# A-LEVEL
# PHYSICS
# 7408/3BE

Paper 3 Section B Electronics

**Mark scheme**

June 2019

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

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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.

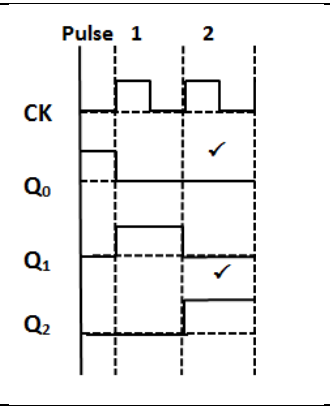
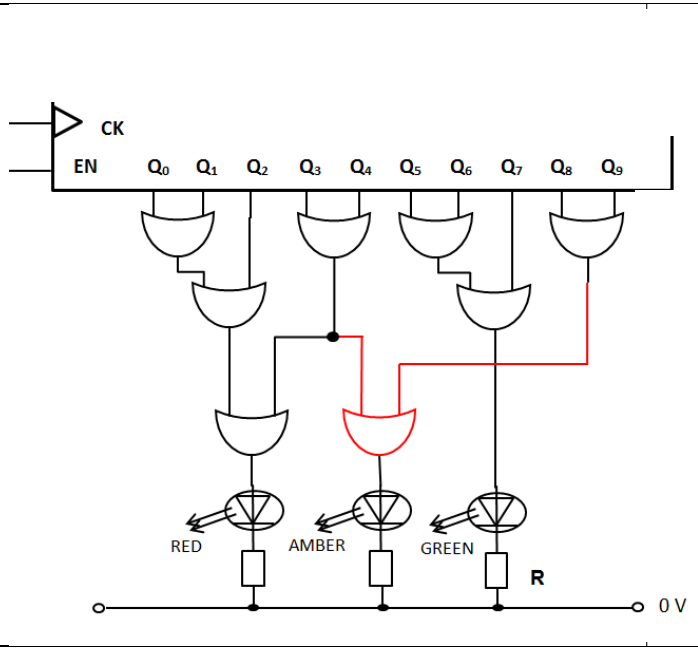
When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level. 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 | ID details |
|---|---|---|---|---|
| 01.1 |  | Flat line of $Q_0$ - 1 mark<br><br>Correct fall of $Q_1$ and rise of $Q_2$ - 1 mark | 2 | AO2 1c |
| 01.2 |  | Logic OR gate correctly connected in position for 1 mark | 1 | AO3 2a |

| Question | Answers | Additional Comments/Guidance | Mark | ID details |
|---|---|---|---|---|
| 01.3 | The ON time for the green LED is determined by:<br><br>the frequency of the clock ✓<br><br>the number of adjacent outputs that are OR'ed ✓ | Accept reference to the period of the clock pulse. | 2 | AO2 1c |
| 01.4 | $\mathbf{R} = V_R / I$ ; $\mathbf{R} = (9 - 2.1)$ V ✓ / 9 mA<br><br>$\mathbf{R} = 6.9$ V / 9 mA ; $\mathbf{R} = 767\ \Omega$ ✓<br><br>Minimum resistor value that can be used in order not to exceed 9 mA is 767 Ω.<br>The 720 Ω resistor range is (684 to 756) Ω and falls below this value so should not be used. ✓<br><br>OR<br><br>Calculation using 720 Ω ±5% Resistor range = (684 to 756) Ω ✓ leading to smallest current of 9.1 mA ✓<br>This current will exceed the permitted value of 9 mA. Don't use. ✓ | 1One mark for voltage across the resistor<br>2One mark for a suitable I-V-R calculation<br>3One mark for conclusion with reason.<br><br>Use of error range to give max resistance must be seen in either 2 or 3 for that mark to be awarded. | 3 | AO3 1a<br><br>AO3 1b |
| **Total** | | | **8** | |

| Question | Answers | Additional Comments/Guidance | Mark | ID details |
|---|---|---|---|---|
| 02.1 | difference amplifier ✓ | | 1 | AO1 1a |
| 02.2 | $V_{out} = (V_+ - V_-) \times (R_f / R_{in})$<br>$V_{out} = (0\ V - 150\ mV) \times (1\ M\Omega / 100\ k\Omega)$ ✓<br>$V_{out} = -1.5\ V$ ✓ | 1 mark for the correct resistor substitution / resistor ratio $(10)$<br>1 mark for $-1.5\ V$ (must have correct sign) | 2 | AO1 1b |
| 02.3 | Signal 2 is subtracted from signal 1 by the difference amplifier ✓<br>Noise is common to both so will be reduced / eliminated when subtracted ✓<br>Signals will also be subtracted resulting in an addition (re-enforcement) of the signal. ✓ | Accept arguments based on the 'phase' relationship | 3 | AO2 1c |
| **Total** | | | **6** | |

