AQA

AS
PHYSICS
7407/1

Paper 1

Mark scheme

June 2022

Version: 1.0 Final

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 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/Guidance	Mark	AO
01.1	2 rows correct ✓ 3 rows correct ✓✓	<table><tr><th></th><th>π^+</th><th>p</th><th>Σ^+</th><th>Y</th></tr><tr><td>B</td><td>0</td><td>(+)1</td><td>(+)1</td><td>0</td></tr><tr><td>Q</td><td>+1</td><td>+1</td><td>+1</td><td>(+)1</td></tr><tr><td>S</td><td>0</td><td>0</td><td>−1</td><td>+1</td></tr></table>	2	1 x AO1 1 x AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
01.2	Tick 3rd box only - Σ^+ ✓		1	AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
01.3	**Y** has a greater rest energy than π^+ / **Y** has a greater mass than π^+ **Or** π^+ and **Y** have the same charge / or charge on both particles identified as having charge of (+)1 / π^+ and K^+ *seen*✓ **Y** is a kaon / **Y** is a k meson ✓ π^+has a greater charge-to-mass ratio because it has the same charge as **Y and** less mass than **Y /** π^+ has a greater specific charge✓	Treat **Y** is larger than the π^+as neutral. MP1: Condone error in mass comparisons where **Y** is identified as having a greater rest energy. Both have a charge of +1(e) Accept for mp2: **Y** contains an s or $\bar{s}$ quark which is more massive than u or d quarks in the pion / **Y** contains an s or $\bar{s}$ quark whereas pion does not. π^+ is 1st generation (meson) while **Y** is 2nd generation (meson) Loses MP2 for stating incorrect number of quarks for **Y** or stating that **Y** is a baryon. Accept converse statement Error carried forward for charge on **Y** from **01.1** **Y** will have a greater specific charge where **Y** has charge greater than +4	3	3 x AO3
Total			**6**	

Question	Answers	Additional Comments/Guidance	Mark	AO
02.1	An electron in the beam collides with an electron in the gas particle. **OR** An electron in the beam transfers (some of its kinetic) energy to an electron in the gas particle ✓ **One** (atomic) electron leaves the gas particle ✓	MP1 is awarded for the description of the electron-electron interaction or the resulting energy transfer between these electrons. Treat the gas particles are 'excited' as neutral, must mention an interaction between beam electron and (atomic) electron or an energy transfer from beam electron to (atomic) electron as cause of excitation Allow beam electron collides with / transfers energy to gas (particle) causing an atomic electron to gain energy Condone use of plurals in MP1 Penalise more than one electron leaving a gas particle Condone **One** (atomic) electron leaves the gas (atom)/ the gas (particle) has lost **one** electron Physics errors that relate the effect to annihilation or beta decay or PEE or electron capture gain zero marks.	2	1 x AO1 1 x AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
02.2	Finds the nucleon number of the more massive isotope: $162 \div 2 = 81$ **OR** $162 - (2 \times 35) = 92$✓ (answer =) 46 ✓ **c.a.o**	Alternative for **MP1**: subtracts proton number from their nucleon number / subtracts total number of protons from total number of nucleons. eg $80 - 35$ or $79 - 35$ or 160 – 70 or 158– 70 Condone 45 or 44 on answer line without working for one mark. Do **not** allow $162 - 35$ or $160 - 35$ or $158 - 35$ Condone 92 on answer line without working for 1 mark. 90 or 88 on answer line without working no marks	2	2 x AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
02.3	The percentage is the same for both isotopes / each isotope makes up 50% of the gas (by number) ✓ 158 is made of two atoms of the lighter isotope and 162 is made of two atoms of the heavier isotope and the percentages of 158 and 162 are: both 25% / both same /present in the same ratio **OR** Half of the 160 is made from the lighter isotope and all of the 158 is made from the lighter isotope (totalling 50%) **OR** Half of the 160 is made from the heavier isotope and all of the 162 is made from the heavier isotope (totalling 50%)✓	Do not allow 50% of 158 and 50% of 162 Where percentage stated must be 50 % Do not allow more than 2 isotopes Or words to that effect Accept equivalent discussion in terms of numbers of neutrons present in nuclei in molecules / nucleon numbers of nuclei in molecules. Restating the percentages of the molecules is insufficient for MP2.	2	2 x AO3
Total			**6**	

