AQA

A-level
PHYSICS
7408/2

Paper 2

Mark scheme

June 2024 REVISED

Version: 1.0 Final

246A7408/2/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.

No student should be disadvantaged on the basis of their gender identity and/or how they refer to the gender identity of others in their exam responses.

A consistent use of 'they/them' as a singular and pronouns beyond 'she/her' or 'he/him' will be credited in exam responses in line with existing mark scheme criteria.

Further copies of this mark scheme are available from aqa.org.uk

Physics - Mark scheme instructions to examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the Examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded.

The extra information is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right-hand side of the mark scheme is there to provide those extra details which confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

2. Emboldening

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.
2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.
2.3 Alternative answers acceptable for a mark are indicated by the use of **or**. Different terms in the mark scheme are shown by a / ; eg allow smooth / free movement.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which candidates have provided extra responses. The general principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error / contradiction negates each correct response. So, if the number of errors / contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (often prefaced by 'Ignore' in the mark scheme) are not penalised.

3.2 Marking procedure for calculations

Full marks can usually be given for a correct numerical answer without working shown unless the question states 'Show your working'. However, if a correct numerical answer can be evaluated from incorrect physics then working will be required. The mark scheme will indicate both this and the credit (if any) that can be allowed for the incorrect approach.

However, if the answer is incorrect, mark(s) can usually be gained by correct substitution / working and this is shown in the 'extra information' column or by each stage of a longer calculation.

A calculation must be followed through to answer in decimal form. An answer in surd form is never acceptable for the final (evaluation) mark in a calculation and will therefore generally be denied one mark.

3.3 Interpretation of 'it'

Answers using the word 'it' should be given credit only if it is clear that the 'it' refers to the correct subject.

3.4 Errors carried forward, consequential marking and arithmetic errors

Allowances for errors carried forward are likely to be restricted to calculation questions and should be shown by the abbreviation ECF or *conseq* in the marking scheme.

An arithmetic error should be penalised for one mark only unless otherwise amplified in the marking scheme. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value from data given in a question.

3.5 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited (eg fizix) **unless** there is a possible confusion (eg defraction/refraction) with another technical term.

3.6 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.7 Ignore / Insufficient / Do <u>not</u> allow

'Ignore' or 'insufficient' is used when the information given is irrelevant to the question or not enough to gain the marking point. Any further correct amplification could gain the marking point.

'Do **not** allow' means that this is a wrong answer which, even if the correct answer is given, will still mean that the mark is not awarded.

3.8 Significant figure penalties

Answers to questions in the practical sections (7407/2 – Section A and 7408/3A) should display an appropriate number of significant figures. For non-practical sections, an A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the **final** answer in a calculation to a specified number of significant figures (sf). This will generally be assessed to be the number of sf of the datum with the least number of sf from which the answer is determined. The mark scheme will give the range of sf that are acceptable but this will normally be the sf of the datum (or this sf -1).

An answer in surd form cannot gain the sf mark. An incorrect calculation **following some working** can gain the sf mark. For a question beginning with the command word 'Show that…', the answer should be quoted to **one more** sf than the sf quoted in the question eg 'Show that X is equal to about 2.1 cm' –

answer should be quoted to 3 sf. An answer to 1 sf will not normally be acceptable, unless the answer is an integer eg a number of objects. In non-practical sections, the need for a consideration will be indicated in the question by the use of ‘Give your answer to an appropriate number of significant figures’.

3.9 Unit penalties

An A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the correct unit for the answer to a calculation. The need for a unit to be quoted will be indicated in the question by the use of ‘State an appropriate SI unit for your answer’. Unit answers will be expected to appear in the most commonly agreed form for the calculation concerned; strings of fundamental (base) units would not. For example, 1 tesla and 1 Wb m^{-2} would both be acceptable units for magnetic flux density but 1 kg m^2 s^{-2} A^{-1} would not.

3.10 Level of response marking instructions

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

Determining 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 2 with a small amount of level 3 material it would be placed in level 2.

