AS PHYSICS 7407/1

Paper 1

Mark scheme

June 2025

Version: 1.0 Final

256A7407/1/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

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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	Any **one** from ✓ • use of specific charge = $\frac{\text{charge}}{\text{mass}}$ • charge = 1.6×10^{-19} • mass = $3 \times 1.67(4) \times 10^{-27}$ 3.1×10^{7} to 3.2×10^{7} (C kg^{-1}) ✓	Condone **one** power of ten error in first bullet point. Third bullet point: Condone any mass for a nucleon than rounds to 1.7×10^{-27} kg to 2 significant figures. For example, $3 \times 1.7 \times 10^{-27}$ would be acceptable Alternative for MP1: Use of proton specific charge ÷ 3 Answer in range gains both marks	2	1 × AO1 1 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
01.2	Idea that nuclei of the hydrogen isotopes have same charge / same number of protons (as hydrogen-3) ✓ Idea that nuclei of other isotopes have less mass / fewer nucleons / fewer neutrons (than hydrogen-3)✓	MP1: Allow correct comparison of hydrogen-3 with either hydrogen-2 or hydrogen-1 MP2: Allow correct comparison of hydrogen-3 with either hydrogen-2 or hydrogen-1 Do not accept incorrect statements about numbers of neutrons or protons as reason for lighter nuclei. Accept reverse argument	2	1 × AO1 1 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
01.3	a statement that strangeness is conserved✓ Any **one** from ✓ • K^- has a quark structure of $\bar{u}s$ / K^- has strangeness of -1 • K^0 (must) contain an $\bar{s}$ quark / K^0 has strangeness of $(+)1$ • π^+ quark structure is up antidown / π^+ is not a strange particle / π^+ has a strangeness of 0 • kaons are produced by the strong interaction $\bar{s}$ d ✓	Accept a demonstration of conservation of strangeness (with numbers seen). Expect to see: 0 + 0 → -1 + 0 + 1 Fo MP1, condone 0 + 0 → 1 + 0 + -1 (MAX 2 where this error seen) **MP2 An incorrect statement in any bullet point does not gain this mark.** **Max 1** where no other mark is scored for: • idea that baryon number must be conserved so all produced particles are mesons • neutral kaon has a quark structure of $\bar{d}s$ treat mention of conservation of lepton number or charge as neutral	3	AO3

Question	Answers	Additional Comments/Guidance	Mark	AO
01.4	Any **one** from ✓ • charge must be conserved **OR** demonstrates conservation of charge • lepton number must be conserved **OR** demonstrates conservation of lepton number first option: **A** = positron and **B** = electron neutrino **OR** Second option: **A** = positive muon and **B** = muon neutrino ✓	For demonstrations expect to see: (+) 1 (e) → (+) 1 (e) + 0 0 → -1 + (+) 1 Treat BP1 and BP2 as independent marks. Max 1 for A and B in the incorrect order. Condone clearly recognisable symbols in place of names.	2	AO3
Total			**9**	

Question	Answers	Additional Comments/Guidance	Mark	AO
02.1	It is unchanged. ✓	Tick ✓ in the 2nd box only	1	AO1

Question	Answers	Additional Comments/Guidance	Mark	AO
02.2	Any **one** from ✓ • use of $\sin\theta_C = \frac{n_2}{n_1}$ OR use of $n_1 \sin\theta_1 = n_2 \sin\theta_2$ where $\theta_2 = 90$(°) • $n_1 = 1.51$ and $\theta_C = 80.7$ (°) (Refractive index of cladding =) 1.49 ✓	Condone mix up in n_1 and n_2 in 1st bullet point in otherwise correct substitution Do not allow use of $n = 1$ in first bullet point Expect to see: $\sin 80.7 = \frac{n_2}{1.51}$ OR $1.51 \sin 80.7 = n_2 \sin 90$ Sin 80.7 = 0.987 Calculator value 1.490152132 Condone an answer of (Refractive index of cladding =) 1.5 where correct working seen to support and is correct rounding of 1.49	2	1 × AO1 1 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
02.3	use of $n_1 \sin\theta_1 = n_2 \sin\theta_2$ ✓	Use of equation includes: $\sin\theta_A = 1.51 \times \sin 9.3$ Condone confusing n=1 and n=1.51 in otherwise correct substitution. Allow $\sin 9.3 = 1.51 \sin\theta$ (as confusing refractive indices) Condone use of $n_2 = 1.49$ in an otherwise correct substitution.	2	1 × AO1 1 × AO2
	(θ_A =) 14° ✓	Calculator value 14.12403075		

