

# Markscheme

**May 2024**

**Physics**

**Standard level**

**Paper 2**

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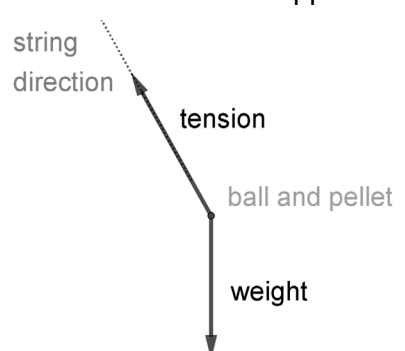
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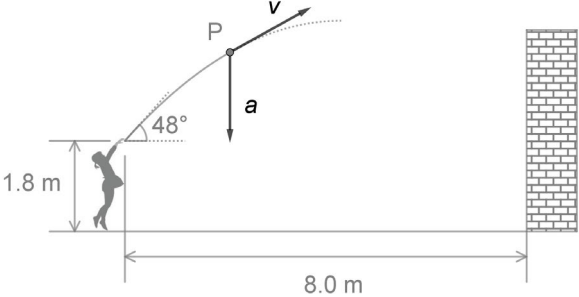
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### Subject Details: Physics SL Paper 2 Markscheme

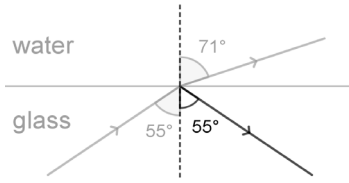
Candidates are required to answer **all** questions. Maximum total = **50 marks**.

1. Each row in the “Question” column relates to the smallest subpart of the question.
2. The maximum mark for each question subpart is indicated in the “Total” column.
3. Each marking point in the “Answers” column is shown by means of a tick (✓) at the end of the marking point.
4. A question subpart may have more marking points than the total allows. This will be indicated by “**max**” written after the mark in the “Total” column. The related rubric, if necessary, will be outlined in the “Notes” column.
5. An alternative wording is indicated in the “Answers” column by a slash (/). Either wording can be accepted.
6. An alternative answer is indicated in the “Answers” column by “**OR**”. Either answer can be accepted.
7. An alternative markscheme is indicated in the “Answers” column under heading **ALTERNATIVE 1** etc. Either alternative can be accepted.
8. Words inside chevrons « » in the “Answers” column are not necessary to gain the mark.
9. Words that are underlined are essential for the mark.
10. The order of marking points does not have to be as in the “Answers” column, unless stated otherwise in the “Notes” column.
11. If the candidate’s answer has the same “meaning” or can be clearly interpreted as being of equivalent significance, detail and validity as that in the “Answers” column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by **OWTTE** (or words to that effect) in the “Notes” column.
12. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.
13. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script. “ECF acceptable” will be displayed in the “Notes” column.
14. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the “Notes” column.

Question		Answers	Notes	Total
1.	a	$(2.0)(160) = (250 + 2.0)v \quad \checkmark$ $v = \frac{(2.0)(160)}{250 + 2.0} \Rightarrow 1.3 \text{ «m s}^{-1}\text{»} \quad \checkmark$	Award [1 max] for 1.28 m/s (mass of pellet neglected)  Award [2] for BCA	2
1	b	« Work is done by contact forces» to penetrate/deform/squash/change shape of the ball / the interaction causes deformation of the ball. $\checkmark$ «this requires energy transfer» from kinetic to other forms e.g. PE of deformation/heat/internal $\checkmark$	Allow 'embedded'.  Do not allow 'inelastic collision' MP2 requires at least one other appropriate energy form to be mentioned having been transferred from KE. NOT 'sound energy'	2
1	c	arrow along the string direction line labelled tension / T $\checkmark$ arrow downwards of approximately correct length labelled weight / W / mg $\checkmark$ 	Allow $F_T$ or T for tension in <b>MP1</b> Allow $F_g$ , $F_w$ , mg, or W for Weight in <b>MP2</b> Do not allow "gravity" for weight in <b>MP2</b> Do not allow $F_c$ for tension in <b>MP1</b> Ignore any additional forces."	2