The exemplar materials used during standardisation will help you to determine the appropriate level. 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
01.1	$n = 43.1$ ✓ (≥ 2 SF)	$n = \dfrac{105\times10^{3}\times1}{8.31\times(273+20.0)}$	1	AO1

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr>
<td>01.2</td>
<td>Use of $m = \frac{\rho V}{nN_A}$ OR $m = \rho V$
OR use of $m_{\text{molecule}} = \frac{m_{\text{gas}}}{N_A}$ OR $N = nN_A$
OR $(c_{\text{rms}})^2 = \frac{3p}{\rho}$ seen in any form
OR use of their mass with $pV = \frac{1}{3}Nm(c_{\text{rms}})^2$
OR use of $\frac{1}{2}m(c_{\text{rms}})^2 = \frac{3}{2}kT$ ✓₁
Correct answer see table ✓₂
Correct SF see table ✓₃
<table>
<tr><th>n</th><th>✓₂
c_{rms} / m s^{-1}</th><th>✓₃
SF</th></tr>
<tr><td>Without n</td><td>500 – 503</td><td>3 SF (501 – 503)</td></tr>
<tr><td>n more than 3SF</td><td>500 – 503</td><td>3 SF (501 – 503)</td></tr>
<tr><td>43.1</td><td>500 – 503</td><td>3 SF (501 – 503)</td></tr>
<tr><td>43</td><td>500 – 503</td><td>2 SF (500)</td></tr>
<tr><td>40
(no evidence of $n = 43$ in 1.1)</td><td>482 – 484
or 500</td><td>2 or 1 SF (480 or 500)</td></tr>
<tr><td>40
(evidence of $n = 43$ in 1.1)</td><td>482 – 484
or 500</td><td>1 SF (500)</td></tr>
</table>
</td>
<td>Allow ecf for incorrect T and/or n in 1.1
Several approaches are possible
$m = \frac{pV}{nN_A} = \frac{1.25\times1.00}{43.1\times6.02\times10^{23}} = 4.82\times10^{-26}$
(5.1×10^{-26} if 40 used)
$c_{\text{rms}} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3\times1.38\times10^{-23}\times293}{4.82\times10^{-26}}} = 502$
OR
$pV = \frac{1}{3}Nm(c_{\text{rms}})^2 \quad p\frac{Nm}{\rho} = \frac{1}{3}Nm(c_{\text{rms}})^2$
$(c_{\text{rms}})^2 = \frac{3p}{\rho}\left(= \frac{3pV}{Nm} = \frac{3p\times1}{\rho}\right)$
$c_{\text{rms}} = \sqrt{\frac{3\times105\times10^{3}}{1.25}} = 502$
</td>
<td>3</td>
<td>AO2</td>
</tr>
</table>

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	$T = 4 \times 293$ or 4 times the starting temperature in K ✓ change in temperature = 879 (K) ✓ (correct answer gains both marks) **Alternative** $T = \frac{m(2c_{\text{rms}})^2}{3k}$ correctly calculated for their m, c_{rms} ✓ Their calculated $T - 293$ ✓ 7709	mp1 Using $\frac{1}{2}m(c_{\text{rms}})^2 = \frac{3}{2}kT$ so $(c_{\text{rms}})^2 \propto T$ $\frac{(c_{\text{rms}})^2}{293} = \frac{(2\times c_{\text{rms}})^2}{T}$ $T = 293 \times 4 = 1172$ K mp2 change in temperature = $1172 - 293 = 879$ K Allow answer that rounds to 880 (K) If no other marks awarded award max 1 when T is 4 times original and $\Delta\theta = 60$	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	Max 2 from: ✓✓ • Calculation of mass of water condensed in one hour $1.25 \times 960 \times (0.0057 - 0.0037) = 2.4$ (kg) • use of their mass with $mc\Delta\theta$ (expect 4.5×10^4 (J)) • use of their mass with mL (expect $5.5(2) \times 10^6$ (J)) heat energy removed = 5.6×10^6 (J) ✓		3	2 × AO2 1 × AO3

