OXFORD AQA

INTERNATIONAL QUALIFICATIONS

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PHYSICS

PH01

Unit 1 Mechanics, materials and atoms

Mark scheme

January 2025

Version: 1.0 Final

251XPH01/MS

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from www.oxfordaqa.com

Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Answers	Additional comments/Guidelines	Mark	AO
01	Volume of nucleus << volume of atom ✓ The nucleus has a charge ✓	Allow radius for volume Condone size Do not accept answers which refer to protons, neutrons or nucleons Do not accept the nucleus is very small Do not accept the nucleus is very dense	2	AO1
Total			**2**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02	Attempts to calculate one area ✓ Correctly calculates both areas ✓ • above displacement axis: 3.53 to 3.61 (J) • below displacement axis: 0.68 to 0.70 (J) Finds difference between their areas ✓	Must be calculated to the displacement axis Correct answer that rounds to 2.8 to 2.9 (J)	3	2 × AO1 1 × AO3
Total			**3**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03	Idea that L is (constantly) increasing (as it is a function of speed through the air which is constantly increasing) ✓ Idea that C decreases to zero at the moment of take-off (since $C + L = W$ and L is increasing and W is constant) ✓ Idea that D is (constantly) increasing as air resistance is a function of speed (through the air) which is (constantly) increasing ✓	Accept reference to increase in drag as flaps are deployed during take-off for MP3 Accept reference to vertical component of drag	3	2 × AO1 1 × AO2
Total			**3**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Determines A (= 5) and Z (= 2) for X ✓ Correct use of $\frac{q}{m}$ to determine specific charge of X or helium nucleus ✓ 9.6×10^6 (C kg^{-1}) ✓		3	1 × AO1 1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Any **two** from ✓✓ • Move in opposite directions… • … with the neutron having the same magnitude of momentum as the helium-4 nucleus **OR** (So that) momentum is conserved • Decay energy transferred to the kinetic energies of the particles Speed of neutron is 4 times greater than the speed of the helium-4 nucleus (ignoring relativistic effects) ✓		3	1 × AO1 2 × AO2
Total			**6**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Any **two** from ✓✓ • Uses $\Delta h = 8.2 \sin 15$ **OR** component of weight parallel to belt $= mg \sin 15$ correctly • Uses $\Delta E\text{p} = mg\Delta h$ correctly for their calculated Δh **OR** Uses $\Delta E\text{p} = \text{Fs}$ correctly for their calculated their component of weight parallel to belt • Divides their value of $\Delta E\text{p}$ by 43 11 (10.7) (s) ✓		3	1 × AO1 1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Any **one** from ✓ • Use output power $= \frac{31}{100} \times 1200$ • Divides their output power by 43 8 bags✓	Expect to see 372 W Condone POT error in MP1 Do not accept 9.	2	1 × AO1 1 × AO2
Total			**5**	

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr>
<td>06.1</td>
<td>The mark scheme gives some guidance as to what statements are expected in a 1- or 2-mark (L1), 3- or 4-mark (L2) or 5-mark (L3) answer.

Guidance provided on page 3 of the Mark Scheme should be used to assist in marking this question.
<table>
<tr><th>Mark</th><th>Criteria</th></tr>
<tr><td>5</td><td>A fair attempt to analyse all three areas in detail.
5 marks can be awarded even if there is an error and/or parts of an aspect missing.</td></tr>
<tr><td>4</td><td>A attempt to analyse all three areas with at least one in detail.</td></tr>
<tr><td>3</td><td>Attempt made to discuss more than one area, and one area covered in detail or an attempt to discuss all three areas. Whilst there will be gaps, there should be only an occasional error.</td></tr>
<tr><td>2</td><td>Attempt made to discuss more than one area, or one area covered in detail. There are likely to be several errors or omissions in the discussion.</td></tr>
<tr><td>1</td><td>Any relevant physics (partial coverage of one area).</td></tr>
<tr><td>0</td><td>No relevant analysis.</td></tr>
</table>
</td>
<td>The following statements are likely to be present:
Making the necessary measurements
• Use of a suitable detector (type of detector need not be named)
• Way of measuring count rate eg ratemeter or scalar counter and stop-clock
• Means of measuring distance between source and detector
• Measures the count rate at a range of distances with at least 5 distances used
• Measure and deduct the background count rate
Performing the experiment safely and accurately
• Eliminates alpha radiation using a suitable named filter or minimum distance greater than 5.0 cm.
• Repeats and averages or counts for a suitably long period (to reduce uncertainties)
• Suitable range of distances with max at least $4 \times$ min (max may be $< 1\ \text{m}$ due to limited intensity of source)
• One suitable safety precaution such as appropriate handling technique, keeping source in suitable container when not in use, avoid directing source towards people etc
Processing results to demonstrate the inverse-square law graphically
• Plots C against $\frac{1}{d^2}$ (accept $\sqrt{C}$ against $\frac{1}{d}$ or log C against log d)
• Inverse-square law demonstrated if the graph is a straight line through the origin (accept and reward comments about intercept relating to position of detection within the detector)</td>
<td>5</td>
<td>AO4</td>
</tr>
</table>