Question	Answers	Additional Comments/Guidance	Mark	AO
02.4	Any **two** from ✓✓ • use of $n = \frac{c}{c_s}$ (1) • use of their speed = $\frac{\text{their distance}}{\text{time}}$ (2) • calculates a component of their velocity of light in the core (3) • evidence of correctly calculating an appropriate distance in the core (4) • makes use of the 31000 reflections (5) (time =) 2.5×10^{-6} (s) ✓	Speed of light in core = 1.99×10^{8} m s^{-1} Do not allow their speed as 3×10^{8} m s^{-1} in 2nd bullet point or bullet point 3 Vertical component = 3.11×10^{7} m s^{-1} Horizontal component = 1.96×10^{8} m s^{-1} Horizontal distance between reflections = 15.8 mm Horizontal distance travelled as light travels from centre to edge = 7.89 mm Distance travelled between reflections = 15.98 mm Distance travelled as light travels from centre to edge = 7.99 mm Total vertical distance travelled by light = 77.5 m Total distance travelled by light= 495 m Length of fibre = 489 m	3	AO3

		Accept any answer that rounds to the two significant figure answer of 2.5×10^{-6} (s) when supported by correct working.		
Total			**8**	

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>AO</th></tr>
<tr><td>03.1</td><td>Any three from ✓✓✓
• (energy absorbed by atom =) $16.64 - 5.92$
$= 10.72\ (\times 10^{-19})$ (1)
• (E_k of scattered electron =) $13.1 - 10.72 = 2.38\ (\times 10^{-19})$ (2)
• Use of $E_k = \frac{1}{2}mv^2$ by substitution with an E_k OR rearrangement where v is subject
OR
$E_k = \frac{p^2}{2m}$ by substitution with an E_k OR rearrangement where p is subject (3)
• Use of $\lambda = \frac{h}{mv}$ OR $\lambda = \frac{h}{p}$ with their v or their p (4)
(de Broglie wavelength =) 1.01×10^{-9} (m) ✓</td><td>In 2nd bullet point: condone 13.1 – their energy absorbed by the atom
Expect to see speed of electron immediately after collision = 7.23×10^5 ms^{-1}
Expect to see momentum of electron immediately after collision = 6.6×10^{-25} kg ms^{-1}
their E_k and speed
<table><tr><th>Kinetic energy (J)</th><th>Speed (m s^{-1})</th><th>de Broglie wavelength (m)</th></tr><tr><td>13.10×10^{-19}</td><td>1.70×10^6</td><td>4.3×10^{-10}</td></tr><tr><td>16.64×10^{-19}</td><td>1.91×10^6</td><td>3.8×10^{-10}</td></tr><tr><td>8.8×10^{-19}</td><td>1.39×10^6</td><td>5.2×10^{-10}</td></tr><tr><td>5.92×10^{-19}</td><td>1.14×10^6</td><td>6.4×10^{-10}</td></tr><tr><td>10.72×10^{-19}</td><td>1.53×10^6</td><td>4.7×10^{-10}</td></tr></table>Accept a correct answer given to at least 2 significant figures
Calculator value $1.00681775 \times 10^{-9}$</td><td>4</td><td>2 × AO2
2 × AO1</td></tr>
</table>

