A-level

PHYSICS

7408/3BD

Paper 3 Section B Turning points in physics

Mark scheme

June 2021

Version: 1.0 Final

216A7408/3BD/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.

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. 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 marks.

Question	Answers	Additional comments/Guidance	Mark	AO
01.1	**A** is filament ✓ **B** is the anode ✓ V_1 is the p.d. to supply energy/ drive current to heat **A**. ✓ V_2 is the p.d./produces accelerating electric field to accelerate electrons.	Allow heated cathode	4	2 × AO1b 2 × AO2.1g

Question	Answers	Additional comments/Guidance	Mark	AO
01.2	(Atom diameter about 0.1 nm) So wavelength should be about 0.05 nm ✓ $\lambda = \frac{h}{\sqrt{2meV}}$ seen ✓ Rearranged with substitutions of h, m, e to give $V = \frac{h^2}{2me\lambda^2}$ ✓ = 600 V ✓	Allow 0.05 nm to 0.1 nm for wavelength Ecf for wavelength for MP 2, 3, 4 Allow 1 sf answer	4	4 × AO3.2a

Question	Answers	Additional comments/Guidance	Mark	AO
01.3	State inverse relationship between wavelength and momentum✓ Identify link between V_2 and momentum of electrons. ✓ Identify how ring diameter is related to wavelength. ✓ State change in ring diameter due to change in V_2 (which is consistent with de Broglie hypothesis) ✓	De Broglie hypothesis suggests that λ will decrease/increase if the momentum increases/decreases Allow qualitative statements. Measure V_2 to determine (KE of electrons and therefore) momentum/speed of electrons Measure ring diameter as increased/decreased diameter indicates increased/decreased wavelength (De Broglie hypothesis therefore supported by) increasing/decreasing V_2 resulting in decreased/increased ring diameter.	4	1 × AO2.1g 3 × AO3.2a

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidance</th><th>Mark</th><th>AO</th></tr>
<tr><td>01.4</td><td>
<table>
<tr><th>STM</th><th>TEM</th><th></th></tr>
<tr><td>Moving electrons can cross a potential barrier.</td><td>Moving electrons can be deflected by a magnetic field.</td><td>✓</td></tr>
<tr><td>Moving electrons can be deflected by a magnetic field.</td><td>Moving electrons can be deflected by a magnetic field.</td><td></td></tr>
<tr><td>Moving electrons can be deflected by a magnetic field.</td><td>Moving electrons can cross a potential barrier.</td><td></td></tr>
<tr><td>Moving electrons can cross a potential barrier.</td><td>Moving electrons can cross a potential barrier.</td><td></td></tr>
</table>
Tick in first box ✓</td><td>Only answer</td><td>1</td><td>AO1.1a</td></tr>
<tr><td>Total</td><td></td><td></td><td>13</td><td></td></tr>
</table>

Question	Answers	Additional comments/Guidance	Mark	AO
02.1	$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ seen AND μ_0 ε_0 substituted separately from data booklet ✓ To give value of c AND compared with c in booklet ✓	For MP1 condone formula seen AND answer given to at least 5 sf (2.9986 x 10^8 (ms^{-1})) For MP2 need to see a valid comment that compares calculated value with data booklet value with units to at least 3sf	2	AO2.1b

Question	Answers	Additional comments/Guidance	Mark	AO
02.2	Maxwell's model as varying perpendicular E and B fields (transmitting through space) ✓ (Oscillating) current in T indicates presence of (oscillating) E field ✓ Oscillating current in T produces (horizontal) B field ✓ Varying (horizontal) B field induces varying emf in loop OR Varying (vertical) E field creates a varying emf in loop ✓	For MP2 allow idea of distribution of charge in T giving rise to electric field For MP3 allow moving electrons produces a (varying) magnetic field For MP4 allow idea of magnetic field applying force on (moving) charges in the receiver (which is an emf) OR Idea of electric field causing change in charge distribution within the loop (which is an emf)	4	1× AO1.1a 3× AO2.1g

Question	Answers	Additional comments/Guidance	Mark	AO
02.3	In order to determine speed, need to measure wavelength/ distance between nodes OR antinodes in stationary wave ✓ From frequency of 75 MHz and $c = f\lambda$, wavelength = 4 m OR nodes/antinodes are 2 m apart ✓ Which is less than separation of transmitter and reflector so YES ✓ Answer refers to nodes ✓	For MP3 and MP4 allow for correct calculation leading to idea that three waves will fit between transmitter and detector so YES In MP3 allow ecf for incorrect wavelength	4	AO3.1a
Total			**10**	

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidance</th><th>Mark</th><th>AO</th></tr>
<tr><td>03</td><td>The mark scheme gives some guidance as to what statements are expected to be seen in a 1 or 2-mark (L1), 3 or 4-mark (L2) and 5 or 6-mark (L3) answer. Guidance provided in section 3.10 of the ‘Mark Scheme Instructions’ document should be used to assist in marking this question.
<table>
<tr><td>Mark</td><td>Criteria</td></tr>
<tr><td>6</td><td>All three areas 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>None 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.
A – outline of experimental procedure
Semi-silvered glass block splits the beam of monochromatic light into two beams
(The plane block ensures that both beams pass through the same thickness of glass and air)
(Beams travel at right angles, to M_1 and M_2 , and return to) combine at telescope with a path difference
Observer sees interference pattern from two beams
Apparatus rotated 90 degrees and pattern observed
B – expected result
Pattern would shift
As path length/speed of light different depending on (orientation relative to) motion of apparatus
So ether exists/absolute motion of Earth detected
C – actual result and significance
No shift in pattern
No evidence of ether
Speed of light is invariant/all motion is relative/no absolute motion</td><td>6</td><td>AO1.1a
× 6</td></tr>
<tr><td>Total</td><td></td><td></td><td>6</td><td></td></tr>
</table>

Question	Answers	Additional comments/Guidance	Mark	AO
04.1	One which moves at constant velocity	Allow: a reference frame in which Newton's laws / Newton's first law holds.	1	AO1.1a

Question	Answers	Additional comments/Guidance	Mark	AO
04.2	In frame of particle beam Distance between detectors = $45\sqrt{1-\frac{(0.97c)^2}{c^2}} = 10.9\text{ m}$ ✓ Time = $10.9 / 0.97\text{c} = 3.8 \times 10^{-8}\text{ s}$ ✓ Half-life = time/3 ✓ = $1.3 \times 10^{-8}\text{ s}$ ✓	MP1 is for determination of distance between detectors in ref frame of particles MP2 is for determining the time between detectors in the ref frame of particles MP3 is for use of reduction to 12.5% is equivalent to 3 half-lives MP4 is for correct final answer Allow alternative route from ref frame of detectors	4	AO2.1f

Question	Answers	Additional comments/Guidance	Mark	AO
04.3	The time taken for particle beam to travel between detectors 'measured' in the reference frame of particle beam✓	Accept: shortest observable time for a particle passing between detectors. Accept $3.8 \times 10^{-8}\text{ s}$	1	AO2.1e
Total			**6**	