A-LEVEL
PHYSICS
7408/3BE

Paper 3 Section B Electronics

Mark scheme

June 2022

Version: 1.0 Final

226A7408/3BE/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.

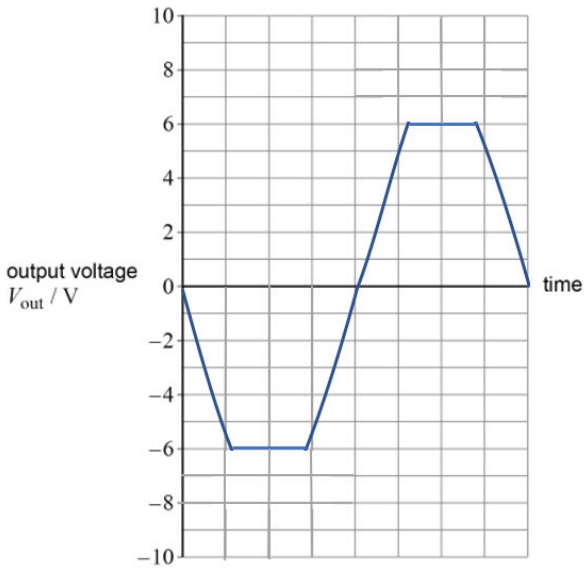
You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

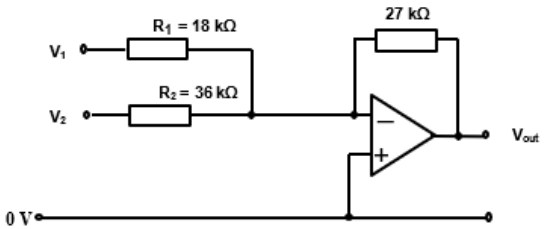
Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme.

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

Question	Answers	Additional comments/Guidelines	Mark	AO
01.1	Label the virtual earth point eg X, **on** the junction between the two resistors ✓	Allow the centre of the 'X' to be placed **on** any of the three lines leading to the op amp inverting input junction. Do not allow an 'X' in space unless accompanied by unambiguous arrow.	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Set up equation for $I = V_{in} / R_{in} = - V_{out} / R_f$ then rearrange ✓ Reason to support setting up of equation ✓	Second mark given only if reason provided for one of: I through $R_{in} = I$ through R_f (Infinite input impedance) –ve sign (Virtual earth point used)	2	2 x AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	Inverted sine wave of same period as signal shown in Fig 2A ✓ Attempt to use a gain of 20 and show a Cut-off/plateau at ± 6 V ✓		2	2 x AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	1 mark for correct connection of resistor R_1 and R_2 ✓ 1 mark for correct values of R_1 and R_2 ✓ 1 mark for values correct way round – referenced to V_1 and V_2 ✓		3	1 x AO1 1 x AO2 1 x AO3

Total			8

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	$\bar{A}$ ✓ **.** B ✓ $\bar{\boldsymbol{A}}$ **. B**	Do not allow $\overline{\boldsymbol{A}+\bar{\boldsymbol{B}}}$	2	1 x AO1 1 x AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	EOR ✓	Accept: XOR ; EXOR; Exclusive OR gate	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3			2	2 x AO2

B	A	C	D	E	X	Y	Z
0	0	1	1	0	**0**	**1**	**0**
0	1	0	1	1	**0**	**0**	**1**
1	0	1	0	1	**1**	**0**	**0**
1	1	0	0	0	**0**	**1**	**0**

X and **Z** correct ✓

Y correct ✓

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	NOR gate ✓	Also accept any of: EXNOR; ENOR; XNOR; Exclusive NOR gate	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.5	**X** **Y** **Z** A = B | A < B | A > B | ☐ A < B | A = B | A > B | ✓ A < B | A > B | A = B | ☐ A > B | A = B | A < B | ☐		1	AO2
Total			**7**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	$(f = 1 / T \ ; f = 1 / 5\ \mu s)$ 200 ✓ (kHz)		1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Measurement from the graph of the half wavelength of signal $T = 2 \times 42\ \mu s$ ✓ Calculation of frequency $(f = 1 / T)$ using their T 11.9 kHz (± 0.6 kHz) ✓	First mark for factor 2 in calculation Allow range $2 \times (40 – 44)\ \mu s$ Second mark – allow ecf only if their T is clearly derived form analysis of the graph	2	1 x AO3 1 x AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Any one from: ✓ • Immune to any noise in amplitude. (since information stored in the frequency variation) • Quality of an FM signal remains high even when the transmitter power is low. (since most of power is in sidebands / information). • Carries more information (since the FM bandwidth is much wider than that of AM)	Max 1 mark	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	=100 stations ✓	$\frac{(108\ \text{MHz} - 88\ \text{MHz})}{200\ \text{kHz}}$	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.5	Bandwidth = $2(\Delta f + f_m) = 2 \times (75\ \text{kHz} + 15\ \text{kHz}) = 180\ \text{kHz}$ ✓ This fits in allocated $200\ \text{kHz}$ band ✓	Second mark – allow ecf if conclusion is consistent with their calc.	2	1 x AO1 1 x AO3