Question	Answers	Additional Comments/Guidance	Mark	AO
03.2	Any **one** from ✓ • use of $E = \frac{hc}{\lambda}$ (1) • use of $E = hf$ and $c = f\lambda$ (2) • conversion of their wavelength in metres to nanometres seen (3) (wavelength =) 254 (nm) ✓	Allow use of $h = 6.6 \times 10^{-34}$ J s where answer is seen as 253 nm if use already penalised in 03.1. Expect to see $\lambda = 2.54 \times 10^{-7}$ Accept a correct answer given to at least 2 significant figures. Calculator value $2.540229885 \times 10^{-7}$	2	1 × AO1 1 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
03.3	Any **one** from ✓ • calculates 82% of 18 W • divides their energy per second by 7.83×10^{-19} (Number of photons per second =) 1.9×10^{19} ✓	Expect to see 14.76 (W) 18 x 0.82 is insufficient on its own. Accept any answer that rounds to two significant figure answer of 1.9×10^{19}	2	1 × AO1 1 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
03.4	Any **two** from ✓✓ • idea of photon being absorbed (by atoms in the coating) (1) • idea that (atomic) electron (in the coating) moves to a higher energy level **and** returns to lower energy level (emitting a photon) **OR** Idea of excitation (of atom in coating) **followed by** de-excitation (emitting a photon) (2) • idea that there are many different energy transitions that lead to the production of white light (3) Energy difference between energy levels (in the coating) is smaller (than the difference in energy levels in mercury atom) therefore emits a radiation with a longer wavelength ✓ (4) Idea that one uv photon being absorbed can produce several lower energy photons when energy is re-emitted ✓ (5)	Condone: Electrons (in the coating) excite then de-excite (emitting a photon) Accept lower frequency in place of longer wavelength	4	2 × AO1 2 × AO3
Total			**12**	

Question	Answers	Additional Comments/Guidance	Mark	AO
04.1	The clockwise moment(s) equals the anticlockwise moment(s) ✓ Includes **all** the following ✓ • (system must be) in equilibrium • moments about the same point • sum of the clockwise moments equals the sum of the anticlockwise moments.		2	AO1

Question	Answers	Additional Comments/Guidance	Mark	AO
04.2	Use of principle of moments ✓$_1$ determines perpendicular distance between 97 N and weight's line of action = 85 – 12 = 73 (cm) **OR** $R = W - 97$ ✓$_2$ (R =) 590 (N) ✓$_3$	Expect to see one of the following • $97 \times 73 = R \times 12$ ✓$_1$✓$_2$ • $W \times 73 = R \times 85$ ✓$_1$✓$_2$ • $97 \times 85 = W \times 12$ ✓$_1$ Condone one error in MP1 • $97 \times$ a *distance* $= R \times 12$ • $97 \times$ a *distance* $= W \times 12$ • $W \times$ a *distance* $= R \times 85$ • $97 \times 85 = W \times$ a distance MP2 (option 1) Accept: • 73 (cm) seen in Figure 4 • 73×97 seen • $73 \times W$ seen MP2 (option 2) Accept $W = R + 97$ Calculator value 590.0833333	3	1 × AO1 2 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
04.3	(The moment of the weight about the back wheel decreases because) perpendicular distance between (line of action of) weight and (centre of back) wheel decreases ✓	Condone: idea that perpendicular component of weight has decreased.	1	AO1

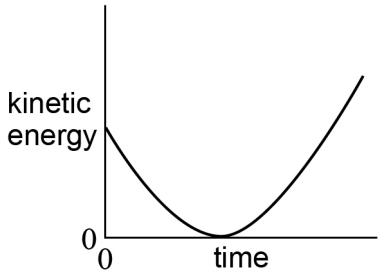
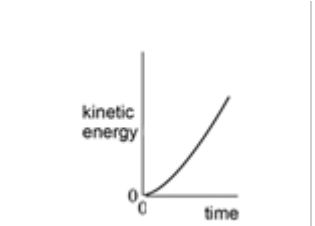
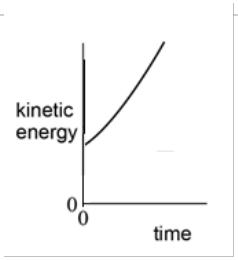
Question	Answers	Additional Comments/Guidance	Mark	AO
04.4	idea that (still in rotational equilibrium therefore) clockwise moment (about back wheel) equals anticlockwise moment (about the back wheel) OR Idea that $W = R_1 + R_2$✓ the perpendicular distance between (the line of action of) R_1 and the point (around which moments are taken) decreases ✓ perpendicular distances (for W and R_1) decrease by the same factor and therefore the magnitudes are the same.✓	Must state that magnitude remains the same for maximum of 3 marks. MP1: Accept that R_1's moment must decrease because weight's moment decreases. MP2: Expect to see point declared as back wheel. MP3: Allow perpendicular distance for R_1 and R_2 decrease by the same amount where go on to state that sum of these equals W	3	1 × AO2 2 × AO3
Total			**9**	