Total			**9**

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Show attempted use of all three equations: gradient = $\frac{\Delta V}{\Delta t}$ AND $I = \frac{\Delta Q}{\Delta t}$ AND $Q = CV$ ✓ $I_0 = C \times$ **initial** gradient ✓	mp2 $V = \frac{Q}{C}$ so $\Delta V = \frac{\Delta Q}{C}$ so gradient $\frac{\Delta V}{\Delta t} = \frac{\Delta Q}{C\Delta t} = \frac{I}{C}$ hence $I_0 = C \times$ initial gradient $(\Delta)Q = I(\Delta)t$ can be seen via substitution if **both** (Δ)Q and $I(\Delta)t$ are seen in equivalent expressions e.g. $I(\Delta)t = CV$ is insufficient without $(\Delta)Q = CV$. Condone omission of Δ's in MP1. Condone C or initial gradient as subject for mp2. Condone a calculation and an **initial** gradient shown on Figure 2 mp1 and mp2 are independent. If no other marks award 1 for $I = C \times$ gradient or C or gradient as subject.	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	time constant $= 7.5 \pm 0.5$ (s) ✓ evaluated $R = \frac{\text{their } T}{C}$ correctly ✓	Do NOT allow $T = RC$ for mp1. Value must come from Figure 3 using a valid method. 7.44 s is likely to come from RC and not from the graph. mp1 Time taken to fall to $1/e$ or 0.37 of its value = time constant eg 0.45 V to 0.166 V takes 7.5 s This may be calculated over a larger range or the time to halve the voltage found and this value divided by ln2 eg 0.45 V to 0.225 V takes 5.2 s giving $= 7.5$ s Half life 5.2 ± 0.5 (s) and $T = \frac{T_{\frac{1}{2}}}{\ln(2)} = \frac{T_{\frac{1}{2}}}{0.69}$ mp2 $T = RC$ so $R = \frac{T}{C} = \frac{7.5}{31.0 \times 10^{-6}} = 2.4(2) \times 10^5\ \Omega$ Condone 2SF for mp2 if working is shown.	2	1 × AO1 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	Supply voltage $V_0 = I_0 R$ (expect $8.6\ \text{V}$)✓1 Use of $V = V_0\left(1 - e^{\frac{-t}{RC}}\right)$ ✓2 **Alternative** Use of $V_0 = I_0 R$ so $I = \frac{I_0 R - 6}{R}$ (expect 1.1×10^{-5} A)✓1 Use of $I = I_0 e^{-\frac{t}{RC}}$ ✓2 Calculation of the time from correct physics (expect 8.8 to $9.0\ \text{s}$) ✓3	Allow 9V for mp1 or mp2 but do not allow ecf for rounded value in mp3 mp2 allow substitutions OR rearrangements using ln or use of $V = \frac{Q}{C}$ and $Q = Q_0\left(1 - e^{\frac{-t}{RC}}\right)$ Allow ecf for ✓3 R, T values but not from the wrong equation or mix up of V and I.	3	1 × AO2 2 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	use of $C = Q/V$ and $C = \varepsilon_r\varepsilon_0 A/d$ ✓ $\frac{V_1}{V_2} = 0.125$ ✓	mp1 $V = \frac{Qd}{\varepsilon_r \varepsilon_0 A}$ may be seen anywhere in the working, possibly with subscripts or rearranged. mp2 $\frac{V_1}{V_2} = \frac{d}{4 \times 2d} = 0.125$ Condone $\frac{1}{8}$ for mp2 Award 1 mark for 8 regardless of working mp2 implies mp1	2	AO2

Total			**9**

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Max 2 from ✓✓ • $\varepsilon = Blv$ seen • $v = \sqrt{2g\Delta h}$ OR $\sqrt{2as}$ seen • $v = 12.5\ (\mathrm{m\ s^{-1}})$ $\varepsilon = 4.5 \times 10^{-4}$ ✓ (V)	Alternative for MP1 and MP2: Two from: • Determines total change in flux $= 1.8 \times 10^{-5} \times 2 \times 8$ • Determines time taken to fall. $t = \left(\frac{2s}{a}\right)^{\frac{1}{2}} = \left(\frac{2 \times 8.0}{9.81}\right)^{\frac{1}{2}} = 1.28$ (s) • Determines their average rate of flux change and doubles.	3	1 × AO1 1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Max 4✓✓✓✓ **Statement** / **Explanation**: the direction of the emf changes — the rod cuts across the magnetic field in both directions / passes parallel point the emf goes through a zero at **P** — momentarily the rod does not cut lines of flux / zero change in flux emf reduces (and then increases) — as (direction of) velocity or motion gets closer to being parallel to field / same direction as field / cuts less flux per unit time	All marking points are to be OWTTE. Statement and explanation are separate marking points. Explanation must not contradict statement to be awarded. Condone emf increases as speed of fall increases (Blv) or smaller time $\left(N\frac{\Delta\Phi}{\Delta t}\right)$✓ ✓.	4	2 × AO2 2 × AO3

Statement	Explanation
the direction of the emf changes	the rod cuts across the magnetic field in both directions / passes parallel point
the emf goes through a zero at **P**	momentarily the rod does not cut lines of flux / zero change in flux
emf reduces (and then increases)	as (direction of) velocity or motion gets closer to being parallel to field / same direction as field / cuts less flux per unit time