Question	Answers	Additional Comments/Guidance	Mark	AO
03.1	Use of $f = \frac{1}{T}$ or (T =) 2.63 x 10^{-15} (s) seen or number of waves = $\frac{6 \times 10^{-9}}{\text{their } T}$ or $6 \times 10^{-9} \times 3.8 \times 10^{14}$✓ 2.3×10^{6} ✓	Condone POT error in MP1 Use of $f = \frac{1}{T}$ is f subsituted and formula rearranged to make T the subject. $\frac{1}{6 \times 10^{-9}}$ is not sufficient for use of $f = \frac{1}{T}$ Alternative for MP1: calculates the length of a pulse ($6 \times 10^{-9} \times 3 \times 10^{8}$ = 1.8 m) **and** calculates the wavelength = $\frac{3 \times 10^{8}}{3.8 \times 10^{14}}$ = 7.9×10^{-7} OR Determines maximum number of pulses per second $\frac{1}{6 \times 10^{-9}}$ **and** divides number of cycles per second by the number of pulses per second. That is: $\frac{3.8 \times 10^{14}}{\frac{1}{6 \times 10^{-9}}}$ or $\frac{3.8 \times 10^{14}}{1.67 \times 10^{8}}$ seen Calculator display 2280000 Unsupported answers with POT error 1 mark	2	1 x AO1 1 x AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
03.2	Use of speed = $\frac{\text{distance}}{\text{time}}$ by substituting for speed (3 x10^8 ms^{-1}) and time ($10.7\times 10^{-6}\ s$) **and** making distance the subject **OR** Use of speed = $\frac{\text{distance}}{\text{time}}$ **and** divides their distance by 2 **OR** (time =) $\frac{10.7\times10^{-6}}{2}$ / (time =)$5.35\times10^{-6}\ s$ ✓ 1.6×10^{3} (m) ✓	Condone POT error on MP1 An answer = 3.2(1) x 10^3 (m) obtains 1 mark with working (allow POT on this compensatory mark) Alternative calculation for total distance: Multiples the wavelength (7.9 x 10^{-7} m) by the number of waves in 10.7 μs ($\frac{10.7\times10^{-6}}{2.63\times10^{-15}}$): That is $\frac{3\times10^{8}}{3.8\times10^{14}}\times\frac{10.7\times10^{-6}}{2.63\times10^{-15}}$ / $\frac{3\times10^{8}}{3.8\times10^{14}}\times\frac{10.7\times10^{-6}}{\frac{1}{3.8\times10^{14}}}$ / 7.9 x $10^{-7}\times\frac{10.7\times10^{-6}}{2.63\times10^{-15}}$ / 7.9 x $10^{-7}\times 4.066\times10^{9}$ seen OR Multiples the wavelength (7.9 x 10^{-7} m) by the number of waves in 10.7 μs. $(10.7\times10^{-6}\times f)$ where $f = 3.8\times10^{14}$ *That is:* 7.9 x $10^{-7}\times10.7\times10^{-6}\times3.8\times10^{14}$ / $\frac{3\times10^{8}}{3.8\times10^{14}}\times10.7\times10^{-6}\times3.8\times10^{14}$ *seen* (Calculator displays 1605)	2	2 x AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
03.3	Use of $n_1 \sin\theta_1 = n_2 \sin\theta_2$ ✓ by substitution $(n_2 =)$ 1.3(1) ✓	Condone use of $\boldsymbol{\theta_1}$**= 38°** provided n_{air}= 1 : need to see an explicit statement 1 x sin $\boldsymbol{\theta_1}$ **and** answer = 1.0(2). Allow their θ_1 from an attempt to find 90 −38 in use of Allow 62 or 42 for θ1 without supporting evidence in use of Do not allow $\theta_1 = 90°$ in use of Allow use of $_1n_2 = \frac{\sin i}{\sin r}$ or $\frac{n_2}{n_1} = \frac{\sin i}{\sin r}$ or $n = \frac{\sin i}{\sin r}$ must see i = their θ_1 **and** r = 37° for use of any of these Do not allow this method for $i = \boldsymbol{\theta_1}$**= 38°** unless answer = 1.0(2) **and** **either** $_1n_2$ / $\frac{n_2}{n_1}$ is seen as subject or n is subject and there is an explicit statement that n_{air} =1	2	1 x AO1 1 x AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
03.4	Attempted use of $n = \frac{c}{c_s}$ Or use of their $c_s = f\lambda$ ✓ 6.0×10^{-7} (m) or 6.1×10^{-7} (m) ✓ Alternative Divides wavelength in air by the refractive index✓ 6.0×10^{-7} (m) or 6.1×10^{-7} (m) ✓	Expect to see $c_s = 2.3 \times 10^{8}$ (m s^{-1}) Ecf from **03.3** in use of $n = \frac{c}{c_s}$ Condone their c_s in use of $c = f\lambda$ Ecf from **03.3** Answer = $7.7(4) \times 10^{-7}$ (m) for $n = 1.02$ Or 7.7(2)x 10-7 (m) for n=1.02 where no rounding on ecf Answer = 7.89×10^{-7} (m) for $n = 1.0$ (only condone this answer where n=1 or n=1.0 seen as ecf from **03.3**) Expect to see 6.03×10^{-7} or 6.07×10^{-7} Maximum of 1 mark where speed in ice sheet is more than speed of light in a vacuum is seen. Penalise 1 significant figure	2	1 x AO1 1 x AO2
Total			**8**	