Question	Answers	Additional Comments/Guidance	Mark	AO
05.1	• Calculation of the weight ✓ • $2\ T \cos 37.5 = \text{their } W$ **OR** $2T \sin 52.5 = \text{their } W$ ✓ • use of Young modulus $= \frac{their\ \ force \times 2.0}{1.4 \times 10^{-4} \times extension}$ **OR** Use of $their\ \sigma = \frac{\text{their } F}{A}$ AND $E = \frac{\text{their } \sigma}{\varepsilon}$ AND their $\varepsilon = \frac{\Delta L}{L}$ ✓ 3.6×10^{-4} (m) ✓	**MP1** e.g. $(W =)$ 850g or 8340 (N) or 850×9.81 seen or calculating the weight of 425 kg. **MP2** is for applying equilbrium condition using their weight. Condone one other error, must see an attempt to resolve that includes the tension. i.e. using $W \sin\theta$ or $W \cos\theta$ does not get this mark **MP3** for use of Young modulus equation. Condone power of ten errors Their stress and their strain must be consistent with their force. Condone power of ten errors Using weight as tension: $\Delta L = 5.7 \times 10^{-4}$(m) obtains 2 marks Accept any answer that rounds to 3.6×10^{-4} (m)	4	2 × AO1 2 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
05.2	determine correct area under graph for correct region with their read-off for v OR determines Δh using appropriate suvat equation ✓ Use of $\Delta E_p = mg\Delta h$ ✓ 1.1×10^4 (J) ✓	Expect to see $\Delta h = 1.275$ (m) Allowable range for v: 1.625 to 1.775 (ms^{-1}) Allowable range for Δh : 1.21875 to 1.33125 (m) Allow their Δh in MP2 Condone answer in range 1.04958×10^4 (J) to 1.0965×10^4 (J) rounded to 2 or more significant figures.	3	2 × AO1 1 × AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
05.3	Any **two** from ✓✓ • acceleration from the graph = (−) 0.85 ($\mathrm{m\ s^{-2}}$) • uses $F = ma$ with their acceleration • subtracts their (resultant) force from their weight **OR** $850\mathrm{g} - T$ = 850 × their acceleration or equivalent seen 7600 (N) ✓	Check their weight against value seen in working in **05.1** (treat as ecf) 3rd bullet point, 2nd option is worth 2nd and 3rd bullet points	3	AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
05.4	uses initial velocity = 1.7 (m s^{-1} upwards) ✓ Use of $v^2 = u^2 + 2as$ with their u **OR** Use of equivalent combination of suvat equations with their u ✓ 11 (m s^{-1}) ✓	 Expect to see $v^2 = 1.7^2 + 2$ x 9.81 x 5.5 MP2 Condone incorrect signs seen in attempted use of $v^2 = u^2 + 2as$ Do not penalise inconsistent signs in **MP2** if combination of suvat equations used Calculator value 10.52615789 **OR** Calculator value 10.54943126 (for student using s = 5.525 m using area under v–t graph in **Figure 7**)	3	AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
05.5	• correct general shape with minimum turning point of zero (displaced to left) (1) ✓ • lower initial non-zero KE than final KE with a minimum turning point inbetween (where final KE is KE just before impact with ground) (2) Max 1 for ECF from 5.4 where u is **indicated as being zero** • correct general shape beginning at (0,0) with increasing gradient for KE with respect to time✓ (3) OR Max 1 ECF from 5.4 where u is **indicated as being downwards** and non-zero • correct general shape beginning at positive y-intercept with increasing gradient for KE with respect to time✓ (4)	 Need to see 5.4 for possible ecf  	2	AO3
Total			**15**	

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</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 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>
Area 1 Produce characteristic experimentally

Use of voltmeter in parallel with test component
Use of (milli)ammeter in series with test component
Method of varying current or pd
Description of taking measurements of V and I for different values (of I)
Accept an appropriate circuit diagram for first three bullets.

