

# Markscheme

**May 2023**

**Physics**

**Standard level**

**Paper 2**

11 pages

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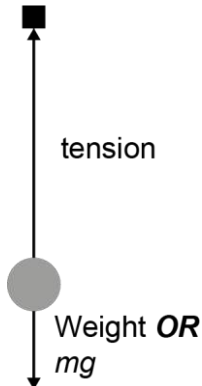
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Question			Answers	Notes	Total
1.	a	i	Tension upwards, weight downwards ✓ Tension is clearly longer than weight ✓	<p>Look for:</p> 	2
1	a	ii	$v = \sqrt{2 \times 9.81 \times 0.95}$ <b>OR</b> $= 4.32 \text{ «ms}^{-1}\text{»}$ ✓	Must see either full substitution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

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

Question		Answers	Notes	Total
2.	a	<p>Reads change in temperature to be 45 – 31 <b>OR</b> 14 °C ✓</p> $Q = 0.082 \times 1.6 \times 10^3 \times 14 = 1.84 \times 10^3 \text{ «J» } \checkmark$ $P = \frac{1.84 \times 10^3}{2.0 \times 60} = 15.3 \approx 15 \text{ «W» } \checkmark$	<p>Must see either full substitution <b>OR</b> answer to at least 3 s.f. in <b>MP3</b></p>	3
2	b	$Q = 15.3 \times 4.0 \times 60 = 3.67 \times 10^3 \text{ «J» } \checkmark$ $L = \frac{3.67 \times 10^3}{0.082} = 4.5 \times 10^4 \text{ «J kg}^{-1}\text{» } \checkmark$	<p>Allow <b>ECF</b> from <b>MP1</b></p>	2
2	c	<p>Internal energy is greater at <math>t = 6</math> min <b>OR</b> internal energy is lower at <math>t = 2</math> min <b>OR</b> internal energy increases «as energy is added to the system» ✓</p> <p>Because kinetic energy «of the molecules» is the same <b>AND</b> potential energy «of the molecules» has increased / <b>OWTTE</b> ✓</p>		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 ✓	<i>Allow medium, material, water, molecules, or atoms for particles.</i>	1
3	a	ii	$v = \ll 0.50 \times 16 \Rightarrow 8.0 \ll \text{ms}^{-1} \gg$ ✓		1
3	a	iii	P at (8,1.2) ✓		1
3	a	iv	<p><b>ALTERNATIVE 1</b></p> <p>Phase difference is <math>\frac{2\pi}{\lambda} \times \frac{\lambda}{2}</math> ✓</p> <p>«= <math>\pi</math> »</p> <p><b>ALTERNATIVE 2</b></p> <p>One wavelength/period represents «phase difference» of <math>2\pi</math> and «corks» are <math>\frac{1}{2}</math> wavelength/period apart so phase difference is <math>\pi</math>/<b>OWTTE</b> ✓</p>		1

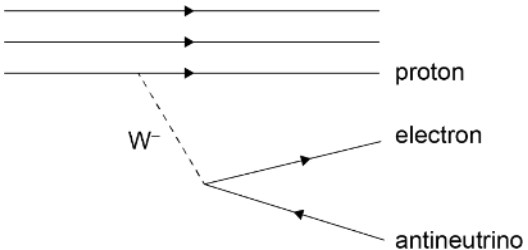
3	b	<p>light acts as a wave «and not a particle in this situation» ✓</p> <p>light at slits will diffract / create a diffraction pattern ✓</p> <p>light passing through slits will interfere / create an interference pattern «creating bright and dark spots». ✓</p>		2 max
3	c	<p>Use of <math>s = \frac{\lambda D}{d} \Rightarrow \lambda = \frac{sd}{D}</math> <b>OR</b> <math>s = \frac{n\lambda D}{d} \Rightarrow \lambda = \frac{sd}{nD}</math> ✓</p> <p><math>\lambda = \left\langle \frac{0.567 \times 10^{-2} \times 0.18 \times 10^{-3}}{2.2} \right\rangle \Rightarrow 4.6 \times 10^{-7}</math> «m» ✓</p>		2

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



Question			Answers	Notes	Total
5.	a		Weak nuclear: 2 ticks ✓ Strong nuclear: quarks only ✓		2
5	b	i	$\llbracket \mu \rrbracket = 2.0141 + 3.0160 - (4.0026 + 1.008665) \llbracket = 0.0188 \text{ u} \rrbracket$ <b>OR</b> In MeV: $1876.13415 + 2809.404 - (3728.4219 + 939.5714475) \checkmark$ $= 0.0188 \times 931.5 \text{ OR } = 17.512 \llbracket \text{MeV} \rrbracket \checkmark$	Must see either clear substitutions or answer to at least 3 s.f. for <b>MP2</b> .	2

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

5	d	i	3 ✓	<i>Do not accept <math>{}^3_2\text{He}</math> by itself.</i>	1
5	d	ii	Proton shown ✓ W- shown ✓ Produces electron/e <sup>-</sup> / $\beta^-$ and antineutrino / $\bar{\nu}$ with proper arrow directions. ✓	 <p><i>Allow solid, dashed, or wavy line for W-particle.</i>  <i>Must see bar on antineutrino if symbol used.</i></p>	3 Max