Question			Answers	Notes	Total
2.	a	i	arrow tangent to the path in the correct direction ✓	<p><i>If the line when produced backwards goes below the curve – no mark.</i></p> <p><i>Arrows not beginning at P score [0]</i></p>	1
2	a	ii	arrow vertically downwards ✓ 		1
2	b		initial vertical velocity $v_y = 9.2 \sin 48^\circ \llcorner = 6.8 \text{ m s}^{-1} \llcorner$ ✓ $h = 1.8 + 9.2 \sin 48^\circ \times 1.3 - \frac{1}{2} \times 9.8 \times 1.3^2 \llcorner$ ✓ 2.4 «m» ✓	<p><i>Award [2] for <math>h=0.6 \text{ m}</math> (candidates have not taken the initial height of 1.8m into account).</i></p> <p><i>Award [2 max] for <math>h=19\text{m}</math></i></p> <p><i>Award 3 for BCA</i></p>	3

Question		Answers	Notes	Total
3.	a	<p>uses any <b>two</b> pairs of points to show that <math>pV = \text{constant}</math></p> <p><b>OR</b></p> <p>a statement that any 2 pairs of values of <math>pV</math> « from graph » always = 12 ✓</p> <p>because <math>pV</math> does not change, air behaves ideally ✓</p>	<p><i>Look for 1x12, 4x3 or any combination leading to 12J for MP1</i></p> <p><i>DO NOT award MP1 or 2 for ‘the graph shows that <math>pV</math> is constant’, or similar with no numerical support</i></p>	2
3	b	<p>Use of <math>pV=nRT</math>. ✓</p> <p>321 (320.89) « K » ✓</p>	<p><i>Look for substitution: 1x12, 4x3 or any combination leading to <math>pV = 12J</math></i></p> <p><i>Award [2] for BCA</i></p>	2
3	c	<p>«absolute» temperature is proportional to/related to the KE of the molecules. ✓</p> <p>pressure is related to the «average» rate of momentum transfer due to the collisions of the molecules with the container</p> <p><b>OR</b></p> <p>average force molecules exert per unit area.</p> <p><b>OR</b></p> <p>pressure is the result of molecular force on /collisions with the container walls. ✓</p> <p>Higher pressure is the result of higher KE of molecules « in constant random motion » or vice versa ✓</p>	<p><i>OK to use atoms/molecules/particles</i></p>	2 max

Question		Answers	Notes	Total
4.	a	$v_{\text{water}} = 2.0 \times 10^8 \times \frac{\sin 71^\circ}{\sin 55^\circ} \checkmark$ $2.3 \times 10^8 \text{ «m s}^{-1}\text{»} \checkmark$ Any answer to 2 s.f. $\checkmark$	Use of Snell's Law for MP1  Award [3] for BCA	3
4	b	speed increases <b>AND</b> frequency unchanged $\checkmark$  «from $\lambda = \frac{c}{f}$ » the wavelength increases $\checkmark$		2
4	c	ray at a correct angle by eye to the normal $\checkmark$  		1

4	d	<p>refractive index of glass = <math>\llcorner \frac{3.0 \times 10^8}{2.0 \times 10^8} \Rightarrow 1.5</math></p> <p><b>OR</b></p> <p>speed of light in air = <math>3.0 \times 10^8 \llcorner \text{m s}^{-1} \llcorner \checkmark</math></p> <p><math>\sin \theta_c = \frac{1}{1.5} \Rightarrow \theta_c = 42^\circ \checkmark</math></p> <p>the angle of incidence is greater than <math>c</math> or <math>\theta_c</math> so no light emerges <math>\checkmark</math></p>	<p><i>Must see a reason for MP3: 'no light emerges' alone is not enough.</i></p>	3
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Question			Answers	Notes	Total
5.	a		<p><b>Alternative 1</b></p> <p>total resistance = <math>\frac{3.00}{59.0 \times 10^{-3}} = 50.85 \text{ «}\Omega\text{»} \checkmark</math></p> <p><math>r = \text{«}50.85 - 50.0 \Rightarrow\text{»}0.85 \text{ «}\Omega\text{»} \checkmark</math></p> <p><b>Alternative 2</b></p> <p><math>r = \frac{\varepsilon}{I} - R = \frac{3}{0.059} - 50 \checkmark</math></p> <p><math>= 0.85 \text{ «}\Omega\text{»} \checkmark</math></p>	Award [2] for BCA	2
5	b	i	<p>external/total/effective/resistance decreases <math>\checkmark</math></p> <p><math>\text{«} I = \frac{\varepsilon}{R_{\text{ext}} + r} \text{»}</math> the current «in the ammeter» increases <math>\checkmark</math></p>		2
5	b	ii	<p><b>Alternative 1</b></p> <p>terminal pd = <math>\varepsilon - Ir \checkmark</math></p> <p>I increases hence terminal pd decreases <math>\checkmark</math></p> <p><b>Alternative 2</b></p> <p>Since lost volts/pd used in the battery = <math>Ir</math> this increases with greater <math>I</math>. <math>\checkmark</math></p> <p>Hence smaller pd available for external circuit. <math>\checkmark</math></p>		2