Area 1 is limited to partial coverage where temperature is varied by a method other than changing current.
Area 2 Behaviour of thermistor

Initially constant resistance (up to about $1\ \text{mA}$)
Resistance then decreases (as current increases)
Rapidly decreasing resistance at greater current (greater than about $2\ \text{mA}$)

Idea that the resistance is represented by gradient of line limits area 2 to partial.
Area 3 Explanation

Initially temperature is constant so thermistor is ohmic
Thermistor warms up due to increased current
Increased temperature of thermistor causes resistance of thermistor to decrease

</td>
<td>6</td>
<td>2 × AO1
2 × AO2
2 × AO3</td>
</tr>
</table>

Question	Answers	Additional Comments/Guidance	Mark	AO
06.2	**Option 1** Any **two** from ✓✓ • (reads off V at $1.0\ \text{mA}$ from their graph =) $2.8\ (\text{V})$ • subtracts their pd from $10\ (\text{V})$ to determine pd across **R** • divides their pd across **R** by $1.0\ (\text{mA})$ (resistance =) $7200\ (\Omega)$ ✓ **Option 2** Any **two** from ✓✓ • (reads off voltage across **T** (V_T) at $1.0\ \text{mA}$ from their graph =) $2.8\ (\text{V})$ • finds resistance of **T** (R_T) by use of $V = IR$ with their read-off for V_T when $I = 1\ \text{mA}$ • use of potential divider formula with their V_T and their R_T **OR** uses ratio of their pds to ratio of their resistances (resistance =) $7200\ (\Omega)$ ✓ **Option 3** Any **two** from ✓✓ • (reads off voltage across **T** (V_T) at $1.0\ \text{mA}$ from their graph =) $2.8\ (\text{V})$ • (finds resistance of **T** (R_T) by use of $V = IR$ with their read-off for V_T when $I = 1\ \text{mA}$) $= 2800(\Omega)$ OR (Uses V=IR to find the total resistance in the circuit) = $10000(\Omega)$ • Subtracts their thermistor resistance(R_T) from their total resistance	In each option: 1st bullet point range for voltage is 2.7 to $2.9\ \text{V}$ Condone one power of ten error between MP1 and MP2	3	1 × AO3 2 × AO2

	(resistance =) 7200 (Ω) ✓			
Total			**9**	

Question	Answers	Additional Comments/Guidance	Mark	AO
07.1	Idea that it is the minimum (photon) frequency needed ✓ for (photo)electron(s) to be emitted ✓		2	AO1

Question	Answers	Additional Comments/Guidance	Mark	AO
07.2	3.4(2) (V) ✓		1	AO1

Question	Answers	Additional Comments/Guidance	Mark	AO
07.3	Any **one** from ✓ • converts 1710 THz to 1.71×10^{15} (Hz) • use of $h \times their\ f = \emptyset + E_{k(max)}$ 5.9×10^{-19} (J) ✓	1st bullet point Accept any number (without prefix) equivalent to 1.71×10^{15} Hz Accept answer in range 5.8×10^{-19} to 5.9×10^{-19}	2	AO2

Question	Answers	Additional Comments/Guidance	Mark	AO
07.4	Gradients of the lines are the same as gradient of magnesium's line✓ **X** line intersects with the frequency axis to the right of the magnesium line's intersection point **AND Y** line intersects with the frequency axis to the left of the magnesium line's intersection point (and still negative y-intercept) ✓ Because: gradient is equal to Planck constant, h, (which has a constant value) **OR** intercept on $E_{k(max)}$ is (–) the work function **OR** lower work function has a lower threshold frequency **OR** **Y**'s photoelectrons will have a greater $E_{k(max)}$ for any given frequency as it has a lower work function.✓	Mp3 is for correct reasoning consistent with correct MP1. Condone MP3 where an attempt made to parallel lines for **X** and **Y** OR MP3 is for correct reasoning consistent with correct MP2 In support of MP1 In support of MP2 In support of MP2 In support of MP2 If no other mark given, **Max 1** for intercepts correct on E_k max axis and correct support seen in MP3.	3	AO2
Total			**8**	