AQA

A-level
Physics

7408/3BD-Paper 3 Section B – Turning Points in Physics
Mark scheme

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

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 not 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. i.e. 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.

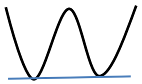
You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

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 mark

Question	Answers	Additional Comments/Guidance	Mark
01.1	Filament / metal is heated due to the current through it ✓ Or temperature of the filament rises due to the current through it (free / conduction) electrons gain sufficient/enough (kinetic) energy to leave (the metal surface) or Work function (defines work function)≤ energy supplied to an electron/electron energy✓ Thermionic emission ✓	Not electrons are heated Not heated due to the pd across it Allow by electrical power or electrically heated Not allowed Reference to electrons leaving <u>atoms</u> or ionisation Allow Energy supplied sufficient to overcome the work function	3
01.2	Use one of $\frac{1}{2}mv^2 = eV$ and $r = \frac{mv}{Be}$ or $\frac{mv^2}{r} = Bev$ to arrive at $\frac{Ber}{m} = v$ or $v = \sqrt{\frac{2eV}{m}}$ or $v^2 = \frac{2eV}{m}$ or $\frac{e}{m} = \frac{v}{Br}$ or $\frac{e}{m} = \frac{v^2}{2V}$ ✓ substitution in the other equation and manipulates <u>correctly</u> and <u>clearly</u> to give $\frac{e}{m} = \frac{2V}{B^2r^2}$ ✓	Condone *q* for *e* Substitution in other equation and correct manipulation NB this is a show that so mark is not simply for stating the equation given I presented such that *v* (velocity) and *V* (voltage) are indistinguishable in manipulation then award only first mark	2

01.3	Correct substitution $\frac{e}{m} = \frac{2 \times 320}{(1.5 \times 10^{-3})^2 \times 0.040^2}$ and answer 1.8×10^{11} ✓ Answer to 2 sig figs ✓ Allow for incorrect answer following incorrect substitution in equation	As answer is on the data sheet must see correct substitution with all correct powers of ten	2
01.4	The specific charge of the cathode rays/the particles was(much) larger/greater than the hydrogen ion/proton ✓ This provided evidence that cathode rays were composed of electrons/particles which have a (very) small mass / have a high (negative) charge or Mass (much) smaller than the mass of a hydrogen (ion)/proton✓	Not higher If mark 1 not given then 0 for the question Not lightest as substitute for mass	2
Total			**9**

Question	Answers	Additional Comments/Guidance	Mark
02.1	Pattern shows: Maximum at start and shows minimum of zero (never negative)✓ Correct periodicity zeros/maxima 180^{o} apart✓ (ie angles in right places) Curvature rather than spikes ie  ✓  × (The graph should fall to zero – (NB First and last parts should ideally be curved not as illustrated here)	**If negative then can get second mark only** Assume that bottom of graph grid is zero unless otherwise stated Must be numbers on x-axis Ignore if graph shows what happens beyond 360 If only one minimum shown then loses this mark Allow if shown starting at zero Freehand sketch so allow if clear attempt to show curvature in most of sketch or arches	3
02.2	<u>Correct substitution</u> leading to a calculation of the speed of electromagnetic wave. $\frac{1}{\sqrt{(4\,\pi\times10^{-7})(8.85\times10^{-12})}}$ = 3.0 (2.9986) x 10^{8} m s^{-1} Comment that this speed agrees with the <u>measured</u> speed of light Or speed determined from <u>experiments</u> <u>Or similar to Fizeau's result</u>		1 1
Total			**5**

Question	Answers	Additional Comments/Guidance	Mark
03.1	Converts 6.2 eV, 0.5 eV or 6.7 eV to J eg 6.2 x 1.6 x 10^{-19} J or 9.9(2) x 10^{-19} seen for 0.5 eV 8.0 x 10^{-20} seen for 6.7eV 1.07 x 10^{-18} seen ✓ $\lambda = \frac{hc}{E}$ or substitution $E = \frac{6.63\times10^{-34}\times3\times10^{8}}{\lambda}$ With one of the above values included for energy ✓ 190 (185,186 or 187) nm ✓	NB use of $\lambda = h/mv$ is a PE and scores 0 May use $f = \frac{E}{h}$ and then $\lambda = \frac{c}{f}$ Treat incorrect *E* in the same way Guidance Use of 0.5 eV gives 4.0 x 10^{-25} 6.2 eV 3.2 x 10^{-26} 6.7 eV 3.0 x 10^{-26} *These will score 1* 8.0 x 10^{-20} gives 2500 nm 9.9(2) x 10^{-19} 200 nm *These will score 2* 1 sf answers are not allowed so correct working with answer 186 nm rounded to 200 nm will also score 2	1 1 1

03.2	**Classical Wave Model** Wave model predicts an increase in the photocurrent Plus one from • as energy transferred into each electron increases (over time) /energy of the emitted electrons increases • electrons can gain sufficient KE to reach T • electrons can leave the surface with greater KE✓ **Photon Model** The photon model predicts no change in the photocurrent Or photocurrent remains at zero ✓ One from • the energy of a photon depends on the frequency not the intensity • energy of each incident photon remains the same • KE of electrons leaving the surface does not change • Electrons released are still unable to reach T✓	NB The response has to discuss the effect of each theory on the maximum KE of the electrons when they leave the surface. Discussions that relate to threshold frequency or delay before emission are not relevant.	3