<b>5</b>	<b>c</b>	Use of $\rho = \frac{RA}{l}$ ✓ $k = \left\langle \frac{4.9 \times 10^{-7}}{3.1 \times 10^{-8}} \Rightarrow 16 \right\rangle$ ✓ $\Omega \text{ m}^{-1}$ ✓	<i>MP1 is for use of the equation</i> <i>MP2 is for calculation</i> <i>MP3 is for unit (<math>\Omega/\text{m}</math>, or <math>\Omega\text{m}^{-1}</math>)</i>  <i>Award [3] for BCA</i>	<b>3</b>
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Question		Answers	Notes	Total
6.	a	time for activity/number of « parent » nuclei in the sample to decrease to ½ of the initial value ✓	Allow 'number of radioactive particles' DO NOT allow 'nuclide'	1
6	b	<p><b>Alternative 1</b></p> <p>«activity reduces to 1/8 after» 3 half-lives ✓</p> $T_{1/2} = \left\langle \frac{37.0}{3} \Rightarrow 12.3 \text{ «y»} \right\rangle \checkmark$ <p><b>Alternative 2</b></p> <p><math>A = A_0 e^{-\lambda t}</math> to find <math>\lambda</math>, = 0.056 «y<sup>-1</sup>» ✓</p> <p>half life = <math>\left\langle \frac{\ln 2}{\lambda} = \frac{\ln 2}{0.056} \Rightarrow 12.3 \text{ «y»} \right\rangle \checkmark</math></p>	0	2
6	c	alpha particle / $\alpha$ / ${}^4_2\text{He}$ ✓		1

6	d	i	$4 \times 7.074 - 2 \times 1.112 - 3 \times 2.827 \checkmark$ 17.6 «MeV» $\checkmark$	<p><i>MP1: Any one of the following calculations:</i></p> $4 \times 7.074$ $2 \times 1.112$ $3 \times 2.827$	2
6	d	ii	some of the mass «of the reactants» converted to energy «according to $\Delta m = \frac{\Delta E}{c^2}$ » $\checkmark$	<p><i>Need to see a connection between mass and energy.</i></p> <p><i>Ignore subsequent description of energy (released, binding energy, etc.)</i></p>	1

Question		Answers	Notes	Total
7.	a	<p>More « long wave » surface radiation / radiation from Earth is absorbed by GHG/the atmosphere ✓</p> <p>increased intensity/more radiation (re)directed back to Earth/ <math>I_2</math> increased ✓</p>	<i>Not 'heat'</i>	2
7	b	<p><math>I_1 = \ll 240 + 150 \Rightarrow 390 \ll \text{W m}^{-2} \gg</math> ✓</p> <p><math>T = \sqrt[4]{\frac{390}{5.67 \times 10^{-8}}} = 288 \ll \text{K} \gg</math> ✓</p>	<i>Award [2] for BCA</i>	2

Question		Answers	Notes	Total
8.	a	$\frac{v^2}{r} = g \Rightarrow v = \sqrt{gr} \checkmark$ $v = \sqrt{4.0 \times 1.0 \times 10^7} = 6.3 \times 10^3 \text{ «m s}^{-1}\text{»} \checkmark$	<p><i>Answer to at least 2 sf for MP2</i></p>	2
8	b	$d = 2\pi \times 1.0 \times 10^7 \text{ «} = 6.23 \times 10^7 \text{»} \checkmark$ $T = \frac{2\pi \times 1.0 \times 10^7}{6.3 \times 10^3} = 9.9 \times 10^3 \text{ «s»} \checkmark$	<p><i>Allow [2] for <math>1.0 \times 10^4</math> s (from orbital speed of <math>6 \times 10^3</math> m s<sup>-1</sup>)</i></p> <p><i>Allow ECF from 8(a)</i></p> <p><i>Allow BCA</i></p>	2