OXFORD AQA
INTERNATIONAL QUALIFICATIONS

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PHYSICS
PH01

Unit 1 Mechanics, materials and atoms

Mark scheme

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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	Any valid equation for power with valid SI units for at least one of the terms ✓ $\text{kg m}^2\text{ s}^{-3}$ ✓	$P = \dfrac{\text{Any energy equation}}{\text{time}}$ **OR** $P =$ any force × equation v Do not penalise incorrect case of letters for mp1 All letters should be clearly lower case for mp2	2	AO1

Total			**2**

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	(A quantity that has) both magnitude and direction ✓	Allow 'size' for magnitude	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Correct vector quantity **AND** correct scalar quantity ✓	e.g. displacement and distance, velocity and speed, etc	1	AO1

Total			**2**

Question	Answers	Additional comments/Guidelines	Mark	AO
03	Any **two** particles correct ✓ All **three** particles correct ✓✓ $^{1}_{0}n \rightarrow {}^{1}_{1}p + {}^{0}_{-1}e^{-} + {}^{0}_{0}\overline{\nu}$	Allow beta minus for e^{-} Condone missing minus sign on e Allow any order of particles	2	AO1
Total			**2**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04	Use of $\frac{1}{2}mv^2$ to find E_k of proton(s) ✓	$\frac{1}{2} \times 1.67 \times 10^{-27} \times \left(1 \times 10^{6}\right)^2 = 8.36 \times 10^{-16}$ $\frac{1}{2} \times 1.67 \times 10^{-27} \times \left(2 \times 10^{6}\right)^2 = 3.35 \times 10^{-15}$	3	AO2
	Converts their proton energy to MeV or electron / positron energy to J ✓	8.18×10^{-14} J **OR** 1.64×10^{-13} J		
	Correct total energy **AND** Compares E_k of proton(s) to rest energy and makes statement, no ✓	4.18×10^{-15} J **OR** 0.026 MeV Accept comparison to single electron		

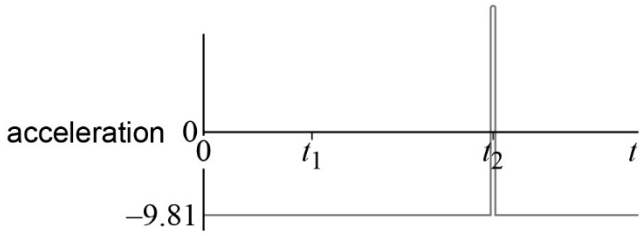
Total			3

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr>
<td>05</td>
<td>
The mark scheme gives some guidance as to what statements are expected to be seen in a 1- or 2-mark (L1), 3- or 4-mark (L2) and 5- or 6-mark (L3) answer.
Guidance provided in section 3.10 of the ‘Mark Scheme Instructions’ document should be used to assist in marking this question.
<table>
<tr><th>Mark</th><th>Criteria</th></tr>
<tr><td>6</td><td>All three areas covered in some detail.
6 marks can be awarded even if there is an error and/or parts of one aspect missing.</td></tr>
<tr><td>5</td><td>All three areas covered, at least two in detail.
Whilst there will be gaps, there should only be an occasional error.</td></tr>
<tr><td>4</td><td>Two areas successfully discussed, or one discussed and two others covered partially.
Whilst there will be several gaps, there should only be an occasional error.</td></tr>
<tr><td>3</td><td>One area discussed and one discussed partially, or all three covered partially. There are likely to be several errors and omissions in the discussion.</td></tr>
<tr><td>2</td><td>Only one area discussed or makes a partial attempt at two areas.</td></tr>
<tr><td>1</td><td>None of the three areas covered without significant error.</td></tr>
<tr><td>0</td><td>No relevant analysis.</td></tr>
</table>
</td>
<td>
Apparatus (1BP = partial, 3BP = full)
• thin gold / gold foil with alpha particles directed towards it.
• in an evacuated chamber / vacuum
• microscope (to detect the alpha particles after deflection) OR fluorescent screen
This area is not addressed if there is no relevant diagram of apparatus

Observations (2BP = partial, first 3BP full)
• most alpha particles were not deflected
• some were deflected by an angle of less than 90 degrees / small angles
• a very few OWTTE were deflected by angles greater than 90 degrees / large angles
• flashes / light observed where alpha particles hit the screen

What Rutherford deduced (1BP = partial, 3BP = full)
• most are undeflected so atom is mostly empty space
• some deflected by large angles so mass is located in the centre / very dense centre of atom
• some deflected so nucleus is (positively) charged
Condone a deduction without explanation for partial only. Minimum 2 explanations required for full
Treat references to electrons as neutral
</td>
<td>6</td>
<td>4 × AO1
2 × AO4</td>
</tr>
</table>

