min
166 in 1 sec

$E = 166 \times 6.56\times10^{-10} = 1.09\times10^{-7}\ J$

Response 2

10 000 muons per minute
~~[illegible]~~
166.7 muons per second

$4.1\times10^9\ eV$
$= (4.1\times10^9\times1.6\times10^{-19})\ J$
$= 6.56\times10^{-10}\ J$ per muon

$166.7\times6.56\times10^{-10} =$ ~~[illegible]~~ $1.09\times10^{-7}\ J$ per second

Response 3

$10\,000\ min^{-1}$

$\therefore \frac{10\,000}{60} = 166.6\dot{7}\ s^{-1}$

average total energy $= 166.67(4.1\times10^9)$
$= 6.833\times10^{11}\ eV$
$= (1.60\times10^{-19})(6.833\times10^{11}) = 1.1\times10^{-7}$

Q8(c) **Maximum mark: 4**

Response 1 **Marks**

$$\lambda = \frac{h}{p}$$

$$= \frac{6.63 \times 10^{-34}}{4.87 \times 10^{-19}}$$

$$= 1.36 \times 10^{-15}$$

It's de broglie wavelength is so small that it can be considered a particle

Response 2

$$\lambda = \frac{h}{p}$$

$$= \frac{6.63 \times 10^{-34}}{4.87 \times 10^{-19}}$$

$$= 1.36 \times 10^{-15} m.$$

∴ as their wavelength is so small that any interference caused by the wave is negligable, they can be regarded as particles.

Response 3

$$\lambda = \frac{h}{p} = \frac{6.63 \times 10^{-34}}{4.87 \times 10^{-19}}$$

$$= 1.36 \times 10^{-15} m$$

- λ is very small ∴ frequency will be very large.
- with such a small wavelength and such a high rate of oscillations per second, the wavelike properties will be too small to be noticed.
- Therefore, muons can be considered particles.