AQA

A-level
PHYSICS
7408/3BE

Paper 3 Section B Electronics

Mark scheme

June 2021

Version: 1.0 Final

216A7408/3BE/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

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.

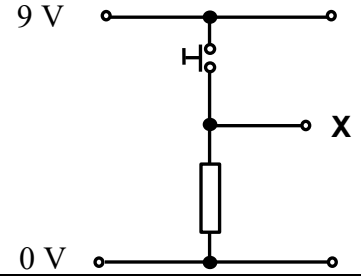
Question	Answers	Additional comments/Guidelines	Mark	AO
01.1	Silicon dioxide layer ✓	Accept Silicon dioxide	1	AO1 1a

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	drain ☐ gate ☐ source ☑		1	AO1 1a

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	For lamp $P = I^2 R$ $I = \sqrt{(P/R)} = \sqrt{(0.65\ \text{W} / 154\ \Omega)} = 65\ \text{mA}$ ✓1 This leads to a voltage across the lamp of approx $10\ \text{V}$ and a V_{DS} of approx $2\ \text{V}$ Read from graph to give $V_{GS} = 3.4\ \text{V}$ ✓2	Must use $P = I^2 R$ Accept a V_{GS} range of $3.3\ \text{V}$ to $3.5\ \text{V}$	2	AO2 1b AO3 1b

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	Current consumption on stand-by: $8.5 \times 10^9 \times 10 \times 10^{-9} = 85$ A ✓1	Makes a meaningful calculation (one which can lead to a conclusion) using data for the CPU.	3	AO2 1b AO2 1b AO3 1a
	Battery life: $3600\ \text{C} \times 3.110 = 1.12 \times 10^4\ \text{C}$ ✓2	Makes a meaningful calculation (one which can lead to a conclusion) using data for battery.		
	Use $1.12 \times 10^4 = 85 \times t$ Gives $t = 131.8$ seconds (accept 132 seconds OR just over 2 mins) which is much less than 12 hours ✓3	Uses the value of t to reach a valid conclusion OR Uses the values of the currents from the CPU and battery to reach a valid conclusion		
Total			**7**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	<table><tr><th colspan="3">Inputs</th><th>Output</th></tr><tr><th>C</th><th>B</th><th>A</th><th>Q</th></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>0</td><td>1</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>1</td><td>1</td></tr></table>	All Q **states** correct for 1 mark	1	AO3 1a

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2		Correct orientation for resistor & switch ✓ Correct tap-off point for **X** ✓	2	AO3 2a AO3 2a

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	$Q = \overline{(C \,.\, A) + (C \,.\, B)}$ Two correct brackets ✓ + with full bar ✓	Allow for 1 mark: $Q = \overline{C \,.\, (A + B)}$	2	AO2 1b AO2 1b

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	The gate acts as an inverter ✓	Accept 'NOT' as the function	1	AO1 1a

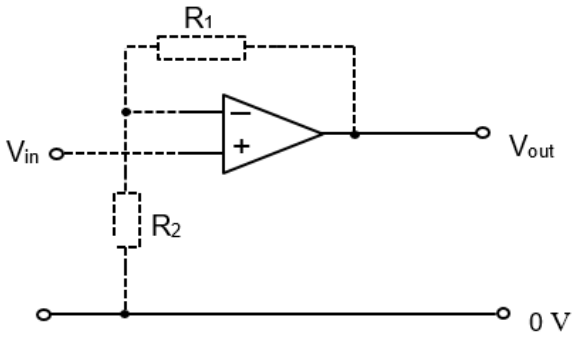
Question	Answers	Additional comments/Guidelines	Mark	AO
02.5	Must be a reason and a consequence for the mark. ✓	eg Uses only one type of logic gate so need to hold less stock OR Uses only one chip rather than two so circuit board can be smaller / less power needed / cheaper Do not allow: Less complex circuit	1	AO2 1c

Total			**7**

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Photoconductive mode	Accept 'reverse bias'	1	AO1 1a

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Dark currents will become a source of noise – need to keep S:N as high as possible OWTTE OR Need to have a large difference in signal when detector is in light and dark ✓	Must include idea of 'noise' OR Must include concept of large signal change to represent digital signal	1	AO2 1c

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	At 850 nm, $R_\lambda = 0.50$ A/W ✓	Reading from graph Allow 0.49 A/W to 0.51 A/W	3	AO3 1b
	Using $R_\lambda = \frac{I_p}{P}$ $I_p = R_\lambda \times P$ $0.50 \times 4 \times 10^{-6} = 2\ \mu A$ ✓ ecf			AO3 1b
	$V_{out} = I_p \times R$ $2\ \mu A \times 560\ k\Omega = +1.12$ V ✓	Accept voltage in range of 1.10 V to 1.14 V Accept value without + sign		AO3 1b

Question	Answers	Additional comments/Guidelines	Mark	AO
03.4		Correct configuration of R_1 and R_2 ✓ $R_1 : R_2$ ratio $3 : 1$ in suggested range ✓ Label the input point which must have a direct connection to the non-inverting input ✓ One mark only An inverting op amp configuration with a voltage gain –4.	3	AO1 1a AO2 1d AO1 1a
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	**Difference:** BCD counter outputs binary codes. A Johnson decade counter outputs a single output sequentially✓ **Similarity:** Both counters recycle at the 10^{th} pulse ✓	Both outputs described. Condone – max counter value for 10^{th} pulse. Accept: both counters count from 0–9 OR both counters count to 10	2	AO1 1a AO1 1a

