



## Cambridge International AS & A Level

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**PHYSICS**

**9702/21**

Paper 2 AS Level Structured Questions

**May/June 2021**

**MARK SCHEME**

Maximum Mark: 60

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| <p><b>Published</b></p> |
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This document consists of **12** printed pages.

**PUBLISHED****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 descriptors 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).

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- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
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**Science-Specific Marking Principles**

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- 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  
  
For questions that require ***n*** responses (e.g. State **two** reasons ...):
  - The response should be read as continuous prose, even when numbered answer spaces are provided.
  - Any response marked *ignore* in the mark scheme should not count towards ***n***.
  - Incorrect responses should not be awarded credit but will still count towards ***n***.
  - 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.
  - Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

**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.

**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 <b>context</b> 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>B</b> marks | These are <u>independent</u> marks, which do not depend on other marks. For a <b>B</b> mark to be awarded, the point to which it refers must be seen specifically in the candidate's answer.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>M</b> marks | These are <u>method</u> marks upon which <b>A</b> marks later depend. For an <b>M</b> 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 <b>M</b> mark, then the later <b>A</b> mark cannot be awarded either.                                                                                                                                                                                                                                                                                                                                                                              |
| <b>C</b> marks | These are <u>compensatory</u> 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 <b>C</b> mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the <b>C</b> mark is awarded.<br>If a correct answer is given to a numerical question, all of the preceding <b>C</b> marks are awarded automatically. It is only necessary to consider each of the <b>C</b> marks in turn when the numerical answer is not correct. |
| <b>A</b> marks | These are <u>answer</u> marks. They may depend on an <b>M</b> mark or allow a <b>C</b> mark to be awarded by implication.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

**Annotations**

|    |                                                                                                                                                                     |
|----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ✓  | Indicates the point at which a mark has been awarded.                                                                                                               |
| X  | Indicates an incorrect answer or a point at which a decision is made not to award a mark.                                                                           |
| XP | Indicates a physically incorrect equation ('incorrect physics'). No credit is given for substitution, or subsequent arithmetic, in a physically incorrect equation. |

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|             |                                                                                                                                                                                                                                                                                                                                                                                                     |
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| <b>ECF</b>  | Indicates 'error carried forward'. Answers to later numerical questions can always be awarded up to full credit provided they are consistent with earlier incorrect answers. <u>Within</u> a section of a numerical question, ECF can be given after AE, TE and POT errors, but <b>not</b> after XP.                                                                                                |
| <b>AE</b>   | Indicates an arithmetic error. Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors.                                                                                                                                                                                                                 |
| <b>POT</b>  | Indicates a power of ten error. Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors.                                                                                                                                                                                                                |
| <b>TE</b>   | Indicates incorrect transcription of the correct data from the question, a graph, data sheet or a previous answer. For example, the value of $1.6 \times 10^{-19}$ has been written down as $6.1 \times 10^{-19}$ or $1.6 \times 10^{19}$ .<br>Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors. |
| <b>SF</b>   | Indicates that the correct answer is seen in the working but the final answer is incorrect as it is expressed to too few significant figures.                                                                                                                                                                                                                                                       |
| <b>BOD</b>  | Indicates that a mark is awarded where the candidate provides an answer that is not totally satisfactory, but the examiner feels that sufficient work has been done ('benefit of doubt').                                                                                                                                                                                                           |
| <b>CON</b>  | Indicates that a response is contradictory.                                                                                                                                                                                                                                                                                                                                                         |
| <b>I</b>    | Indicates parts of a response that have been seen but disregarded as irrelevant.                                                                                                                                                                                                                                                                                                                    |
| <b>M0</b>   | Indicates where an A category mark has not been awarded due to the M category mark upon which it depends not having previously been awarded.                                                                                                                                                                                                                                                        |
| <b>^</b>    | Indicates where more is needed for a mark to be awarded (what is written is not wrong, but not enough). May also be used to annotate a response space that has been left completely blank.                                                                                                                                                                                                          |
| <b>SEEN</b> | Indicates that a page has been seen.                                                                                                                                                                                                                                                                                                                                                                |

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| Question | Answer                                                                    | Mark      |
|----------|---------------------------------------------------------------------------|-----------|
| 1(a)     | mass / volume                                                             | <b>B1</b> |
| 1(b)(i)  | absolute uncertainty = $4.0 \times (5 / 100)$<br>= $(\pm) 0.2 \text{ cm}$ | <b>B1</b> |
| 1(b)(ii) | percentage uncertainty = $2 + 4 + (5 \times 2)$                           | <b>C1</b> |
|          | = $(\pm) 16\%$                                                            | <b>A1</b> |
| 1(c)     | $p = F / A$ <b>or</b> $p = W / A$                                         | <b>C1</b> |
|          | $p = (19.5 \times 10^{-3} \times 9.81) / (4.0 \times 10^{-2})^2$          | <b>C1</b> |
|          | = 120 Pa                                                                  | <b>A1</b> |