Total			7

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	The idea that the coolant extracts heat from the core and delivers it to the boiler/turbine via a heat exchanger. ✓	OWTTE Condone the omission of the heat exchanger Reject answers which suggest the coolant is turned directly into steam (to drive the turbine).	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Any two points from the following list ✓✓ • Ability to absorb neutrons (It should not absorb neutrons or should have small neutron absorption cross-section (this is function of moderator)) • Stability under conditions of high temperature and/or high levels of radiation • (It should be) non-corrosive / unreactive / reactivity / inert • (It should have a high) boiling point • (It should have low) viscosity / ability to flow • (It should have a high) specific heat capacity	Condone: (it should have a) • (low) melting point • (high) thermal conductivity. Ignore references to latent heat / cost / flammability / availability / mass / density Apply the list principle.	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Idea that control rods are inserted (further) / lowered into the core ✓ Decrease the neutron flux in the reactor/core OR decreases the rate of fission reactions (and hence the power output) ✓	OWTTE Condone insert (more) control rods for mp1 Condone for control named material from boron, cadmium, silver, indium. Condone decrease the number of neutrons / absorb neutrons for decrease neutron flux Condone number of fissions for rate of fissions Do **not** allow reduce the speed of neutrons.	2	AO1

Total			**5**

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	$\omega = \frac{2\pi}{T} = \frac{2\pi}{27.3\times24\times60\times60} = 2.664\times10^{-6}$ (rad s^{-1}) ✓	At least 3 sf.	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	1 mark from: ✓ • Idea (resultant) gravitational field strength is equal to centripetal acceleration e.g. $g_R = a$ or $g_R = r\omega^2$ or $g_R = \frac{v^2}{r}$ (= 3.19×10^{-3} m s^{-2}) • Idea that $g_M = g_R - g_E$ $1.21\times10^{-3} \geq 3$ SF from correct working ✓ (N kg^{-1})	Ignore PoT, rounding errors and minor copy errors for MP1 A substitution into $T^2 = \frac{4\pi^2r^3}{GM}$ or equivalent is not accepted for the first bullet. In the second bullet point do not allow g_m MP3 must follow from correct working Allow ecf from **05.1**	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	$r = \sqrt{\frac{GM}{g_M}} = \sqrt{\frac{6.67\times10^{-11}\times7.35\times10^{22}}{1.21\times10^{-3}}}$ ✓ 6.37×10^7 (m) ✓	Allow ecf from **05.2** Allow 6.38×10^7 or 6.39×10^7 or 6.4×10^7 (m)	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	Idea that the force from the Moon is in the opposite direction to the force from the Earth ✓$_1$ **An expression of why S_2 can't orbit Earth at this ω and r without the moon.** Idea that the Earth's gravitational force is too great or that it causes an angular velocity that is too great (without the presence of the Moon) OR Application of the idea that orbital period decreases with radius ✓$_2$ **An expression of how the moon enables S_2 to orbit Earth with this ω and r.** Idea that the Moon and the Earth reduce the resultant or centripetal force (causes the angular speed of S_2 and the Moon to be the same) OR Effect of the moon's gravitational force or field is to reduce the (angular) speed or increase period ✓$_3$	✓$_1$ Allow gravitational field strength from the Moon is in the opposite direction to the gravitational field strength from the Earth. Condone balanced forces for ✓$_1$ but not ✓$_3$. ✓$_2$ Alternatives (Without the Moon's gravitational influence) • the force or gravitational field (strength) from the Earth is too large • the force or gravitational field is larger as it is closer to the Earth (than **S_1** or the moon) • the required centripetal force is smaller as it closer to the Earth (than **S_1** or the moon, at the same angular velocity) • satellite's angular velocity is greater than the Moon • satellite's period is less than the moons • satellite's angular velocity would be too large. ✓$_3$ The resultant/total centripetal force/centripetal acceleration/gravitational field strength is less (because of the Moon's presence and so orbits at the same angular velocity as the Moon). Reject the idea that the centripetal force on the moon and S_2 are the same. Do not credit arguments based around being closer to moon	3	AO2