Total			7

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	• When V_c reaches a value of V_U, the output voltage V_{out} drops LOW. ✓ • The capacitor now discharges through the resistor causing the value of V_c to fall. ✓ • When V_c reaches a value of V_L, the output voltage V_{out} jumps HIGH. ✓		3	3 x AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	**Mark-to-space ratio** R_B gets smaller and hence (t_H) is reduced OR R_A gets bigger and hence (t_L) is increased ✓ Hence mark:space ratio is reduced / smaller ✓ **PRF** = $\frac{1}{T} = \frac{1}{(t_H + t_L)} = \frac{1}{0.7C\,(2R+R_A+R_B)}$ The total resistance $(2R + R_A + R_B)$ is constant ✓ As a result of a constant resistance in the circuit, PRF does not change ✓	First mark: Either statement or equivalent labelled diagram(s). Second mark: Conclusion First mark: explanation of how total resistance in the circuit affects the periodic time. Second mark: Conclusion	4	4 x AO3

Total			7

<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>The candidate shows a good understanding of the way both systems operate.
They propose a valid and reasoned solution for both Island B and Oil rig C.

They use technical terms correctly; the answer has structure and clearly conveys the information required.</td></tr>
<tr><td>L3
5
marks</td><td>The candidate shows a good understanding of the way both systems operate.
They propose a valid and reasoned solution for both Island B and Oil rig C.

However, there may be minor gaps in knowledge OR the style / structure may lead to a lack of clarity in some of the information being presented.</td></tr>
<tr><td>L2
4
marks</td><td>The candidate shows a general understanding of the material but one of the systems or supported solutions will be treated superficially.

Structure and technical language used is generally good.</td></tr>
</table>
</td>
<td>Supporting points that may be made.

General system operation:

a)
Fibre optic cable
• Digital data placed on transmission line using high power IR diode.
• The light ray travels by TIR through the fibre.
• Opto / Electronic repeater / regenerators used - (more recently only opto amplifiers required).
• Data received by a photodiode – converts opto data to electrical.

b)
Satellite
• Typical frequency 12 to 18 GHz
• Digital data sent through free space using a high directional/focused microwave dish (uplink).
• Microwaves used to penetrate atmosphere.
• Satellite likely to be in geostationary orbit.
• Satellite receives data and re-transmits on a different microwave frequency.
• Same dish or dish in another location receives the information (down link).</td>
<td>6</td>
<td>4 × AO1

2× AO3</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>L2
3
marks</td><td>The candidate shows a general understanding of the material but one of the systems or supported solutions will be treated superficially.

There may be some lack of clarity either through the structure or in use of technical terms.</td></tr>
<tr><td>L1
2
marks</td><td>The candidate shows a basic understanding of the way one system operates.
They propose a supported valid solution for either Island B or Oil rig C.

There may be some lack of clarity in structure, but there is good use of technical terms.</td></tr>
<tr><td>L1
1 mark</td><td>The candidate shows a basic understanding of the way one system operates.
They propose an unsupported but valid solution for either Island B or Oil rig C.

There may be some lack of clarity either through the structure or in use of technical terms.</td></tr>
<tr><td>L1
0
marks</td><td>The work contains no significant analysis of the question asked.</td></tr>
</table>
</td><td>Proposed solution:
Island B
Initial phase – use of satellite link
• Quick and easy to set up mobile sat unit(s).
• Initial usage and platform range likely to be low, hence lower bandwidth / data rates not an issue.
• Some difficulties with two-way conversations due to signal delay.
• Higher maintenance costs and possible interference problems due to EM noise and security issues.
Later phase – install submarine cable
• More forward planning / expense needed to put this in – cable ship / terminations / internal network
Heavier usage as development proceeds and wider platform support – hence more bandwidth / larger data rate required.
• More reliable link
• Low security issues and immune to EM interference.
Oil rig C
Satellite link
• Fibre optic cable not an option due to mobile nature of the rig.
• Satellite link is a low-cost short-term solution.
• Light use and limited platform requirement so reduced bandwidth / lower data rate not critical.
• Some difficulties with two-way conversations due to signal delay.
• Reliability issues.</td><td></td><td></td></tr>
<tr><td>Total</td><td></td><td></td><td>6</td><td></td></tr>
</table>