# Markscheme

## May 2023

## Physics

## Standard level

## Paper 2

11 pages

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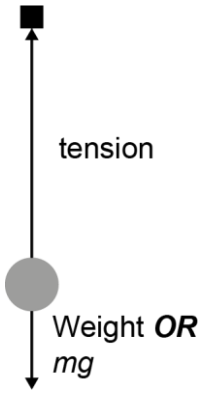
| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| **1.** | **a** | **i** | Tension upwards, weight downwards✓<br>Tension is clearly longer than weight✓ | *Look for:*<br>  <br> | **2** |
| **1** | **a** | **ii** | $v = \sqrt{2 \times 9.81 \times 0.95}$ ***OR*** $= 4.32$ **«**$\text{m s}^{-1}$**»** ✓ | *Must see either full substitution or answer to at least 3 s.f.* | **1** |
| **1** | **a** | **iii** | $T\text{-}mg = F_{\text{net}}$ ***OR*** $T - mg = \frac{mv^2}{r}$ ✓<br>$T$ **«**$= 0.800 \times 9.81 + \frac{0.800 \times 4.317^2}{0.95}$**»** $= 23.5$ **«**N**»** ✓ | | **2** |
| **1** | **b** | **i** | Use of conservation of momentum. ✓<br>Rebound speed = 2.16 **«** m $s^{-1}$**»** ✓<br>Calculation of initial KE = **«** $\frac{1}{2} \times 0.800 \times 4.317^2$ **»** = 7.46 **«** J **»** ✓<br>Calculation of final KE = **«** $\frac{1}{2} \times 0.800 \times 2.16^2 + \frac{1}{2} \times 2.40 \times 2.16^2$ **»** = 7.46 **«**J**»** ✓<br>**«**hence elastic**»** | | **4** |

| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| 1 | b | ii | ***ALTERNATIVE 1***<br>Rebound speed is halved so energy less by a factor of 4 ✓<br>Hence height is $\frac{95}{4}$ =23.8 **«**cm**»** ✓<br><br>***ALTERNATIVE 2***<br>Use of conservation of energy / $\frac{1}{2}\times 0.800\times 2.16^2 = 0.800\times 9.8\times h$ ✓<br>***OR***<br>Use of proper kinematics equation (e.g. 0 = $2.16^2$ - 2 x 9.8 x h)<br>*h* = 23.8 **«**cm**»** ✓ | *Allow* ***ECF*** *from* ***b(i)*** | **2** |
| 1 | c | | ***ALTERNATIVE 1***<br>Frictional force is $f$ **«**$= 0.400\times 2.40\times 9.81$**»** $= 9.42$ **«**N**»** ✓<br>$9.42\times d = \frac{1}{2}\times 2.40\times 2.16^2$ ***OR*** $d = \frac{5.5987}{9.42}$ ✓<br>$d = 0.594$**«**m**»** ✓<br><br>***ALTERNATIVE 2***<br>$a =$ **«**$\frac{f}{m} = \mu g = 0.4\times 9.81$**»** 3.924 «m $s^{-2}$» ✓<br>Proper use of kinematics equation(s) to determine ✓<br>*d* = 0.594 **«**m**»** ✓ | | **3** |

| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| **2.** | **a** | | Reads change in temperature to be 45 – 31 ***OR*** 14 °C ✓<br><br>$Q = 0.082 \times 1.6 \times 10^3 \times 14 = 1.84 \times 10^3$ **«J»** ✓<br><br>$P = \frac{1.84 \times 10^3}{2.0 \times 60} = 15.3 \approx 15$**«W»** ✓ | *Must see either full substitution* ***OR*** *answer to at least 3 s.f. in* ***MP3*** | **3** |
| **2** | **b** | | $Q = 15.3 \times 4.0 \times 60 = 3.67 \times 10^3$ **«J»** ✓<br><br>$L = \frac{3.67 \times 10^3}{0.082} = 4.5 \times 10^4$ **«J kg$^{-1}$»** ✓ | *Allow* ***ECF*** *from* ***MP1*** | **2** |
| **2** | **c** | | Internal energy is greater at $t$ = 6 min ***OR*** internal energy is lower at $t$ = 2 min ***OR*** internal energy increases **«**as energy is added to the system**»** ✓<br><br>Because kinetic energy **«**of the molecules**»** is the same ***AND*** potential energy **«**of the molecules**»** has increased / ***OWTTE*** ✓ | | **2** |

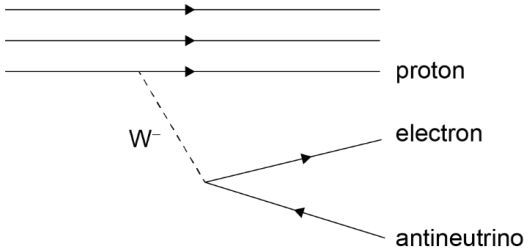
| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| **3.** | **a** | **i** | **«**A wave where the**»** displacement of particles/oscillations of particles/movement of particles/vibrations of particles is perpendicular/normal to the direction of energy transfer/wave travel/wave velocity/wave movement/wave propagation ✓ | *Allow medium, material, water, molecules, or atoms for particles.* | **1** |
| **3** | **a** | **ii** | $v = \text{«}0.50 \times 16 = \text{»}8.0\ \text{«m s}^{-1}\text{»}$ ✓ | | **1** |
| **3** | **a** | **iii** | P at (8,1.2) ✓ | | **1** |
| **3** | **a** | **iv** | ***ALTERNATIVE 1***<br>Phase difference is $\frac{2\pi}{\lambda} \times \frac{\lambda}{2}$ ✓<br>**«**= π »<br><br>***ALTERNATIVE 2***<br><br>One wavelength/period represents **«**phase difference**»** of 2π and **«**corks**»** are ½ wavelength/period apart so phase difference is π/***OWTTE*** ✓ | | **1** |

