CAMBRIDGE
International Education

# Cambridge International AS & A Level

**PHYSICS** **9702/23**

Paper 2 AS Level Structured Questions **May/June 2024**

MARK SCHEME

Maximum Mark: 60

**Published**

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

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## Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptions for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

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|---|
| GENERIC MARKING PRINCIPLE 5:<br><br>Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen). |
| GENERIC MARKING PRINCIPLE 6:<br><br>Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind. |

**Science-Specific Marking Principles**

| | |
|---|---|
| 1 | Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly. |
| 2 | The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored. |
| 3 | Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection). |
| 4 | The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted. |
| 5 | ‘List rule’ guidance<br><br>For questions that require ***n*** responses (e.g. State **two** reasons …):<br><br>• The response should be read as continuous prose, even when numbered answer spaces are provided.<br>• Any response marked *ignore* in the mark scheme should not count towards ***n***.<br>• Incorrect responses should not be awarded credit but will still count towards ***n***.<br>• Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response.<br>• Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science. |

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6 Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient ($a$) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

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**Abbreviations**

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|---|---|
| **/** | Alternative and acceptable answers for the same marking point. |
| **( )** | Bracketed content indicates words which do not need to be explicitly seen to gain credit but which indicate the **context** for an answer. The context does not need to be seen but if a context is given that is incorrect then the mark should not be awarded. |
| **___** | Underlined content must be present in answer to award the mark. This means either the exact word or another word that has the same technical meaning. |

**Mark categories**

| | |
|---|---|
| **B** marks | These are independent marks, which do not depend on other marks. For a **B** mark to be awarded, the point to which it refers must be seen specifically in the candidate's answer. |
| **M** marks | These are method marks upon which **A** marks later depend. For an **M** mark to be awarded, the point to which it refers must be seen specifically in the candidate's answer. If a candidate is not awarded an **M** mark, then the later **A** mark cannot be awarded either. |
| **C** marks | These are compensatory marks which can be awarded even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known them. For example, if an equation carries a **C** mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C** mark is awarded.<br>If a correct answer is given to a numerical question, all of the preceding **C** marks are awarded automatically. It is only necessary to consider each of the **C** marks in turn when the numerical answer is not correct. |
| **A** marks | These are answer marks. They may depend on an **M** mark or allow a **C** mark to be awarded by implication. |

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| Question | Answer | Marks |
|---|---|---|
| 1(a) | units of $F$: kg m $s^{-2}$ | **C1** |
| | units of $r$: m and units of $v$: m $s^{-1}$<br>units of $\eta$: kg m $s^{-2}$ / (m × m $s^{-1}$) = kg $m^{-1}$ $s^{-1}$ | **A1** |
| 1(b) | viscosity = 0.096 / (6 × π × 0.03 × 2.0) | **C1** |
| | = 0.085 kg $m^{-1}$ $s^{-1}$ | **A1** |
| 1(c) | one arrow vertically downwards labelled weight / $W$ | **B1** |
| | arrow(s) vertically upwards labelled $U$ / upthrust **and** drag / $F_D$ / viscous force | **B1** |
| 1(d)(i) | $V$ = (4 / 3) $\pi r^3$ | **C1** |
| | upthrust = (4 / 3) × π × $0.03^3$ × 920 × 9.81 = 1.0 N | **A1** |
| 1(d)(ii) | weight = 1.0 + 0.096 (= 1.096 N) | **C1** |
| | $m$ = 1.096 / 9.81<br>= 0.11 kg | **A1** |

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| Question | Answer | Marks |
|---|---|---|
| 2(a) | distance (from the point) in a straight line in a given direction | **B1** |
| 2(b)(i) | distance = speed × time = 6.0 × 0.71<br>= 4.3 m | **A1** |
| 2(b)(ii) | $s = ut + \frac{1}{2}at^2$<br>$= \frac{1}{2} \times 9.81 \times 0.71^2$ | **C1** |
| | = 2.5 m | **A1** |
| 2(b)(iii) | $\tan\theta = 2.5 / 4.3$<br>**or**<br>hypotenuse $= \sqrt{(4.3^2 + 2.5^2)}$<br>(= 4.97 m)<br>$\cos\theta = 4.3 / 4.97$ **or** $\sin\theta = 2.5 / 4.97$ | **C1** |
| | $\theta = 30°$ | **A1** |

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| Question | Answer | Marks |
|---|---|---|
| 2(b)(iv) | displacement = $\sqrt{(4.3^2 + 2.5^2)}$ | **C1** |
| | = 4.9 m or 5.0 m | **A1** |
| | **or** | |
| | displacement = 2.5 / sin 30° **or** displacement = 4.3 / cos 30° | **(C1)** |
| | = 5.0 m | **(A1)** |
| 2(b)(v) | KE = $\frac{1}{2}mv^2$ **or** GPE = $mgh$ | **C1** |
| | initial KE + loss in GPE = final KE<br>$(\frac{1}{2} \times m \times 6.0^2) + (m \times 9.81 \times 2.5) = (\frac{1}{2} \times m \times v^2)$ | **C1** |
| | $v$ = 9.2 m s$^{-1}$ | **A1** |