Total			**8**

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	(-)4 J of work done per unit charge ✓ moving from infinity to the point / point to infinity✓ correctly linking direction of movement and sign of charge to gain or loss of energy / sign of energy✓	Do not allow 4V for 4J in mp1 only Condone answer in terms of eV and electron or proton. Do not consider the sign of the charge or work in mp1 and mp2 Allow ideas in terms of energy transfer from kinetic to potential (or vice versa). It is insufficient for mp1 to only refer to potential energy. Example 3 mark answers −4 J of work is done in moving (+) 1 C charge from infinity to the point. 4 J of work is done in moving a -1 C charge from infinity to the point. −4 J of work is done in moving a −1 C charge from the point to infinity. 4 J of work is done in moving (+)1 C charge from the point to infinity.	3	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Appreciation that the electric field is the potential gradient OR identify highest electric field occurs in the straight section ✓$_1$ Tangent drawn along the straight section and used for gradient or straight section used with triangle of sufficient size ($\Delta V \geq 1.5V$) ✓$_2$ Value between 1.8 and 2.2×10^7 (or 2.0×10^7) when rounded to 2 SF✓$_3$ Unit V m^{-1} or N C^{-1} ✓$_4$	Allow ✓$_1$ for use of $E_{avg} = \frac{\Delta V}{\Delta d}$ not from a tangent (outside of straight section) Just stating $E = \frac{\Delta V}{\Delta r}$ (or $\frac{\Delta V}{\Delta d}$) is not sufficient for mp1. Straight section of line x =110 to 230, 350 to 480 No credit for ✓$_1$, ✓$_2$ or ✓$_3$ attempt to find Q from a V, d pair then use of $E = \frac{Q}{4\pi\varepsilon_0 r}$ Expected value $2.01 \times 10^7 \text{ V m}^{-1}$ ✓$_4$ is standalone mark with some working Do **not** accept a unit given in base units. Allow unit consistent with their value in mp3 and mp4.	4	2 × AO1 1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	(Loss in) kinetic energy = (Gain in) potential energy OR use of $W = QV$✓ E_k $(= e \times (V_{\text{peak}} - V_{\text{trough}}) = 1.60 \times 10^{-19} (-0.20 - -3.40)) = 5.12 \times 10^{-19}$ (J) ✓	mp1 can be from an attempt to calculate potential energy even with a mistake in data values.	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	Initial direction of motion e.g. electron initially moves left/towards $x = 0$ / $x = 100$ ✓$_a$ Explanation for motion in terms of field e.g. electric field is to the right but electron charge is negative ✓$_b$ Linking the gradient of the electrical potential/graph to the magnitude of the acceleration of the electron ✓$_c$ Explanation for motion in terms of potential/energy eg electron moves towards higher potential (due to negative charge) / lower potential energy ✓$_d$ Electrical potential energy is converted into kinetic energy ✓$_e$ Recognition that the electron oscillates (about $x = 100$ nm) ✓$_f$ Explanation for oscillation in terms of potential / field ✓$_g$	**Max 3** Allow ✓$_f$ for oscillations about the wrong point or if it is unclear where it oscillates about. Accept acceleration is 0 at e.g. 100 nm for ✓$_c$ Condone reference to SHM for oscillate. Reject vibration for ✓$_f$ Condone Ep → Ek → Ep → Ek without reference to oscillation in ✓$_f$	3	AO3

Total			12

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	Data covers 3/multiple (allow 2) orders of magnitude OR To allow trends across the range of data to be seen on a reasonably sized sheet of paper. OR The relationship (between N and number of throws) is expected to be exponential ✓	Ignore reference to determination of gradient. Condone large range of N. Condone radioactive decay is exponential. Condone to make a straight line.	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Draw line of best fit from 0 to 19✓$_1$ Correct readings from log scale i.e. one correct reading other than $N = 10$ OR half-life of $2.5 - 2.7$ (throws) OR Use of ruler on vertical axis to give a relative log value (values can then be used so λ =gradient) ✓$_2$ (Can be awarded from points or line, evidence can been seen on the graph) Step to correct answer ✓$_3$ (See additional guidance) $\lambda = 0.25$ to 0.28 (throw^{-1}) when rounded to 2SF correctly deduced from **Figure 10** ✓$_4$ relate n to λ, $n = \frac{1}{\lambda} (= 4)$ ✓$_5$	**If there is no line of best fit or the data is taken from points not on the line, max 3** **Alternative 1** number of throws taken for undecayed dice to half (or multiple of half) or use of $\lambda = \frac{\ln 2}{t_{0.5}}$ with their $t_{0.5}$✓$_3$ **Alternative 2** number of throws for undecayed dice to reduce by a factor of e^{-1} or use of $\lambda = \frac{1}{t_{e^{-1}}}$ with their $t_{e^{-1}}$ ✓$_3$ **Alternative 3** stating or implied in a calculation that $\lambda = -$gradient ✓$_3$ $\lambda = -\frac{(\ln(N_2) - \ln(N_1))}{(\tau_2 - \tau_1)}$ **Alternative 4** use of $\lambda = \frac{\ln\left(\frac{N}{N_0}\right)}{-t}$ with their readings ✓$_3$ **Alternative 5** Use of $\lambda = \frac{\Delta N}{\mathrm{N}}$ do **not** allow over more than 1 throw ✓$_3$ Do **not** credit $\lambda = \frac{1}{4} = 0.25$ for ✓$_4$ but condone for ✓$_5$ MP5 can be awarded independently. (when n is referred to it must be an integer)	5	3 × AO2 2 × AO3