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>AO</th></tr>
<tr>
<td>04.1</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 marking this question.
<table>
<tr><th>Mark</th><th>Criteria</th></tr>
<tr><td>6</td><td>All three areas (as outlined alongside) covered with at least two aspects 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>A fair attempt to analyse all three areas. If there are several errors or missing parts then 5 marks should be awarded.</td></tr>
<tr><td>4</td><td>Two areas successfully discussed, or one discussed and two others covered partially. Whilst there will be 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>One of the three areas covered without significant error.</td></tr>
<tr><td>0</td><td>No relevant analysis.</td></tr>
</table>
</td>
<td>
The following statements are likely to be present.
Area A Loses its charge:

Emission of electrons from the surface (when electromagnetic radiation is incident on plate) (A)
Number of surplus electrons remaining on plate decreases with time / (photo)electrons carry away negative charge(B)

Area B Frequency:

Minimum energy required /work function (C)
A photon must supply this energy in one interaction. (D)
The energy of a photon is directly proportional to its frequency / $E = hf$ (E)
Minimum frequency is the threshold frequency (F)

Area C Intensity:

Increased intensity (at same frequency) results in more photons per second incident on plate. (G)
Must increase the number of photons per second even if frequency increases. (H)
More electrons released from plate every second so loses charge more rapidly. (I)

