AQA

A-level
PHYSICS
7408/3BE

Paper 3 Section B Electronics

Mark scheme

June 2023

Version: 1.0 Final

236A7408/3BE/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

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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.

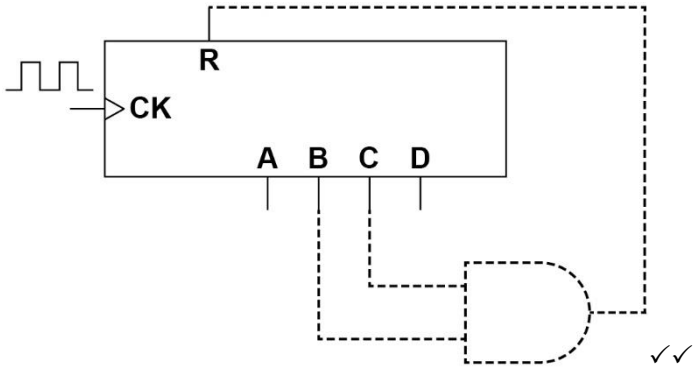
When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use 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.

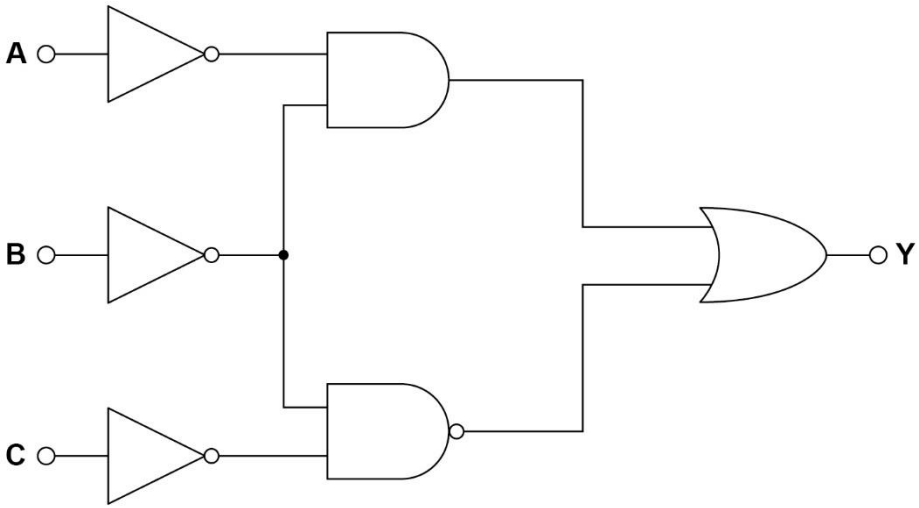
Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Answers	Additional comments/Guidelines	Mark	AO
01.1	 ✓✓	1 mark for use of the correct counter outputs 1 mark for the correct logic gate connected to reset **R**	2	1× AO2 1 x AO3

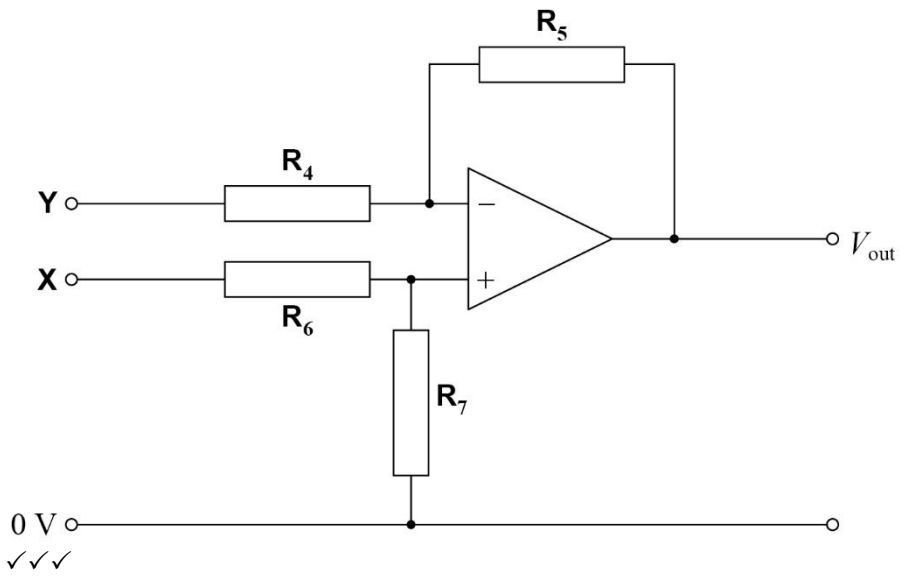
Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	input **C** segment **b** ✓	Both input and segment needed for the mark Do not allow **B** for **b**	1	1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	**f** ✓	Allow **F** for **f**	1	1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	 ✓✓✓	**MP1**: all inputs inverted (accept a shorted-out NAND or NOR gates for the inverters) **MP2:** for correct use of AND and NAND Condone a NOT following an AND for the NAND gate. **MP3:** for final gate being OR	3	3 × AO3
Total			**7**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Method indicated for calculation of potential at **X** ✓ Correct calculation to give voltage at **X** $= 5.00(125)$ V ✓ Reading = their value for potential at **X** – 5 V ✓	**MP1**: expect to see use of potential divider formula / other method (e.g V=IR) explained **MP2**: Correct calculation for potential at **X** **MP3**: Expect to see 1.25 mV Allow 1.2 mV or 1.3 mV to 2 sf.	3	1× AO2 2 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	A resistor (used instead of strain gauge **B)** would not have same response to temperature changes as strain gauge **A** **OR** Using strain gauge **B** will have same response to temperature as strain gauge **A** ✓ By using two strain gauges the (voltmeter) reading will only be affected by changes in strain (as temperature effects will cancel) OR use of a resistor will cause the (voltmeter) reading to change due to strain and temperature changes ✓	Do not allow just the phrase: 'for temperature compensation'	2	2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	 ✓✓✓	**MP1:** for correct configuration Condone incorrect op amp terminal signs in **MP1**. **MP2:** for **X** and **Y** leading to correct op amp terminals. **MP3:** for $R_5/R_4 = R_7/R_6 = 5$ Do not award **MP3** if any resistance value is outside the range $(10\ \text{k}\Omega–10\ \text{M}\Omega)$	3	1× AO1 1× AO2 1× AO3
Total			**8**	