Total			**6**

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Single horizontal line either above or below axis to at least approximately t_2 ✓ $-9.8(1)$ labelled on the y-axis and line drawn horizontally from this point. Allow inverted graph labelled $9.8(1)$ ✓ Vertical (or almost vertical) line drawn at t_2 that goes through the x-axis ✓	 Accept the bounce to start at t_2 and not go beyond the "t" in "the" from the wording above. Condone a lack of ruler in MP2 and MP3 For 3 marks valid line must continue past t_2	3	2 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Any **two** from: ✓✓ • determines initial vertical velocity ($18\sin 49$ or 13.58 seen) • uses appropriate equation of motion with their vertical velocity • adds 1.5 m to their height 11 (m) ✓	mp1 and mp2 can also be awarded for $mg\Delta h = \frac{1}{2}mv^2$ route expect 9.406 m g = 9.81 gives 10.906 m g = 9.8 gives 10.916 m	3	2 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Minimum velocity is at the peak / maximum height ✓ Horizontal component is constant **AND** (at peak) vertical velocity = 0 ✓	For MP1, allow correct annotation on **Figure 3** Condone it has horizontal speed **AND** vertical speed = 0 for MP2 For MP2 allow correct energy argument including reference to conservation of energy.	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	$18 \cos 49 = 11.8$ (m s^{-1}) ✓		1	AO2

Total			**9**

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	Calculation of initial velocity of target and arrow from conservation of energy ✓ Calculation of initial momentum of target and arrow **OR** Momentum after = momentum before ✓ $u = 23.4$ (m s^{-1}) ✓	Expect to see $u = \sqrt{2gh} = 1.7155\ldots$ $2.22\ldots$ N s $2.22 = 0.095 \times u$ (or correct momentum equation) 23.3 if 9.8 used for g Do not allow use of suvat in MP1 but allow ecf in MP2 and MP3 if used	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Height is greater, with any **three** from: ✓✓✓ • change in momentum / impulse of arrow will be greater • (therefore) change in momentum / impulse of target will be greater to conserve momentum • kinetic energy of target after impact will be greater OR initial velocity / speed of the target is greater • gravitational potential energy of target will be greater	Alternative for mp1 and mp2: • arrow will have negative momentum • target must have more positive momentum to conserve momentum.	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	Use of $E_k = \frac{1}{2}mv^2$ (91.96 J) ✓1a Equates their kinetic energy with work done (Fs) ✓2a Use of $v^2 = u^2 + 2as$ to determine acceleration (80 667 m s^{-2}) ✓1b Use of $F = ma$ with their a ✓2b Use of $s = (u + v)\frac{t}{2}$ to determine Δt (5.45×10^{-4} s) ✓1c Use of $F = \frac{\Delta mv}{\Delta t}$ with their Δt ✓2c (-)7700 (N) ✓3	(7663 N)	3	AO2

Total			9

Question	Answers	Additional comments/Guidelines	Mark	AO
08.1	Description or diagram showing radiation source and detector with material in between ✓1 At least **one** of the following points: ✓2 All **three** of the following points: ✓2✓3 • if radiation is blocked by paper or several cm of air then alpha • if radiation is not blocked by several mm of aluminium then gamma • if radiation is not blocked by paper or several cm of air but is blocked by aluminium then beta	Do not allow an uncorrected count rate to decrease to 0 (OWTTE) for✓3 but condone for ✓2 Alternative using PH03 physics: Allow use of a magnetic or electric field with a movable detector ✓1 At least **one** of the following points: ✓2 First **three** or **first and last** of the following points: ✓2✓3 • if undeflected gamma • with E field, alpha is detected towards negative plate • with E field beta is detected towards positive plate • with B field deflection consistent with FLHR	3	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
08.2	Any **two** from: ✓ • use **long** tongs to handle source • do not point the source towards people • keep sources in a lead-lined box when **not in use** • display warning signs • keep suitable distance (e.g. $2\ \mathrm{m}$) away from source when not moving source Accept reference to correct record-keeping	Allow other **sensible** precautions Do **not** allow use goggles / radiation suit	1	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
08.3	The barium-$137\mathrm{m}$ nucleus is in an excited state ✓ Idea that gamma emission / de-excitation is not immediate ✓ (and) after 153 seconds half of the excited nuclei will have de-excited / decayed / released a gamma photon / no longer be excited / no longer be in a metastable state ✓	Condone missing nucleus but do not allow atom or isotope Condone gamma ray or gamma for gamma photon Allow answers that refer to number remaining Allow Ba or barium-137 for barium-$137\mathrm{m}$	3	2 × AO1 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
08.4	Appropriate working leading to an answer of 28 years ✓	Working could be seen on the graph	1	AO2