</td>
<td>6</td>
<td>4 x AO1
2 x AO2</td>
</tr>
</table>

Question	Answers	Additional Comments/Guidance	Mark	AO
04.2	Use of $E = hf$ or converts their photon energy in J to eV / converts 1.1 (eV) to 1.76×10^{-19} (J)✓ Use of $hf = \Phi + E_{k(max)}$ ✓ $\Phi = 3.9$ (eV) ✓	For use of $E = hf$: $6.63 \times 10^{-34} \times 1.2 \times 10^{15}$ / 7.956×10^{-19} (J) / 4.97 eV seen MP2: rearrangement of terms is insufficient. Correct substitution in eV or J with or without rearrangement (condone one consistent POT error) Expect to see $(\Phi =) 4.97 - 1.1$ / $\Phi + 1.1 = 4.97$ / $(\Phi =) 7.956 \times 10^{-19} - 1.76 \times 10^{-19}$ / $(\Phi =) 6.196 \times 10^{-19}$ / $\Phi + 1.76 \times 10^{-19} = 7.956 \times 10^{-19}$ Condone **one** error in either hf or $E_{k(max)}$ or signs but must be rearranged where Φ would be subject. Common error seen in $E_{k(max)} = 6.875 \times 10^{18}$ Examples: $(\Phi =) 7.956 \times 10^{-19} - 1.1$ $(= -1.1)$ / $(\Phi =) 6.63 \times 10^{-34} \times 1.2 \times 10^{15} - 1.1$ / $(\Phi =) 4.97 - 1.76 \times 10^{-19}$ $(=4.97)$ Condone error in Accept a correctly rounded answer to 2 or more significant figure. Condone answer (with working seen) = 6.1 or 6.07 for 2 marks. (Calculator displays 3.8725)	3	1 x AO1 2 x AO2
Total			**9**	

Question	Answers	Additional Comments/Guidance	Mark	AO
05.1	**Q**✓ Diffraction as the electron move between the layers in the graphite/ electrons spread out as they move between the layers in the graphite✓	Talk out of **Q** where diffraction linked to any other location (positive plate or screen) Accept gaps between (graphite) atoms acts as slits for electrons to diffract through Graphite acts like a diffraction grating is not enough. Talk out where particle property is used to describe interaction between the electrons and the graphite (e.g. electrons repelled by graphite) Treat interference at **R** as neutral. Treat interference at **Q** as neutral Allow maximum of one mark for describing particle behaviour at **P** or **R** with a reason given: - acceleration is a particle phenomenon (**P**) - fluorescence is due to a collision with atomic electron which is particle phenomenon. (**R**)	2	2 x AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
05.2	decreases (associated) wavelength / Momentum of electrons increases ✓ quotes $\lambda = \frac{h}{mv}$ / wavelength is inversely proportional to speed / wavelength is inversely proportional to momentum ✓ less diffraction because shorter wavelength relative to the spacing between layers in the graphite / less diffraction because shorter wavelength relative to gaps (in graphite target)✓	Treat double slit formula as neutral MP1 and MP2: talk out on use of wave equation / talk out on frequency remaining constant / talk out on frequency increases Accept: less diffraction because shorter wavelength relative to size of slits Where no other mark is scored allow 1 mark for: less diffraction ✓ 'Spreads out less' is insufficient here	3	3 x AO2
Total			**5**	