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| Question | Answer | Marks |
|---|---|---|
| 3(a) | extension is proportional to (applied) force | **B1** |
| 3(b)(i) | P at (60, 5.4) | **A1** |
| 3(b)(ii) | E at (80, 5.9) | **A1** |
| 3(c)(i) | $k = F / x$ **or** $k$ = gradient of (straight line section of) graph | **C1** |
| | e.g. gradient = 5.4 / 0.060<br>$k = 90\ \text{N m}^{-1}$ | **A1** |
| 3(c)(ii) | Young modulus or $E = \sigma / \varepsilon$ **or** $FL / Ax$ **or** $kL / A$ | **C1** |
| | $E = (5.4 \times 3.2) / (4.0 \times 10^{-7} \times 0.06)$ **or** $90 \times 3.2 / (4.0 \times 10^{-7})$ | **C1** |
| | $E = 7.2 \times 10^{8}\ \text{Pa}$ | **A1** |
| 3(d) | work done = area under graph | **B1** |
| | $= (1.0 \pm 0.2)\ \text{J}$ | **A1** |
| 3(e) | the extension will be smaller (for the same force on the thicker sample)<br>**or**<br>a greater force is required (to extend the thicker sample by the same amount)<br>**or**<br>spring constant is proportional to area | **M1** |
| | the spring constant (of the second sample) will be greater | **A1** |

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| Question | Answer | Marks |
|---|---|---|
| 4(a) | 270° | **A1** |
| 4(b) | arrow pointing vertically downwards at T | **A1** |
| 4(c) | $v = f\lambda$<br>**or**<br>$v = \lambda / T$ **and** $f = 1 / T$ | **C1** |
| | wavelength $= 0.62 \times 10^{-2} \times (4 / 3)$<br>$(= 0.83 \times 10^{-2}$ m) | **C1** |
| | $f = 0.27 / (0.83 \times 10^{-2})$<br>$= 33$ Hz | **A1** |
| 4(d) | resultant displacement is the sum of the displacements of the waves (from $S_1$ and $S_2$)<br>**or**<br>waves (from $S_1$ and $S_2$) superpose (at P) | **B1** |
| | *Any one point from*:<br>• (at P) the waves (from the two sources) (always) destructively interfere<br>• (at P) the waves have a path difference that is (always) an odd number of half-wavelengths / their path difference is one and a half wavelengths<br>• (at P) the waves have a phase difference that is (always) 180° / they are in antiphase / crest of one wave meets trough of other wave | **B1** |
| | amplitude (of the resultant wave) is zero (at all times) | **B1** |

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| Question | Answer | Marks |
|---|---|---|
| 5(a)(i) | sum of electromotive force(s) = sum of potential difference(s) around a (closed) loop<br>**or**<br>the (algebraic) sum of the p.d.(s) and e.m.f.(s) is zero around a (closed) loop | **B1** |
| 5(a)(ii) | (law of conservation of) energy | **B1** |
| 5(b)(i) | (by Kirchhoff's first law) $I = I_1 + I_2$ | **B1** |
| | $V / R_T = V / R_1 + V / R_2$ therefore $1 / R_T = 1 / R_1 + 1 / R_2$ | **B1** |
| 5(b)(ii) | resistance of parallel combination $= (15 \times 10) / (15 + 10)$ $(= 6.0\,\Omega)$ | **C1** |
| | $r = (E - V) / I$ | **C1** |
| | $I = 1.38 / 6.0 = 0.23$ A<br>$r = (1.50 - 1.38) / 0.23$<br>$= 0.52\,\Omega$ | **A1** |
| | **or** | |
| | (by potential divider principle) $r / R_T = Ir / V$ | **(C1)** |
| | $r / 6.0 = 0.12 / 1.38$<br>$r = 0.52\,\Omega$ | **(A1)** |
| | **or** | |
| | (by potential divider equation) $V = E \times R_T / (R_T + r)$ | **(C1)** |
| | $1.38 = 1.5 \times 6.0 / (6.0 + r)$<br>$r = 0.52\,\Omega$ | **(A1)** |

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| Question | Answer | Marks |
|---|---|---|
| 5(c)(i) | as the (total) resistance has decreased (and e.m.f. is unchanged) | **M1** |
| | current will (in the cell) increase | **A1** |
| 5(c)(ii) | (as greater current means a) bigger drop in p.d. across the internal resistance | **M1** |
| | p.d. (on voltmeter) will decrease | **A1** |

| Question | Answer | Marks |
|---|---|---|
| 6(a) | $^{147}_{62}\text{Sm}$ | **A1** |
| 6(b)(i) | the (kinetic) energy of the particles is discrete / has only one value (so must be alpha) | **B1** |
| | and beta particles have a (continuous) range of (kinetic) energies (so can't be beta) | **B1** |
| 6(b)(ii) | $^{147}_{62}\text{Sm} \rightarrow {}^{143}_{60}\text{Nd} + {}^{4}_{2}\alpha$<br><br>values for Sm and Nd correct with no other extra particles on either side of the equation | **A1** |
| | $^{4}_{2}\alpha$ correct | **A1** |
| 6(c)(i) | up quark charge is +(2 / 3) (*e*) **or** bottom quark charge is –(1 / 3) (*e*) | **C1** |
| | 0 = +(2 / 3) (*e*) – (1 / 3) (*e*) + *q*<br><br>(so) charge (on third quark must be) –(1 / 3) (*e*) | **A1** |
| 6(c)(ii) | down **or** strange | **A1** |

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