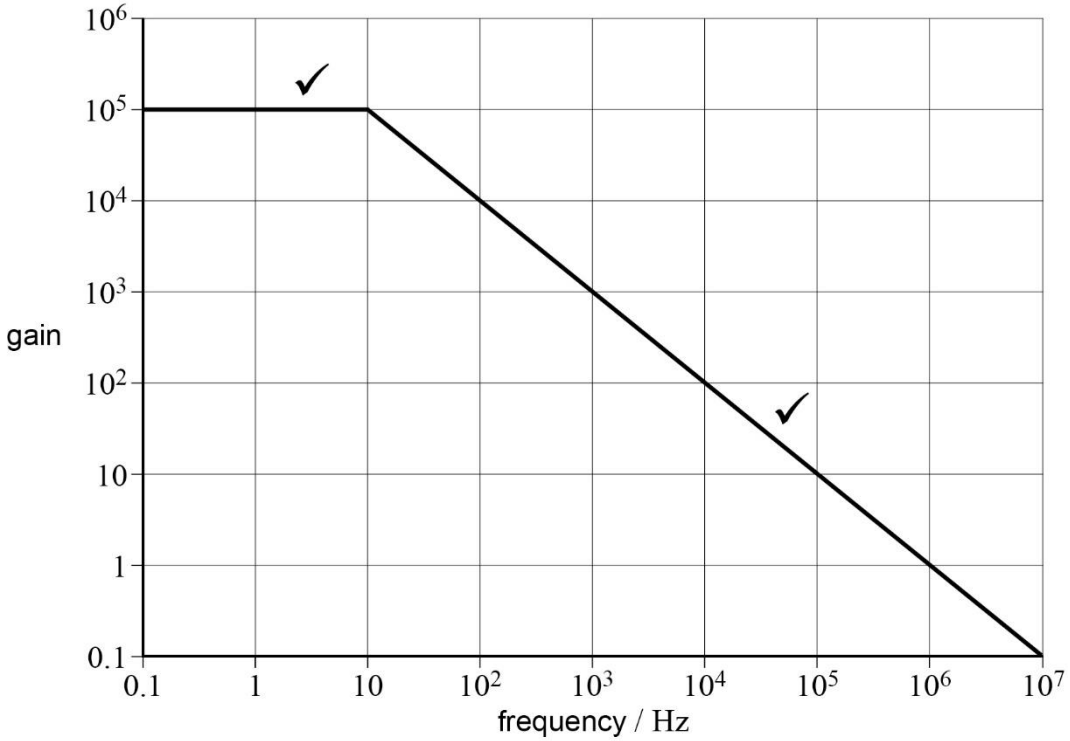
Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	modulator amplifier receiver demodulator ✓		1	1× AO1