Question	Answers	Additional Comments/Guidance	Mark	AO
06.1	attempted use of principle of moments: seen by one correct side of an attempted principle of moments equation. full use of principle of moments ✓ (d =) 2.4 (m) ✓ **Alternative** Finds component of tension in **P** due to worker's weight = 250 N / Finds tension in **P** (due to weight of worker) by dividing weight of platform by 2 and subtracts from 1150 N **OR** Finds component of tension in **Q** due to worker's weight = 500 N / Finds tension in **Q** (due to weight of worker) by dividing weight of platform by 2 and subtracts from 1400 N ✓ Recognises the ratio of weight distribution to worker position relative to cables **P** and **Q** 250 N : 500 N = $3.6 - d : d$ ✓ (principle of moments) (d =) 2.4 (m) ✓	examples of acceptable responses for MP1 1150×3.6 or 1400×3.6 or $1800 \times 1.8 + 750(3.6 - d)$ or $1800 \times 1.8 + 750\,x$ or $750 \times d + 1800 \times 1.8$ ✓ Condone **one** error in distance or signs or force in an attempted use of principle of moments (must have 3 forces multiplied by 3 distances) For moments about **B** (or **Q**): $1150 \times 3.6 = 1800 \times 1.8 + 750(3.6 - d)$ / $1150 \times 3.6 = 1800 \times 1.8 + 750\,x$ x seen (with appropriate working) as 1.2 m or 2.4 m (even when not answer line) gains MP1 and MP2 Moments about **A** (or **P**): $750 \times d + 1800 \times 1.8 = 1400 \times 3.6$ Alternative for MP1 and MP2**:** Moments about worker's centre of gravity: 1150 × d + 1800(1.8 – d) = 1400 (3.6 – d) MP1 for one correct side of equation seen. MP2 all correct terms seen (condone one error) d = 1.2 m **with supporting working gains** MP1 and MP2 (need principle of moments)	3	2 x AO1 1 x AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
06.2	Extension $= 0.18$ mm **or** use of $\varepsilon = \frac{\Delta L}{L}$ **or** reads off d correctly for their extension (+/- half a square) (where working for extension seen)✓ $(d =)$ 1.8 m ✓	Use of $\varepsilon = \frac{\Delta L}{L}$ is by rearrangement to make ΔL the subject **and** 6 x 10^{-5} × 3 seen (condone use of L=3.6 m here). Condone POT error on extension Allow range of 1.75 m to 1.85 m Some supporting use of graph for read-off seen	2	1 x AO1 1 x AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
06.3	$(\sigma =)$ 1.1(4) × 10^{7} (N m^{-2}) ✓ c.a.o		1	AO1

Question	Answers	Additional Comments/Guidance	Mark	AO
06.4	Straight line with negative gradient that intercepts extension axis and has a d range of 3.5 m to 3.7 m ✓ Straight line passes through (0, 0.46) ✓ Straight line passes through (3.6, 0.26) ✓	Penalise double and thick lines (limit on thickness of line: must be less than half square thick) Within 1/2 square Within 1/2 square Condone accuracy within a square **max 1** for MP2 and MP3	3	3 x AO3
Total			**9**	