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| Question  | Answer                                                                                                     | Mark      |
|-----------|------------------------------------------------------------------------------------------------------------|-----------|
| 2(a)(i)   | $P = Fv$                                                                                                   | <b>C1</b> |
|           | $= 18 \times 1.4$                                                                                          | <b>A1</b> |
|           | $= 25 \text{ W}$                                                                                           |           |
| 2(a)(ii)  | $a = F / m$                                                                                                | <b>C1</b> |
|           | $a = 18 / 72 = 0.25 \text{ (ms}^{-2}\text{)}$                                                              | <b>C1</b> |
|           | $t = 1.4 / 0.25$                                                                                           |           |
|           | $= 5.6 \text{ s}$                                                                                          | <b>A1</b> |
| 2(b)(i)   | $a = (54 - 18) / 72 \text{ or } 36 / 72 (= 0.50 \text{ ms}^{-2})$                                          | <b>C1</b> |
|           | $v^2 = 2 \times 0.50 \times 9.5$                                                                           | <b>C1</b> |
|           | $v = 3.1 \text{ m s}^{-1}$                                                                                 | <b>A1</b> |
| 2(b)(ii)  | $W = 54 \times 9.5$                                                                                        | <b>A1</b> |
|           | $= 510 \text{ J}$                                                                                          |           |
| 2(b)(iii) | curved line from the origin                                                                                | <b>M1</b> |
|           | gradient of line increases                                                                                 | <b>A1</b> |
| 2(c)      | (force due to) air resistance increases/changes/not constant <b>or</b> air resistance increases with speed | <b>B1</b> |

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| Question | Answer                                                                                                                                                                                | Mark      |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 3(a)     | solid straight line drawn between centre of sphere at X and at Y                                                                                                                      | <b>B1</b> |
| 3(b)     | $p = mv$ <b>or</b> $0.72 = mv$                                                                                                                                                        | <b>C1</b> |
|          | $E = \frac{1}{2}mv^2$ <b>or</b> $0.86 = \frac{1}{2}mv^2$                                                                                                                              | <b>C1</b> |
|          | $(m =) 0.72^2 / (2 \times 0.86) = 0.30 \text{ (kg)}$<br><b>or</b><br>$v = 2E_K / p$<br>$v = (0.86 \times 2) / 0.72 = 2.4 \text{ (to 2 s.f.)}$<br>$m = 0.72 / 2.4 = 0.30 \text{ (kg)}$ | <b>A1</b> |
|          |                                                                                                                                                                                       |           |
| 3(c)     | $(\Delta)E = mg(\Delta)h$                                                                                                                                                             | <b>C1</b> |
|          | $h = 0.86 / (0.30 \times 9.81)$<br>$= 0.29 \text{ m}$                                                                                                                                 | <b>A1</b> |
| 3(d)     | $\cos \theta = (0.93 - 0.29) / 0.93$ so $\theta = 47^\circ$                                                                                                                           | <b>A1</b> |
| 3(e)     | moment = $(0.30 \times 9.81) \times 0.93 \times (\sin 47^\circ \text{ or } \cos 43^\circ)$<br><b>or</b><br>moment = $(0.30 \times 9.81) \times [0.93^2 - (0.93 - 0.29)^2]^{0.5}$      | <b>C1</b> |
|          | $= 2.0 \text{ N m}$                                                                                                                                                                   | <b>A1</b> |

| Question | Answer                                                                                                                                                              | Mark      |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 3(f)     | there is a <u>resultant</u> force (acting on sphere)<br><b>or</b><br>there is a <u>resultant</u> moment (about P acting on pendulum)<br><br>(so) not in equilibrium | <b>B1</b> |

| Question | Answer                                                                                                                                                                                                            | Marks     |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 4(a)     | distance moved by wavefront/energy during one cycle/oscillation/period (of source)<br><b>or</b><br><u>minimum</u> distance between two wavefronts<br><b>or</b><br>distance between two <u>adjacent</u> wavefronts | <b>B1</b> |
| 4(b)     | $v = \lambda / T$<br><b>or</b><br>$v = f\lambda$ <b>and</b> $f = 1 / T$                                                                                                                                           | <b>C1</b> |
|          | $T = 460 \times 10^{-9} / 3.00 \times 10^8$                                                                                                                                                                       | <b>C1</b> |
|          | $= 1.5 \times 10^{-15} \text{ s}$                                                                                                                                                                                 | <b>A1</b> |
| 4(c)     | waves pass through/enter the slit(s)                                                                                                                                                                              | <b>B1</b> |
|          | waves spread (into geometric shadow)                                                                                                                                                                              | <b>B1</b> |
| 4(d)(i)  | $n\lambda = d \sin \theta$                                                                                                                                                                                        | <b>C1</b> |
|          | $G = \sin \theta / \lambda$                                                                                                                                                                                       | <b>A1</b> |
|          | $d = 4 / G$                                                                                                                                                                                                       |           |
| 4(d)(ii) | straight line from 400 nm to 700 nm that is always below printed line                                                                                                                                             | <b>M1</b> |
|          | straight line has smaller gradient than printed line and is 5 small squares high at wavelength of 700 nm                                                                                                          | <b>A1</b> |