Question	Answers	Additional Comments/Guidance	Mark
03.3	Fewer electrons will have sufficient energy to move away from the surface/or to reach T/anode Or Electrons need more energy to cross the gap Or Some of the electrons released were more tightly bound to the surface Or Electrons have a range of energies(when emitted from surface) or Some electrons use more of the photon energy to escape from the surface (this is related to the energy of the photoelectrons). ✓ Fewer electrons per second/rate at which electrons reach T will reach terminal T/cross the gap (the per second part captures what is going on in terms of the current)✓	Fewer electrons per second have sufficient kinetic energy to reach T scores 2 Do not allow fewer photoelectrons per second flowing through the circuit	1 1
03.4	A > B > C ✓		1

Total			**9**

Question	Answers	Additional Comments/Guidance	Mark
04.1	**The mark scheme gives some guidance as to what statements are expected to be seen in a 1 or 2 mark (L1), 3 or 4 mark (L2) and 5 or 6 mark (L3) answer. Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist in marking this question.**	The following statements are likely to be present: **Bullet point 1 in question** **(Explanation of how shift expected)** 1. PM_2 lies in the direction of the Earth's velocity. 2. Speed of light different in the two directions 3. The time taken for light to travel from P to M_2 and back to P would be greater than the time taken from P to M_1 and back to P 4. If the speed of light depends on the Earth's velocity through the ether. 5. Rotating the apparatus through 90° would cause the time difference to reverse/change, 6. When rotated there would be a change in the phase difference between the waves (at each point in the fringe pattern) **Bullet point 2 in the question** **(Results compared with prediction)** 7. The apparatus was capable of detecting shifts of 0.05 fringe, 8. No shift was detected then or in later experiments when apparatus rotated **Bullet point 3 in the question** **(Conclusions)** 9. The experiment showed that there is no absolute motion 10. Ether did not exist so light travels without the need for a material medium, 11. The Earth was dragging the ether with it.	6

Mark	Criteria	QoWC
6	<u>A thorough and well communicated</u> discussion using most of the statements in bullets 1 2 and 3	The student presents relevant information coherently, employing structure, style and SP&G to render meaning clear. The text is legible.
5	<u>A explanation that includes</u> discussion using most of the statements in bullets 1 , 2 and 3 but may contain minor errors or omissions	

	4	<u>The response includes a well presented</u> discussion of two from bullets 1 and two from bullet 3 and one from bullet 2	The student presents relevant information and in a way which assists the communication of meaning. The text is legible. SP&G are sufficiently accurate not to obscure meaning.	Many responses fail to demonstrate an understanding that the shift pattern is there in the first place and the shift occurs due to rotation of the apparatus. They often imply that the shift is due to differences in the distance travelled	
	3	<u>The response includes a</u> discussion of one comment from each bullet			

	2	<u>The response</u> makes comments about two bullet points (This is likely to be from bullets 2 and 3)	The student presents some relevant information in a simple form. The text is usually legible. SP&G allow meaning to be derived although errors are sometimes obstructive.		
	1	Makes relevant comment from the list			
	0	No relevant coverage of the likely statements.	The student's presentation, SP&G seriously obstruct understanding.		

Question	Answers	Additional Comments/Guidance	Mark
04.2	Correct postulate invariance of the speed of light <u>in free space/vacuum</u>. speed of light the same in free space		1
04.3	Laws of physics have the same form in all inertial frames Laws of physics unchanged from one inertial frame to another	The <u>same</u> laws of physics are obeyed/apply/hold in (all) inertial frames of reference/non accelerating frames of reference/frames moving at a constant velocity Not Allowed All laws of physics Laws of physics are the same Laws of physics are constant…. Mention of Newton's laws being obeyed Allow 1 here if both 4.2 and 4.3 are correct but reversed	1

04.4	Time of flight is found to be 4.41×10^{-6} s ✓ $t_o = t\sqrt{1-\frac{v^2}{c^2}}$ or $t_o = 4.41 \times 10^{-6}\sqrt{1-0.99^2}$ ✓ (Proper time t_0 is) 6.22×10^{-7} s ✓ Percentage remaining is (found from the graph) 82 +/– 1 OR In muon reference frame $L = 1310\sqrt{1-0.99^2}$ ✓ 185 m✓ $t = \frac{185}{0.99 \times 3 \times 10^8} = 6.23 \times 10^{-7}$ s✓ allow ecf for incorrect length calculation 82 +/– 1%✓	May do Number of half lives = $6.22 \times 10^{-7}/2.2 \times 10^{-6}$ fraction remaining = $0.5^{0.283}$=0.82 185 m seen scores 2 Must see this stage with speed = 0.99 x 3 x 10^8 Final answer in range can be awarded even if 0.99 omitted in MP3 Allow minor differences in time (3rd sf) due to rounding in processing	4
Total			**12**