Question	Answers	Additional Comments/Guidance	Mark	AO
07.1	(Component of total weight parallel to slope =) $640 \sin \theta$ ✓	Allow $mg \sin \theta$ or $65g \sin \theta$ *or* $638 \sin \theta$ *or* $637.7 \sin \theta$ *or* $637.65 \sin \theta$ Condone labelling this component as W in statements such as $W = 640 \sin \theta$ Do not accept $W \sin \theta$ unless W *is defined as* mg	1	AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
07.2	use of $P = Fv$ ✓ $(\theta =)$ 17(.4) (°) ✓	Ecf from **07.1** for MP1 and MP2 Use of $P = Fv$ by substitution and rearrangement to make F the subject. Expect to see $(F =)$ 190(.184) (N) Accept a correctly rounded answer to 2 or more significant figure. (Calculator displays: 17.35298907 for mg sin θ *and* 65g sin θ *and 637.65* sin θ*)* As an alternative to 17.35298907 may see Calculator display or answer of: • 17.34316751 for 638 sin $\theta = 17(.3)$ • 17.3515853 for 637.7 sin $\theta = 17(.4)$ • 17.28726034 for 640 sin $\theta = 17(.3)$ Common ecf: $(65g\cos\theta = 190)$ = 72.6 (°) or 73(°) scores MP1 and MP2 $(65\ tan\theta = 190)$ = 71.1 (°) or 71(°) scores MP1 and MP2 Use of $W = Fs\ cos\theta$ is only acceptable as an ecf where $F = 65g$ and component of weight is given as $65g\cos\theta$ (or equivalent) in **07.1** Alternative MP1: height gain per second = 0.486 m **and** distance along the slope per second = 1.63 m **OR** Use of $\sin\theta = \frac{\text{height gained per second}}{\text{distance travelled per second}}$	2	1 x AO1 1 x AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
07.3	Less (useful) power output ✓ Same gain in (gravitational) potential energy (in climbing hill) / same amount of work done (in climbing hill) / gains same height (in climbing hill) ✓ Gains less (gravitational) potential energy every second ✓ **OR** (component of weight doing work against) Less (useful) power output ✓ Effective θ has decreased / $mg \sin \theta$ has decreased / component of the weight parallel to the slope has decreased ✓ Smaller force does less work per second✓ **OR** (component of vertical velocity) Less (useful) power output ✓ The vertical component of the velocity has decreased / height gained per second decreases ✓ $(P =)\ mg\ v \sin \theta$ has decreased / P = $\frac{\Delta W}{\Delta t}$ has decreased / less work done (against the weight) per second / Less gain in (gravitational) potential energy per second✓ **OR** (distance travelled) Less (useful) power output ✓ Less force is exerted over greater distance (for same change in height) ✓ Smaller force does less work per second✓	General marking principle: MP1 less (useful) power output MP2 basic point MP3 explains consequences of basic point in terms of power (MP3 is an extension of MP2, quoting P = $\frac{\Delta W}{\Delta t}$ without linking to an appropriate explanation is insufficient). Loses MP1: where conflicting statements made about (useful) power output / states more power output / total power output is same Loses MP3 for conflicting statements made in support of explanation. Accept θ as the effective angle to the slope. Condone P= $\frac{E}{t}$ has decreased as MP3 Treat 'inputs more energy' or 'does more work' as neutral	3	3 x AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
07.4	Draws tangent which touches curve between 9 and 11 s ✓ Determine gradient of a tangent drawn at 5s / Determines gradient of tangent drawn at 10s✓ (acceleration =) 0.21 (m s^{-2}) ✓	Must see an attempt to draw a tangent to curve to score any marks. Read-offs must be within ½ square of accuracy Condone one read-off error. For tangent at t =5s, expect to see an answer of 0.61 to 0.71 (m s^{-2}). MAX 2 marks for this. Accept answers in range 0.15 to 0.27 (m s^{-2}) Accept 2 or 3 significant figures only. **MAX 1 mark** Condone a correctly determined gradient for a tangent to the curve at **any other** point **between** 5 and 11 seconds.	3	1 x AO1 1 x AO2 1 x AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
07.5	Air resistance increases (with speed) / resistive forces increase (with speed) / Energy is transferred from the cyclist (due to work done) by resistive forces ✓ **MAX 3** from: Initially, any of the gravitational potential energy that is transferred is transferred to kinetic energy of cyclist ✓ As speed increases, less of the gravitational potential energy transferred per second is transferred to kinetic energy of cyclist✓ As speed increases, energy transferred per second to the air increases / as the speed increases, the energy transferred per second from the cyclist increases✓ At top speed, the gravitational potential energy that is transferred (per second) is transferred to the air / the gravitational potential energy (transferred per second) is being transferred (from the cyclist) due to work done by resistive forces ✓	Condone 'frictional forces increase with speed' Treat kinetic energy is transferred from the cyclist as neutral. The answer must be written in terms of energy transfers	4	1 x AO1 3 x AO2
Total			**13**	