| Question | Answers | Additional Comments/Guidance | Mark | ID details |
|---|---|---|---|---|
| 03.1 | **With the north pole facing the sensor:**<br>Higher sensitivity/larger gradient ✓ over very short range ✓<br>Some ambiguity in liquid level due to peak in graph – (more than one level referenced to a single output reading) ✓<br><br>OR<br><br>**With the south pole facing the sensor:**<br>Less sensitivity/smaller gradient ✓ but covers a larger range ✓<br>No ambiguity in liquid level – (each level produces a discrete output up to saturation) ✓ | Mark awarded for each compared point | 3 | 3 × AO3 1a |
| 03.2 | 2.4 divisions @ 5 ms / div = 12 ms<br><br>Periodic time $T$ = 12 ms × 3 = 36 ms ✓<br>Or<br>7.2 divisions @ 5 ms / div = 36 ms<br><br>$f$ = 1 / $T$ ; $f$ = 1 / 36 ms ; 27.8 rev / sec ✓<br><br>27 full revolutions in one second ✓ | One mark for appropriate reading from graph to produce periodic time (T).<br><br>One mark for frequency using their (T).<br><br>One mark for rounding down | 3 | AO2 1d |
| **Total** | | | **6** | |

| Question | Answers | Additional Comments/Guidance | Mark | ID details |
|---|---|---|---|---|
| 04.1 | +ve knee develops at 0.7 V and does not exceed 1.5 V at 30 mA ✓<br>–ve knee develops at 5.1 V; 5 mA with near vertical drop.<br>Does not exceed – 5.5 V at –30 mA ✓ | | 2 | AO1 1a |
| 04.2 | Zener diode provides a reference voltage for non-inverting input ✓<br>Or<br>Zener diode provides a stabilised voltage for non-inverting input ✓ | Accept combination of the two statements | 1 | AO2 1c |
| 04.3 | $\mathbf{I = V/R}$ = 3.9 V / 100 Ω = 39 mA<br>This is larger than the minimum current to make Zener diode work so the resistor value is fine. ✓<br>$\mathbf{P = I^2 R} = (39 \times 10^{-3})^2 \times 100$ = 0.152 watts<br>This is greater than the power rating for the resistor, so is not a suitable power rating for the resistor ✓ | Ecf form value of **I** | 2 | AO2 1e |
| 04.4 | The reference voltage at the non-inverting input is now smaller ✓<br>This will cause the output **W** to switch at a lower light intensity than before ✓ | | 2 | AO1 1a |

| Question | Answers | Additional Comments/Guidance | Mark | ID details |
|---|---|---|---|---|
| 04.5 | $Q = (\overline{X + Y}) . W$ ✓ | Accept transformations eg:<br>$Q = \overline{X} . (Y + \overline{W})$<br>$Q = \overline{X} . \overline{Y} . W$ | 1 | AO2 1b |
| 04.6 | MOSFET has large input impedance<br>OR<br>MOSFET causes no loading of the logic gate output. ✓ | | 1 | AO1 1a |
| **Total** | | | **9** | |

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>ID details</th></tr>
<tr>
<td>05</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>Level</th><th>Criteria</th></tr>
<tr><td>L3<br><br>6 marks</td><td>The candidate shows a good knowledge of PCM, TDM and the process of noise reduction using regenerators in this context.<br>They use the technical terms correctly, the answer has structure and clearly conveys the information required by the question.<br>The candidate may show a depth of understanding that goes beyond basic recall.</td></tr>
<tr><td>L3<br><br>5 marks</td><td>The candidate shows a good knowledge of PCM, TDM and the process of noise reduction using regenerators in this context.<br>However, there may be minor gaps in knowledge / detail OR the style and structure may lead to a lack of clarity in some of the information being presented.</td></tr>
</table>
</td>
<td>
PCM<br><br>
PCM – the analog signal is sampled and then quantised, converting it into a serial n-bit binary code for transmission.<br>
The sampling, which should be done at twice the max frequency contained within the signal and quantisation are responsible for the bit rate which will determine the bandwidth needed for transmission.<br><br>
TDM<br><br>
Without TDM, the 15 channels of speech would each need their own cable to create an independent link as the total bandwidth would exceed that of the link.<br><br>
With TDM, the system allocates time slots so that data blocks of code from each speech channel can be transmitted in sequence (multiplexed) across a single link. The full bandwidth of the link is available to each channel.
</td>
<td>6</td>
<td>3 × AO1 1a<br><br>3 × AO3 1b</td>
</tr>
</table>

| Question | Answers | | Additional Comments/Guidance | Mark | ID details |
|---|---|---|---|---|---|
| | **4 marks** | The candidate will show a good understanding of **two** of the processes / subsystems in bold in this context.<br>Technical terms will be used correctly and the information will generally be presented in a structured and coherent manner | **Regenerators**<br><br>**Regenerators** work by using a **switching** circuit (**Schmitt trigger**) which has two different **switching thresholds**. This will usually take out most of the noise sitting on the signal. | | |
| | **3 marks** | The candidate will show a good basic understanding of **two** of the processes / subsystems in bold.<br>However, there may be minor gaps in knowledge / detail OR the style and structure may lead to a lack of clarity in some of the information being presented. | | | |
| | **2 marks** | The candidate will show a superficial understanding of **two** of the processes / subsystems in bold. Overall, this will be a limited answer with significant detail missing. The material may lack clarity / organisation. | | | |
| | **1 mark** | The candidate will show a superficial understanding of **one** of the processes / subsystems in bold. Overall this will be a limited answer. The material may lack clarity / organisation. | | | |
| | **0 marks** | The work contains no significant analysis of any of the techniques / subsystems in bold. | | | |
| **Total** | | | | **6** | |