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 <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.

Level of response marking instructions

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

Step 1 Determine 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 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. 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	ID details
01.1	Weight/gravitational force AND electric/electrostatic force ✓ Equal (magnitudes) and opposite directions, AND one direction at least specified✓	The second mark is conditional on the first. First mark is for naming the two forces. Condone 'electromagnetic' for 'electric' Do not allow field or potential for force. Allow "force due to electric field"; "force due to magnetic field" Penalise additional forces in MP2. The second mark is for the relationship between them. Must include idea of size and direction. e.g. weight down equals E force up/towards positive plate/away from negative plate. Do not allow 'balanced' or 'in equilibrium' for equals The forces can be in the form of formulae for MP1 and MP2 (e.g. Eq, EV/d, mg)	2	AO1 1a AO2 1d

01.2	$m = 4\pi r^3\rho/3$ and $mg = 6\pi\eta rv$ seen✓ $r^2 = 18\eta v / 4\rho g$ is seen in in some form, in symbols or through substituted data,✓ Correct use of equations to obtain $r = 9.7 \times 10^{-7}$ m ✓	Do not allow backward calculaton Can be seen by substitution. Can be seen in single equation: $4\pi r^3\rho g/3 = 6\pi\eta rv$ Do not award if v and V confused Do not condone 1sf answer. Must be clear answer refers to r, not r^2 for example. If no other mark given MP1 can be awarded if F used for mg, and/or volume AND density equations seen separately	3	AO2 1h
01.3	The number of excess electrons on the droplet is 3 ✓ In order for each half to remain stationary, the charge would have to split equally OR Due to the quantisation of charge, the charge cannot split equally ✓ It is not possible for both droplets to remain stationary / the student is wrong ✓	May be seen in terms of values of charge or e Award for idea that charge would have to be 1.5e Evidence for MP1 and MP2 may be seen together. E.g. charge on drops are e and 2e, OR 1.6×10^{-19} and 3.2×10^{-19} Ignore reference to particles repelling each other	3	1 × AO3 2a 2 × AO3 2b

Total			**8**

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>ID details</th></tr>
<tr><td>02.1</td><td>Unchanged Changed</td><td></td><td>1</td><td>AO2 1a</td></tr>
<tr><td>02.2</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><th>Mark</th><th>Criteria</th><th>QWC</th></tr>
<tr><td>6</td><td>All 3 areas A B and C covered
Only allow minor omissions</td><td rowspan="2">The student presents relevant information coherently, employing structure, style and SP&G to render meaning clear. The text is legible.</td></tr>
<tr><td>5</td><td>2 complete descriptions with one partial from A, B and C</td></tr>
<tr><td>4</td><td>Full description of one area, with partial description of other two</td><td>The student presents relevant information and in a way which assists the communication of meaning.</td></tr>
</table>
</td><td>
The following statements are likely to be present.
Area A
Description of corpuscular explanation of refraction
i)Light is made up of particles/corpuscles
ii)Force acts attracting them to the water.
iii)Attraction only affects motion at the interface/boundary.
iv)Only one component of velocity / momentum (vertical) changes at the interface.
v)The (vertical component of) velocity / momentum increases which causes the change in direction.
Partial answers may be missing idea of Force (ii) or component AND boundary (iv)(iii)
</td><td>6</td><td>AO1 1a</td></tr>
</table>

		OR Full descriptions of two areas with very little on third or nothing at all	The text is legible. SP&G are sufficiently accurate not to obscure meaning.	**Area B** **Description of wave explanation of refraction** i)Wave front is incident on interface ii)Huygens secondary <u>wavelets</u> at wave fronts. iii)Wavelets travel more slowly in the water. iv)The slowing down of the waves / wavelets causes the change in direction. A partial answer may have no reference to <u>wavelets</u> **Area C** **Acceptance of wave theory** Discussion of speed: (Newton's theory required light to travel faster in the water. And Huygens' theory required light to move more slowly in the water.) When the speed of light was measured in water, the value found supported Huygens' prediction. Discussion of wave properties Light was observed to show interference		
	3	A full description of one area and a partial description of one area OR A partial discussion of all three areas				
	2	A full discussion of one area OR A partial discussion of two areas	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	Only one area covered, and that partially.				
	0					

		effects that cannot be explained using corpuscular theory.) Interference effects in Young's double slit experiment can be explained by Huygens' wave theory but not by Newton's corpuscular theory. A partial answer will refer to only one piece of evidence.		