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Duty cycle: From oscilloscope $t_{on} = 3$ div @ $50\ \mu s$ / div $= 150\ \mu s$ OR $t_{off} = 2$ div @ $50\ \mu s$ / div $= 100\ \mu s$ ✓ $\frac{t_{on}}{(t_{on} + t_{off})} \times 100 = 60\%$ OR 0.6 ✓ (accept 'divisions' to signify the values of t_{on} and t_{off}) Frequency: From CRO $t_p = 5$ div @ $50\ \mu s$ / div $t_p = 250\ \mu s$ $f = 1/t_p = 4$ kHz ✓	Only 1 mark for: either of t_{on} or t_{off} correct but duty cycle wrong OR correct use of both wrong t_{on} and t_{off} One mark for: correct use of their $t_{on} + t_{off}$	3	 AO2 1h AO2 1h AO3 1b

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	**BCD:** $Q_2 = 600 / 10 = 60$ Hz ✓ (only one pulse is produced in 10 clock pulses at Q_2) **Johnson:** $Q_2 = 600 / 10 = 60$ Hz ✓		2	AO2 1d AO2 1d
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>Candidate matches the three areas of the communications spectrum with the correct pathway. They provide a coherent and comprehensive explanation of the properties of each pathway. The answer has structure and detail.</td></tr>
<tr><td>L3
5
marks</td><td>Candidate matches the three areas of the communications spectrum with the correct pathway. They provide a comprehensive explanation of the properties of each pathway, but the answer may lack structure / detail.</td></tr>
<tr><td>L2
4
marks</td><td>Candidate matches two areas of the communications spectrum with the correct pathway. They provide a coherent and comprehensive explanation of the properties of each pathway. The answer has structure and detail.</td></tr>
</table>
</td>
<td>
Longwave
Typical frequency range
Broadcasts between $150\ \text{kHz} - 300\ \text{kHz}$ which fits into the LF band.
Also accept extended ($3\ \text{kHz} - 500\ \text{kHz}$) range to allow for special applications.
Pathway – Ground (surface waves)
i. Generally, line of sight.
ii. Beyond the horizon communication by following earth's curvature.
iii. Diffraction in the atmosphere due to different refractive index.
iv. Diffraction due to interaction of the wave with conductive surface (earth).
v. Diffraction due to interaction with geographical topography – hills / buildings.
vi. Long distance propagation due to low attenuation of low frequency waves.
vii. Transmission severely attenuated by ionosphere so little reflection
Shortwave
Typical frequency range
Normally taken as $3\ \text{MHz} - 30\ \text{MHz}$ which includes the full HF band. (Accept lower limit of $1.7\ \text{MHz}$)
Pathway – Sky waves
i. Ionosphere acts to refract and hence reflect waves back to the earth.
ii. This allows beyond the horizon reception due to single/multiple reflections (skips).
iii. Below this frequency, ionosphere will absorb waves.
iv. Above this frequency, the wave will pass through the ionosphere.
v. Can suffer disruption due to the state of the ionosphere day/night effects or sunspot cycle.
</td>
<td>6</td>
<td>AO1 1a
AO1 1a
AO1 1a

AO3 1b
AO3 1b
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>L2
3
marks</td><td>Candidate matches the two areas of the communications spectrum with the correct pathway. They provide a comprehensive explanation of the properties of each pathway, but the answer may lack structure / detail.</td></tr>
<tr><td>L1
2
marks</td><td>Candidate matches one area of the communications spectrum with the correct pathway. They provide a coherent and comprehensive explanation of the properties of that pathway. The answer has some structure and detail.</td></tr>
<tr><td>L1
1
mark</td><td>Candidate matches one area of the communications spectrum with the correct pathway. They provide some explanation of the properties of the pathway. The answer may lack structure / detail.</td></tr>
<tr><td>L1
0
marks</td><td>The work contains no significant analysis of the question asked.</td></tr>
</table>
</td><td>Microwaves
Typical frequency range
Normally taken as 2 GHz – 100 GHz
Accept 1.7 GHz – 300 GHz

Pathway – Space wave
i. Due to high frequency, microwaves do not diffract around terrestrial objects, so line of sight required.
ii. Microwaves travel straight through atmosphere and ionosphere.
iii. Significant attenuation of transmission by atmosphere and ionosphere.
iv. Different frequencies used for up-link and down-link so that satellite receiver is not desensitized.
v. Up-link normally at higher frequency (17 – 18 GHz) than down-link (10 – 13 GHz) since higher frequency gives narrower beam and can be given more power to overcome attenuation.
(Converse argument for down-link based on wider target area and low power available from satellite).
vi. Microwave communication allows for greater bandwidth to carry complex information.</td><td></td><td></td></tr>
<tr><td>Total</td><td></td><td></td><td>6</td><td></td></tr>
</table>