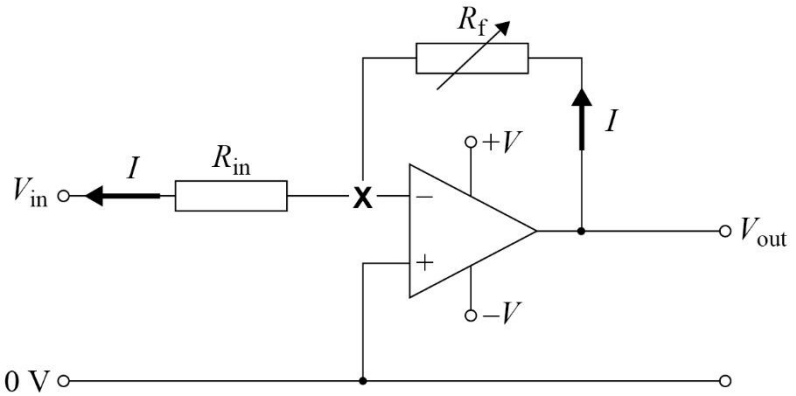
Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	The up-link and down-link frequencies were made different. ✓		1	1× AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Evidence of travel time calculation using: distance travelled in single/return journey ÷ speed of e-m wave (in free space) ✓ Processing time = time delay – travel time ✓	Single journey time $= 80 \times 10^6$ m ÷ 3×10^8 m s^{-1} = 267 ms OR Return journey time $= 160 \times 10^6$ m ÷3×10^8 m s^{-1} = 533 ms (accept 534 ms) Do not allow use of 40×10^6 m Must be a round-trip calculation for second mark. E.g. Processing time = 900 ms – 533 ms = 367 ms Accept their **return** journey travel time as ecf in MP2	2	2× AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	**USA** - Geostationary satellite provides permanent link ✓ **UK** – idea that the satellite is in communication with UK and USA (only) for (short) periods of time. ✓	Accept reference to additional time delay for live events in UK due to extra distance travelled by e-m wave.	2	1× AO1 1× AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.5	any two from ✓✓ • more secure - need to break into the cable to read data in transition. • continuous communication as link is always connected. • larger bandwidth. • reduced time delay between signal transmission and reception due to shorter distance travelled (even allowing for slower signal speed in cable). • reduced interference - e-m noise will not interfere with optical transmission.	Allow other correct answers.	2	1× AO1 1× AO2
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1		**MP1:** Flat top at gain = 10^5 from 0.1–10 Hz Accept either sharp or rounded break frequency roll-off **MP2:** Slope from end of flat down through unity gain and 10^6 Hz Do not penalise if line not taken beyond unity gain and 10^6 Hz	2	1× AO1.1b 1× AO2.1d

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2		**MP1**: for placing **X on a wire** somewhere between R_{in} and R_f and the inverting input. **MP2:** for showing I in the correct direction through both R_f and R_{in}	2	1× AO1 1× AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	(Since the gain of the amplifier in this mode is $\frac{-R_f}{R_{in}}$) (As R_f increases) the (closed loop voltage) gain increases ✓ (As gain increases then) bandwidth decreases ✓	If no other mark given, allow 1 mark for decrease in gain giving increase in bandwidth	2	1× AO2 1× AO3

Total			6

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</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
6
marks</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>L3
5
marks</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>L2
4
marks</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>L2
3
marks</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>
</table>
</td>
<td>
The following information is likely to appear in the answer statements.

Component A - Zener diode
Role in circuit
• Used to provide a reference voltage for component B.
• Reference voltage set at a value below the noise level / to exclude the noise on the signal.

Useful characteristic properties
• Used in reverse bias mode.
• Produces a fixed reverse breakdown voltage.

Component B - operational amplifier
Role in circuit
• Used as a comparator.
• Output will saturate high when the input signal is larger than the reference voltage (V+ > V-).
• Output will drop to zero volts when the signal voltage is below the level of the reference voltage (V+ < V-).

Useful characteristic properties
• Very high open loop gain which provides saturation for very small voltage difference at the inputs.
• Very high input resistance - negligible load on input signals.
• Produces a clean switching pulse at the output when signal voltage transits the reference voltage.
</td>
<td>6</td>
<td>2× AO1.1a

2× AO1.1b

1× AO2.1a

1× AO3.1b</td>
</tr>
</table>

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr><td>05</td><td>
<table>
<tr><th>Level</th><th>Criteria</th></tr>
<tr><td>L1
2
marks</td><td>Only one area discussed or makes a partial attempt at two areas.</td></tr>
<tr><td>L1
1
mark</td><td>None of the three areas covered without significant error. Response is likely to show weakness in technical detail.</td></tr>
<tr><td>L1
0
marks</td><td>No relevant analysis.</td></tr>
</table>
</td><td>Component C - MOSFET
Role in circuit
• Acts as a voltage-controlled switch.

Useful characteristic properties
• The MOSFET is a voltage-controlled device.
• Has a very high input resistance to interface with comparator (draws negligible current from the comparator).
• Low drain-source resistance when ON leads to very little power dissipated in the MOSFET.
• Can be considered as a current amplifier</td><td></td><td></td></tr>
<tr><td>Total</td><td></td><td></td><td>6</td><td></td></tr>
</table>