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr>
<td>07.3</td>
<td>Suitable precaution ✓

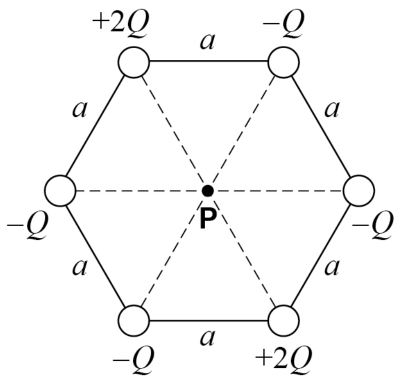
Valid assessment of suitability based on the increased activity of the medical source ✓</td>
<td>Example answers
<table>
<tr><td>Mp1</td><td>Mp2</td></tr>
<tr><td>Keep distance of at least 2 m / keep a long distance</td><td>distance does reduce intensity / inverse square law but 2 m not enough / not be in the room</td></tr>
<tr><td>Condone don’t point at people</td><td>Not being in the room</td></tr>
<tr><td>Put warning sign on the door</td><td>Install permanent warning signs</td></tr>
<tr><td>Store in lead-lined box</td><td>increase thickness of lead (condone concrete for mp2)</td></tr>
<tr><td>Put away when not using it</td><td>Exclude unnecessary people</td></tr>
<tr><td>Handle with long tongs / forceps / tweezers</td><td>need to keep larger distance so use eg robot arms or remote handling

Do NOT allow longer tongs</td></tr>
<tr><td>Using a small portable lead screen while source is in use</td><td>need a larger / thicker screen</td></tr>
</table>
Ignore references to wearing gloves</td>
<td>2</td>
<td>1 × AO1
1 × AO3</td>
</tr>
</table>

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	Ionising radiation damages cells/kills cells/causes cancer/causes mutations ✓ comment reflecting balance of risk and benefits when a filling is required e.g. risk of single scan is balanced by the benefits of treating the tooth decay✓	Example of second point: Condone for mp2 the risk can be minimised by reducing or minimising the number of X-rays taken ignore references to exposure to dentist. "only when necessary" is insufficient for mp2. Condone references to γ for X rays.	2	AO1

Total			**10**

Question	Key	Answer
8	B	doubling the volume at constant pressure
9	C	$3.87v$
10	B	400 K
11	B	a decrease in the charge held on the capacitor plates.
12	B	decreasing the frequency of the ac input voltage
13	C	2.5 V div^{-1}
14	D	25 0.15π
15	A	doubling the transmission voltage of the cable
16	D	$\dfrac{Be}{2\pi m_e}$
17	C	7.5 MeV
18	A	${}^{146}_{57}\text{La}$ has the greatest binding energy per nucleon of the three nuclides.
19	C	2.2×10^{-10} kg
20	D	$r\left(\dfrac{y}{x}\right)^{\frac{1}{3}}$
21	C	$\dfrac{R}{2}$

22	B	10^4 m
23	D	The work done moving from **Q** to **R** and moving from **Q** to **S** is the same.
24	B	the charge stored on a capacitor consisting of two parallel plates of area 1 m^2 separated by 1 m when the potential difference between the plates is 1 V
25	A	$16F$
26	D	
27	B	1.38×10^{-7} V m^{-1} downwards
28	A	an electron and a positive pion
29	A	$r < 10^{-14}$ m
30	C	β^- emission.
31	B	145
32	A	0.23 billion years