Total			**8**

Question	Answers	Additional comments/Guidelines	Mark	AO
09.1	Any **two** from: ✓✓ • correct use of $230 \sin 35$ or $2.4 \sin 35$ • attempts to apply principle of moments with correct distances • calculates mass of the bar using their **weight** 27 (kg) ✓	or $\cos 55$	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
09.2	Calculation of cross-sectional area ($9.50331777 \times 10^{-5}$ m^2) OR Use of $E = \dfrac{FL}{A\Delta L}$ ✓ 6.1×10^{-5} (m) ✓	Allow a POT error in MP1	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
09.3	660 to 680 (N) ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
09.4	Attempt to calculate an area under the graph ✓ linear unloading curve, starting at $(8,1000)$ drawn on graph meeting the x axis between 5.5 and 6.5 mm ✓ Work done = 5 to 6 (J) from correct working ✓	Expect to see the area between the loading and unloading curves Allow 1 sf	3	AO3

Total			**9**

Question	Answers	Additional comments/Guidelines	Mark	AO
10.1	Uncertainty in L or $L_0 = 2 \times 0.5\ (= 1\ \text{mm})$ ✓$_1$ Idea that subtraction of data leads to addition of uncertainties ✓$_2$ OR Idea that there are 4 readings taken (for one spring) so $4 \times 0.5\ \text{mm}$ ✓$_1$ ✓$_2$		2	AO1

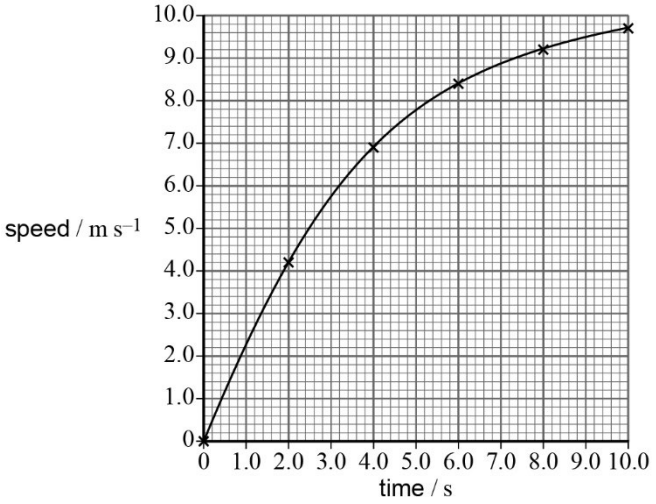
Question	Answers	Additional comments/Guidelines	Mark	AO
10.2	Correct steepest and shallowest lines with both lines going through all error bars. ✓	Steepest through right side of the second from bottom error bar and left side of the second from top error bar Shallowest through left side of bottom and right side of top Ignore addition line of best fit drawn	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
10.3	Calculates at least one gradient using correct method and triangle with minimum change in ΔL of $4\ \text{cm}$ ✓ Attempts to find both gradients and calculates their mean ✓ $k_{\text{t}} = 0.81$ to 0.83 ✓	Expect to see: minimum gradient $= 0.79$ maximum gradient $= 0.86$ Do not allow "gradients" taken from points not on the line	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
10.4	uncertainty $= \dfrac{\text{max gradient} - \text{minimum gradient}}{2}$	Expect to see 0.035 Accept max-mean or mean-max	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
10.5	ΔL decreases (for same F) **OR** F increases (for same ΔL) **OR** gradient is steeper (same error bar width) ✓ uncertainty increases / higher (for similar random error) ✓	MP2 dependent on MP1 **Alternative:** cannot say as uncertainty is based on scatter of points ✓✓	2	AO3

Total			9

Question	Answers	Additional comments/Guidelines	Mark	AO
11.1	Appropriate line of best fit drawn ✓		1	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
11.2	Tangent to the line drawn on the steepest part of the line ✓ Their acceleration × 95 ✓ Answer between 300 and 500 (N) when rounded to 1 sf ✓	Max 1 if their acceleration is not from a gradient	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
11.3	Air resistance increases with speed ✓ Idea that resultant force = force exerted by rider – air resistance, so resultant force decreases ✓ Gradient is proportional to force / gradient is acceleration so gradient decreases ✓	Allow drag / air friction for air resistance Condone resistive forces / friction in MP2 only "Gradient is acceleration" alone is not enough for MP3 If no other mark awarded, then allow 1 mark for linking gradient to acceleration	3	AO3

Total			**7**

Question	Key	Answer	AO
12	**B**	electron	AO1
13	**A**	**X** and **Y** are isotopes.	AO3
14	**D**	4.7×10^3 kg	AO1
15	**C**	3	AO1
16	**C**	Each emitted beta particle shares the released energy with another particle.	AO1
17	**A**	conserved | not conserved	AO1
18	**A**	240×10^{-3} N s	AO2
19	**D**	$2e$	AO1
20	**C**	15 kW	AO3
21	**C**	$mg \sin \theta$ | $+y$	AO2
22	**B**	77 W	AO2
23	**B**	0.32 m	AO2
24	**A**	8.7 W m^{-2}	AO2
25	**C**	**S** has the largest spring constant.	AO1