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Any **one** from ✓ • Makes one half-life determination correctly from graph • Multiplies half-life by 4 Makes at least two determinations and averages ✓ 5.4×10^{10} (s) ✓	Allow POT error in MP1 and MP2 Expect to see $1.3 \times 10^{10} - 1.4 \times 10^{10}$ Allow mp2 for candidates who determine the time taken for the activity to fall to $\frac{1}{4}$ or $\frac{1}{8}$ of original. Accept answer in the range 5.2×10^{10} to 5.6×10^{10} (s)	3	1 × AO1 2 × AO3
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	Uses $F = ma$ to calculate acceleration of **B** **Or** use of $F = \frac{\Delta mv}{\Delta t}$ ✓ Attempts to use $s = ut + \frac{1}{2}at^2$ or other equation of motion to calculate s ✓ 0.56 (m) ✓	Expect to see $\frac{410}{56}$ or $7.3(2)$ (m s^{-2}) Allow MP2 for candidates who think that $u = 0$ Award both MP1 and MP2 for use of $F = \frac{\Delta mv}{\Delta t}$ and $\Delta\text{KE} = \frac{1}{2}m(v^2 - u^2)$ from energy approach	3	2 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Concludes that **B** has the greater magnitude of acceleration with some justification ✓ Idea that the magnitude of the force on each is the same (Newton's 3rd law) and **B** has a smaller mass **and** reference to $a = \frac{F}{m}$ **OR** Change in momentum is the same for **A** and **B** (conservation of momentum with no external forces) and **B** has a smaller mass plus reference to $\Delta p = m\Delta v$ (and period of the acceleration is the same for both) ✓		2	AO2
Total			**5**	

Question	Answers	Additional comments/Guidelines	Mark	AO
08.1	Initial vertical component of the velocity is zero for both balls **and** vertical acceleration is the same / $9.81\ \text{m s}^{-2}$ for both balls ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
08.2	Use of $v^2 = u^2 + 2as$ to give $h = 0.90\ \text{m}$ ✓	Allow $h = 0.899\ldots\ (\text{m})$	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
08.3	Correct rectangle or triangle of velocities with scale quoted ✓ $6.5 \pm 0.2\ (\text{m s}^{-1})$ ✓ Scale diagram must use half the available space ✓ $50^{\text{o}} \pm 2^{\text{o}}$ (to the vertical) ✓	MP2 and MP4 may be awarded for an algebraic method for max 2 marks	4	1 × AO1 1 × AO2 2 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
08.4	Plastic ball **R** will take a longer time to reach the ground than steel ball **P** because of air resistance ✓ Because $F = ma$ **AND** any **one** from ✓ • Air resistance on plastic ball **R** is greater than on steel ball **P** (at the same speed) because of plastic ball **R**'s greater diameter • Air resistance has greater effect on time for plastic ball **R** because of plastic ball **R**'s smaller mass • The resultant force on **steel** ball **P** is greater		2	1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
08.5	Idea that v_s is smaller because the horizontal deceleration (due to air resistance) is greater ✓ Idea that v_s is smaller because time of fall is longer (due to reduced vertical component) giving longer time for the deceleration to have an effect ✓	allow v_s is smaller because air resistance is greater	2	1 × AO2 1 × AO3
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
09.1	${}^{3}_{1}\mathrm{H} \rightarrow {}^{3}_{2}\mathrm{Z} + {}^{0}_{-1}\beta^{-} + {}^{0}_{0}\overline{\nu}_{e}$ Helium and electron numbers correct ✓		1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
09.2	Any **two** from ✓✓ • Correct read-off in the range 2.5 to $2.7\ \mathrm{keV}$ • Converts their value to joules • Use of $E_{\mathrm{k}} = \frac{1}{2}mv^2$ with their converted value Final answer in the range that rounds to $3.0 \times 10^{7}\ \mathrm{m\ s^{-1}}$ or $3.1 \times 10^{7}\ \mathrm{m\ s^{-1}}$ ✓	Allow POT error in MP1 and MP2 expect to see $4.16 \times 10^{-16}\ \mathrm{J}$	3	1 × AO1 1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
09.3	(There is a range of beta particle kinetic energies) Idea that the sum of the beta particle energy and the energy of the neutrino is constant ✓ Energy (and momentum) must be conserved ✓ Idea that if there is a range of kinetic energies then another particle must be carrying away some energy ✓	Allow the same amount of energy is released in each decay	3	1 × AO1 2 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
09.4	Minimum energy (close to) zero **and** Maximum energy 18.6 (keV) ✓	condone zero energy allow 18.4 – 18.8 (keV)	1	AO3
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
10.1	Equates the clockwise moment to the anticlockwise moment and correct rearrangement ✓	Expect to see $Mgs = mg(d–s)$	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
10.2	Correct plotting of values as x or + ✓	(6.71,0.40), (8.00,0.50), (9.35,0.60) Condone ⊙ Allow ± half a grid square horizontally	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
10.3	Line of best fit with equal number of crosses either side of line ✓		1	AO3

