A-LEVEL
Physics
7408/3BD

PAPER 3 SECTION B – Turning points in physics

Mark scheme

June 2017

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 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 weber/metre^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/Guidelines	Mark
01.1	Cathode rays/electrons move from cathode toward anode The paddle wheel has gained energy from cathode rays/electrons. ✓	Accept move left to right. Accept as alternatives for energy kinetic, energy/momentum/impulse ✓ Ignore references to force. Ignore references to applying a magnetic field.	1 1
01.2	Electrons are pulled out/escape from atoms OR gas atoms are ionised ✓ (Positive ions generated near the cathode are attracted to the cathode causing free) electrons emitted from the cathode.✓ Electrons are accelerated toward the anode (by the potential difference) ✓	Condone molecules as alternative to atoms. Do not accept attraction as an alternative to acceleration.	1 1 1
01.3	Reason: Idea of fewer electrons/cathode rays ✓ Effect: Paddle wheel rotates less ✓ ***OR*** Reason: Idea of electrons/cathode rays have higher energy/speed/momentum ✓ Effect: Paddle wheel rotates more ✓	Must score the reason mark to score the effect mark. Ignore references to air resistance. If no mark is awarded, one mark can be awarded for the effect of the paddle wheel rotating more where the reasoning is limited to less collisions of electrons with air molecules.	2
Total			**7**

Question	Answers	Additional Comments/Guidelines	Mark
02.1	Observation A – When rotation speed is low the light returns through the original gap. ✓ Observation B – The light is blocked when it hits an adjacent tooth on return from the mirror. ✓	Condone an answer where candidate has substituted tooth for gap throughout.	1 1
02.2	$c = 4 \times 8600 \times 720 \times 12 = 2.97 \times 10^8\ ms^{-1}$ ✓ Comparison to speed of light $3.0 \times 10^8\ ms^{-1}$ and judgement that they are similar. ✓	Speed of light must be given to 2 or 3 significant figures.	1 1
02.3	Must go past a gap and to the next tooth ✓ 36 rotations per second / Hz ✓	Accept a clear diagram as an alternative	2
02.4	Maxwell's theory of electromagnetic waves predicted a value for the speed of electromagnetic waves ✓ Fizeau's result is close to the predicted speed (of electromagnetic waves) ✓ Implies that light is an electromagnetic wave. ✓		3
Total			**9**

Question	Answers	Additional Comments/Guidelines	Mark
03.1	<table><tr><th></th><th>Tick (✓) if correct</th></tr><tr><td>Beta particle emission</td><td></td></tr><tr><td>Electron diffraction</td><td></td></tr><tr><td>Photoelectric effect</td><td></td></tr><tr><td>Thermionic emission</td><td>✓</td></tr></table>		1
03.2	Use of $\lambda = \frac{h}{\sqrt{(2mE)}}$ seen including correct substitution λ = 2.4 x 10^{-11} (m) Statement to the effect that this is similar to or less than 0.1 nm/atomic dimension/diameter of the atom (so individual atoms can be resolved).	Condone missing unit Allow a correct conclusion that follows from an incorrect value of λ	1 1 1

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr><td>03.3</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>QoWC</th></tr>
<tr><td>6</td><td>At least six of the likely statements will be covered to a good standard including at least three from image formation and at least three from quality and detail.</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>At least five of the likely statements will be covered to a good standard including at least two from image formation and at least one from quality and detail.</td></tr>
<tr><td>4</td><td>At least three of the likely statements will be covered to a good standard. The response must include one of both image formation and factors affecting quality and detail.</td><td rowspan="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.</td></tr>
<tr><td>3</td><td>At least two of the likely statements will be covered to a good standard. The response must include one of both image formation and factors affecting quality and detail.</td></tr>
<tr><td>2</td><td>At least two of the likely statements</td><td>The student presents</td></tr>
</table>

</td><td>

The following statements are likely to be present.

<u>Process of Image formation</u>

- Electrons through the middle of the lenses are undeviated
- Electrons on the edges are deflected by magnetic fields toward the axis of the TEM
- The condenser lens deflects the electrons into a wide parallel beam incident uniformly on the sample.
- The objective lens then forms an image of the sample.
- The projector lens then casts a second image onto the fluorescent screen.

<u>Factors affecting the quality and level of detail</u>

- Wavelength depends on speed of the electrons
- Lower the wavelength gives greater the detail.
- Emitted electrons come from a heated cathode and therefore have a speed distribution dependent on temperature.
- The speed of the electrons is not always the same which causes different pathways through the lens and so aberration.
- The sample thickness reduces the speed of the electrons increasing the wavelength and decreasing the detail.

</td><td>6</td></tr>
</table>

		from image formation or quality and level of detail will be covered to a good standard. The other area (if covered) will have errors and omissions.	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	One of the likely statements will be covered to a good standard.				
	0	No relevant coverage of the likely statements.	The student's presentation, SP&G seriously obstruct understanding.			

Total			**10**

Question	Answers	Additional Comments/Guidelines	Mark
04.1	(for Proper time, t_0 = 31,536,000 s / 365 days) Dilated time, t = 31,561,259 s ✓ Time dilation is 25,259 s / 421 minutes / 7.0 hours / 0.29 days ✓ The recorded time will be longer (as predicted) ✓ The recorded time will be less than several days longer (as predicted) ✓	Accept answers in other units (e.g. 365.3 days) Accept an answer of 31582876 seconds / 365.5 days where a proper time of 365.25 days has been used.	4
04.2	Theory of Special Relativity requires no acceleration ✓ (The spacecraft/frame of reference is) accelerating ✓ Alternative answer: Theory of Special Relativity requires inertial reference frame ✓ (The spacecraft/frame of reference is) not an inertial reference frame ✓	Accept change in direction / speed / velocity as alternatives for accelerating.	2
Total			**6**

Question	Answers	Additional Comments/Guidelines	Mark
05	Conversion of 3.7 x 10^{9} eV to 5.9 x 10^{-10} J✓ Correct use of $$E = m c^2 = \frac{m_0 c^2}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}}$$ including correct substitution ✓ 0.97(c) ✓	Accept substitution of 3.7 x 10^{9} x 1.6 x 10^{-19}	3
Total			**3**