| | | | | | |
|---|---|---|---|---|---|
| **3** | **b** | | light acts as a wave **«**and not a particle in this situation**»** ✓<br><br>light at slits will diffract / create a diffraction pattern ✓<br><br>light passing through slits will interfere / create an interference pattern **«**creating bright and dark spots**»**. ✓ | | **2 max** |
| **3** | **c** | | Use of $s = \frac{\lambda D}{d} \Rightarrow \lambda = \frac{sd}{D}$ ***OR*** $s = \frac{n\lambda D}{d} \Rightarrow \lambda = \frac{sd}{nD}$ ✓<br><br>$\lambda = \text{«}\frac{0.567\times10^{-2}\times0.18\times10^{-3}}{2.2}\text{»} = 4.6\times10^{-7}$ **«**m**»** ✓ | | **2** |

| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| **4.** | **a** | **i** | Voltage across P is 1.4 **«**V**»** ✓<br><br>Voltage across Q is 4.6 **«**V**»** ✓<br><br>And 6 – 1.4 = 4.6 **«**V**»** ✓ | *Need to see a calculation involving the two voltages and the total voltage in the circuit for **MP3** (e.g. 1.4 + 4.6 = 6).* | **3** |
| **4** | **a** | **ii** | Current in R is **«(**0.45 - 0.4)=**»** 0.05 A ✓<br>So resistance is **«**$\frac{1.4}{0.05}$**»** $= 28$ **«**$\Omega$**»** ✓ | *Allow **ECF** from **a(i)***<br>*Allow **ECF** from **MP1*** | **2** |
| **4** | **a** | **iii** | **«**$0.45 \times 6.0$**»** $= 2.7$ **«**W **»** ✓ | | **1** |
| **4** | **b** | | Q will have a smaller resistance ✓<br><br>**«**Because total resistance in the circuit is now larger so**»** the current **«**through the circuit/Q**»** is smaller / ***OWTTE*** ✓ | *Allow similar argument for **MP2** based on voltage across* Q *becoming smaller.* | **2** |

| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| **5.** | **a** | | Weak nuclear: 2 ticks ✓<br>Strong nuclear: quarks only ✓ | | **2** |
| **5** | **b** | **i** | **«**$\mu$**»** = 2.0141 + 3.0160 - (4.0026 + 1.008665) **«**= 0.0188 u**»**<br><br>***OR***<br><br>*In* MeV*:* 1876.13415 + 2809.404 - (3728.4219 + 939.5714475) ✓<br><br>$=0.0188\times931.5$ ***OR*** $=17.512$ **«**MeV**»** ✓ | *Must see either clear substitutions or answer to at least 3 s.f. for* ***MP2****.* | **2** |

| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| 5 | b | ii | ***ALTERNATIVE 1***<br>0.40 kg of deuterium is **«**$\frac{400}{2}\times 6.02\times 10^{23}$**»** $= 1.2\times 10^{26}$ nuclei<br>«0.60 kg of tritium is the same number» ✓<br><br>So specific energy **«**$\frac{1.2\times 10^{26}\times 17.51\times 10^{6}\times 1.6\times 10^{-19}}{0.4+0.6}$**»** = 3.4 x $10^{14}$ «J $kg^{-1}$ » ✓<br><br>***ALTERNATIVE 2***<br><br>«17.51x$10^{6}$ x 1.6x$10^{-19}$ =» 2.8x$10^{-12}$ «J»<br><br>***AND***<br><br>«(2.0141 + 3.0160) x 1.66x$10^{-27}$ =» 8.35x$10^{-27}$ ✓<br><br>**«**$\frac{2.8\times 10^{-12}}{8.35\times 10^{-37}}$**»** $= 3.4\times 10^{14}$ **«**$Jkg^{-1}$**»** ✓ | *Allow ~2.1 x $10^{27}$* MeV $kg^{-1}$ *for **MP2**.*<br><br>*Allow **ECF** from **MP1** for both **ALTs.*** | **2** |
| 5 | c | i | Requires high temp/pressure ✓<br>Must overcome Coulomb/intermolecular repulsion ✓<br>Difficult to contain / control «at high temp/pressure» ✓<br>Difficult to produce excess energy/often energy input greater than output / ***OWTTE*** ✓<br>Difficult to capture energy from fusion reactions ✓<br>Difficult to maintain/sustain a constant reaction rate ✓ | | **2 max** |
| 5 | c | ii | Plentiful fuel supplies ***OR*** larger specific energy ***OR*** larger energy density ***OR*** little or no **«**major radioactive**»** waste products ✓ | *Allow descriptions such as "more energy per unit mass" or "more energy per unit volume"* | **1** |

| | | | | | |
|---|---|---|---|---|---|
| **5** | **d** | **i** | 3 ✓ | *Do **not** accept* $^{3}_{2}He$ *by itself.* | **1** |
| **5** | **d** | **ii** | Proton shown ✓<br>W- shown ✓<br>Produces electron/e $^{-}$ / $\beta^{-}$ and antineutrino / $\overline{\upsilon}$ with proper arrow directions. ✓ |  <br>*Allow solid, dashed, or wavy line for* W- *particle.*<br>*Must see bar on antineutrino if symbol used.* | **3 Max** |