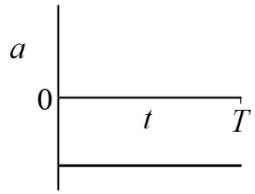
Question	Answers	Additional comments/Guidelines	Mark	AO
10.4	Correctly reads their M-intercept ✓	Expect to see $0.14–0.16$ (kg)	1	AO1

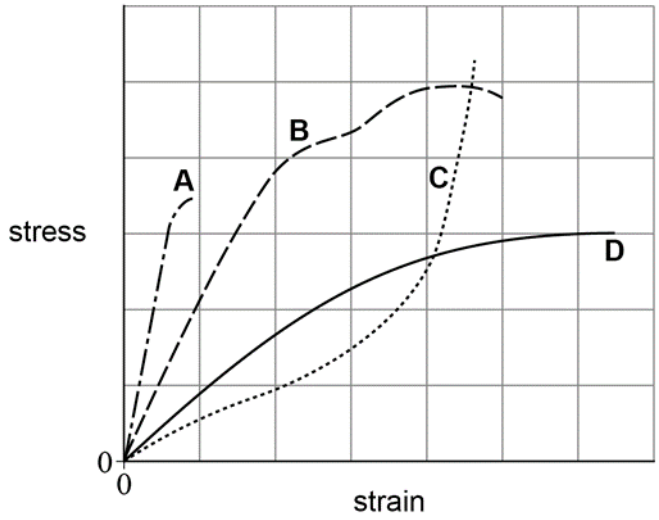
Question	Answers	Additional comments/Guidelines	Mark	AO
10.5	Points taken from large gradient triangle ✓ Gradient in the range $0.079–0.083$ ✓ Divides their gradient by their answer to Question 10.4 ✓	At least 5 cm horizontally expect to see d in the range 0.50 to 0.56 (m)	3	1 × AO2 1 × AO3 1 × AO4
Total			**7**	

Question	Answers	Additional comments/Guidelines	Mark	AO
11.1	Uses $T\cos 35 = mg$ ✓ Use of $E = \frac{TL}{A\Delta L}$ or use of $E = \frac{\sigma}{\epsilon}$, $\sigma = \frac{F}{A}$ and $\epsilon = \frac{\Delta L}{L}$ ✓ Uses $A = \frac{\pi d^2}{4}$ or $A = \pi r^2$ ✓ $14(.2)$ (mm) ✓	Expect to see 916 or 920 (N)	4	2 × AO2 2 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
11.2	Idea that angle between the building and the rope decreases ✓ Idea that T is inversely proportional to $\cos\theta$ so as $\cos\theta$ increases T will decrease ✓ Idea that N is proportional to $\sin\theta$ **and** to T so as T and $\sin\theta$ decrease N will decrease ✓	MP1 can be expressed in either part of the answer Allow N is proportional to $\tan\theta$ *or* $1/\tan(90\text{-}\theta)$ Allow use of Pythagoras with a triangle of forces and a constant weight	3	1 × AO1 1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
11.3	Uses $F = k\Delta L$ to show that k is inversely related to ΔL (for a constant force) so extension is greater ✓ Idea that the change in momentum of the climber happens over a greater time so less force exerted (on the climber) ✓	Allow use of $\Delta GPE = 1/2\ k\Delta L^2$ show that k is inversely related to ΔL (for an approximately constant GPE) so extension is greater Allow and work is done over a larger distance so less force exerted (on the climber) Allow an acceleration is lower so less force exerted (on the climber)	2	AO2
Total			**9**	

Question	Key	Answer	AO
12	A	$\frac{EA}{L}$	AO2
13	B	$T_1 + T_2 > mg$	AO2
14	B	The total increase in kinetic energy of the rocket is $F\alpha$	AO3
15	A		AO3
16	D	$0 \qquad v$	AO2
17	B	2.1×10^{8}	AO2
18	C	$2.1 \times 10^{-16}\ \text{N}$	AO2
19	C	$0.18\ \text{m}$	AO2

20	B		AO3
21	A	0.3%	AO2
22	C	2.0×10^4	AO1
23	C	electron and positron	AO1
24	D	600 300 225 75	AO3
25	A	4	AO3

Total: 14 marks