Question	Answers	Additional Comments/Guidance	Mark	AO
08.1	(pd across the variable resistor) = 11.25 (V) seen **OR** Use of $V_0 = \frac{R_1}{R_1 + R_2} \times V_{in}$ **OR** use of $V_1 : V_2 = R_1 : R_2$ or $\frac{V_1}{V_2} = \frac{R_1}{R_2}$ **OR** $(I =)$ 0.45 A✓ $(R =)$ 1.7 (Ω) ✓ **c.a.o**	For **Max 1**: Condone mix up of R_1 and R_2 Condone V=12 V and R=25 Ω leading to an answer of 1.56 Ω or 1.6 Ω Condone V=12 V and R=25 Ω leading to I= 0.48 A and an answer of 1.56 Ω or 1.6 Ω Accept a correctly rounded answer to 2 or more significant figure. (Calculator displays 1.66666666)	2	1 x AO1 1 x AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
08.2	Clear read-off seen on graph of $I = 1.7$ A **Or** use of $V = IR$ ✓ ($R =$) 4.7 (Ω) ✓	Within ½ square of accuracy (1.65 A to 1.75 A) Accept $\frac{8}{1.65} = 4.8(4)$ or $\frac{8}{1.75} = 4.5(7)$ in use of $V=IR$ (condoning 'read-off' to within 1 square of accuracy) Don't need to see read-off for use of $V=IR$ 8 × 1.7 = 13.6 would be insufficient as use of and in this case MP1 can only be scored where read-off is seen. Allow answer in range 4.57 to 4.85 Do not accept 1 significant figure in answer	2	1 x AO1 1 x AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
08.3	As voltage increases the current increases / as the voltage increases more electrons move through the wire (per second)✓ More collisions (per second) between the (conduction) electrons and the lattice ions / Vibration of the lattice ions increases ✓ (Rate of) vibration of the lattice ions increases causing a greater number of collisions **per second** causing increased resistance✓	Allow vibration of the ions in the filament / wire / metal increases Accept rate of collisions for number of collisions per second. Talk out on MP3 where current decreases	3	3 x AO1

Question	Answers	Additional Comments/Guidance	Mark	AO
08.4	use of $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ or $R_T = \frac{R_1 \times R_2}{R_1 + R_2}$ $(R =)\ 4.8(4)\ (\Omega)$ ✓	allow use of $\frac{1}{6} + \frac{1}{25}$ seen without subject Alternative MP1: $(I_T = I_{lamp} + I_{XY} = 2.48\ A)$ **and** use of $V = IR$ Accept a correctly rounded answer to 2 or more significant figure. (Calculator displays 4.838709677)	2	1 x AO1 1 x AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
08.5	use of $P = \frac{V^2}{R}$ by substitution of V = 12 V and R = 4.8 Ω ✓ (P =) 30 (W) ✓	Ecf from **08.4** for MP1 and MP2 MP1: Condone use of R = 6 Ω or R = 25 Ω in this substitution for MP1 (where not ecf from **08.4**) **OR** Condone use of $P=IV$ or use of $P=I^2R$ *by* substitution of their (battery) I and ecf R from **08.4.** Must have clearly identified I in working in **08.4** or by use of $I = \frac{12}{ecf\ R}$ here Ecf answer must be $\frac{12^2}{R\ on\ answer\ line\ in\ 08.4}$ (Calculator display for non-rounded answer 29.76) Penalise answers with more than two digits that have been rounded to 1 significant figure.	2	1 x AO1 1 x AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
08.6	Wider range in Figure 14's circuit **and** lower efficiency in Figure 14's circuit ✓ Details: Voltage range is wider $0–12\ \text{V}$ (in Figure 14's circuit) compared to $0.75\ \text{V} – 12\ \text{V}$ (in Figure 12's circuit) / can't get voltages between 0 and 0.75 V In Figure 12 / wider range when using **XY** as a potentiometer **OR** bulb won't light at lower voltages, so control is unaffected ✓ At any particular voltage across lamp more power dissipated in circuit in Figure 14 / any voltage across the lamp there is always $12\ \text{V}$ across the resistor in Figure 14's circuit which produces more heating (whereas only the remaining portion of $12\ \text{V}$ is across the resistor in Figure 12's circuit) / for any current in the lamp there is always more current in Figure 14's circuit which produces more heating✓	Condone referring to Figure 12 as Figure 13. Allow 'can get zero volts in Figure 14' Current splits in Figure 14 is insufficient	3	3 x AO3
Total			**14**	