02.3	(vibrations of) the electric wave/field and magnetic wave/field are: perpendicular to each other ✓ perpendicular to the labelled direction of motion ✓ in phase with each other ✓	Names of both waves needed for first mark But condone missing labels (E and B) on diagram if mentioned in text Condone single arrow unlabelled to represent direction of travel But Reward unlabelled arrow on axis only if no arrows on other axes Credit writing over poor diagram	3	3.12.1.3 AO1 1b
Total			**10**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
03.1	(All matter particles) have a wave-like nature/wave-like properties✓ (and an associated) wavelength/λ = $\frac{h}{\text{momentum of the particle}}$ ✓	Condone named particle e.g. electron Condone 'particles have a wavelength Condone mv for momentum Do not allow p unless defined (eg p=mv) Do not allow 'inversely proportional	2	AO1 1a
03.2	Use of de Broglie equation $\lambda = h / \sqrt{2meV}$ to give 0.021 nm ✓ (Comparison of calculated value of λ to given value) and consistent conclusion ✓	Allow reverse calculation to give **3800V** Allow 0.02 if substitution of 3500 V seen If no other mark given allow mp1 for substitution of 3500 into equation Allow ecf in MP2 only for POT error.	2	*AO2* *AO3*
03.3	First Change One statement ✓ Relevant explanation✓ Second Change One statement✓ Relevant explanation✓ Statement 1 Use target with greater spacing between atoms	Condone Statement: use particles of bigger mass (e.g. protons) smaller wavelength (at same speed) If no other marks are awarded, give 1 mark for stating that any one of the following could change but do not allow physics errors The target/spacing of atoms	Max 4	AO3 2b

	Explanation Larger separation gives rise to narrower fringes Statement 2 Increase the p.d. Explanation Reduces wavelength (which gives rise to narrower fringes) Statement 3 Decrease distance between foil and film Explanation for same angles, maxima closer together.	Potential difference Velocity of electrons Wavelength of electrons. Do not allow 'does not spread out as much'		

Total			**8**

Question	Answers	Additional Comments/Guidance	Mark	ID details
04.1	Calculation of constant of proportionality for at least two data sets ✓ Allow conversion to J Calculation of at least three data sets and conclusion to the effect that as the constants differ, the classical prediction is not true ✓	Alternative methods of calculation: Calculation of constant of proportionality and then using to calculate other E, v, v^2 and comparing with table. Checking ratio of $\frac{E_m}{E_n} \neq \frac{v_m^2}{v_n^2}$ 1 mark for any calculation that shows KE ≠ $1/2mv^2$ ✓ If more than 3 calculations shown, reward any three correct	2	AO2 1h AO3 1b

Question	Answers	Additional Comments/Guidance	Mark	ID details
04.2	v has upper limit as Ek increases✓ Explanation: As v increase mass increases✓ As v approaches c, mass approaches infinity/increase in mass significant✓ Near c, increases in Ek are due to increase in mass/Ek tends to infinity✓	For MP1 allow comment on their calculations from 4.1 e.g. Ek/v2 increases Do not reward references to 'constant increases' Treat 'exponentially' as neutral Condone energy/total energy for Ek	4	AO3 1b
04.3	$E_0 = m_0c^2 = 8.2 \times 10^{-14}$ J $E = \frac{m_0c^2}{\left(1-\frac{v^2}{c^2}\right)^{\frac{1}{2}}} = 2.6 \times 10^{-13}$ J ✓ E_k (= $E - E_0$) = $2.6 \times 10^{-13} - 8.2 \times 10^{-14}$ ✓ 1.8×10^{-13} J ✓	If no marks are scored 1 mark can be given for *seeing* 8.2×10^{-14} J Allow ecf from MP1 for incorrect m_o eg use of proton Give all 3 marks for correct answer	3	2 × AO1 1a 1 × AO2 1c
Total			**9**	