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| Question  | Answer                                                                                                           | Mark      |
|-----------|------------------------------------------------------------------------------------------------------------------|-----------|
| 5(a)      | <u>sum of</u> e.m.f.(s) = <u>sum of</u> p.d.(s)<br><b>or</b><br>(algebraic) sum of e.m.f.(s) and p.d.(s) is zero | <b>M1</b> |
|           | around a loop/around a <u>closed</u> circuit                                                                     | <b>A1</b> |
| 5(b)(i)   | $I = 1.8 / 0.90$<br><br>$= 2.0 \text{ A}$                                                                        | <b>A1</b> |
| 5(b)(ii)  | $Q = It$                                                                                                         | <b>C1</b> |
|           | number = $(2.0 \times 45) / 1.60 \times 10^{-19}$<br><br>$= 5.6 \times 10^{20}$                                  | <b>A1</b> |
| 5(b)(iii) | $4.0 = 1.8 + [2.0 \times (0.35 + R)]$<br><br><b>or</b><br>$4.0 = 2.0 \times (0.90 + 0.35 + R)$                   | <b>C1</b> |
|           | $R = 0.75 \Omega$                                                                                                | <b>A1</b> |
| 5(c)(i)   | $1.2 / 1.8 = 0.30 / L$                                                                                           | <b>C1</b> |
|           | $L = 0.45 \text{ m}$                                                                                             | <b>A1</b> |
| 5(c)(ii)  | p.d. across XY decreases/p.d. across XP decreases                                                                | <b>B1</b> |
|           | (so) P is moved towards Y/away from X/to the right                                                               | <b>B1</b> |

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| Question  | Answer                                                                                                                            | Mark      |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------|-----------|
| 6(a)(i)   | (electron) neutrino                                                                                                               | <b>B1</b> |
| 6(a)(ii)  | weak (nuclear force/interaction)                                                                                                  | <b>B1</b> |
| 6(a)(iii) | $\beta^+$ (particle)                                                                                                              | <b>B1</b> |
| 6(a)(iv)  | (quark structure is) up up down <b>or</b> uud                                                                                     | <b>B1</b> |
|           | $(2/3)e + (2/3)e - (1/3)e = (+)e$                                                                                                 | <b>B1</b> |
| 6(a)(v)   | up up down changes to up down down <b>or</b> uud $\rightarrow$ udd<br><b>or</b><br>up changes to down <b>or</b> u $\rightarrow$ d | <b>B1</b> |
| 6(b)(i)   | $F = Eq$                                                                                                                          | <b>C1</b> |
|           | ratio = $6/8$<br><br>= 0.75                                                                                                       | <b>A1</b> |
| 6(b)(ii)  | ratio = $0.75 \times (16/12)$<br><br>= 1.0                                                                                        | <b>A1</b> |
| 6(b)(iii) | horizontal straight line at a non-zero value of $a$                                                                               | <b>B1</b> |



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| <b>AE</b>   | Indicates an arithmetic error. Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors.                                                                                                                                                                                                                 |
| <b>POT</b>  | Indicates a power of ten error. Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors.                                                                                                                                                                                                                |
| <b>TE</b>   | Indicates incorrect transcription of the correct data from the question, a graph, data sheet or a previous answer. For example, the value of $1.6 \times 10^{-19}$ has been written down as $6.1 \times 10^{-19}$ or $1.6 \times 10^{19}$ .<br>Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors. |
| <b>SF</b>   | Indicates that the correct answer is seen in the working but the final answer is incorrect as it is expressed to too few significant figures.                                                                                                                                                                                                                                                       |
| <b>BOD</b>  | Indicates that a mark is awarded where the candidate provides an answer that is not totally satisfactory, but the examiner feels that sufficient work has been done (‘benefit of doubt’).                                                                                                                                                                                                           |
| <b>CON</b>  | Indicates that a response is contradictory.                                                                                                                                                                                                                                                                                                                                                         |
| <b>I</b>    | Indicates parts of a response that have been seen but disregarded as irrelevant.                                                                                                                                                                                                                                                                                                                    |
| <b>M0</b>   | Indicates where an A category mark has not been awarded due to the M category mark upon which it depends not having previously been awarded.                                                                                                                                                                                                                                                        |
| <b>^</b>    | Indicates where more is needed for a mark to be awarded (what is written is not wrong, but not enough). May also be used to annotate a response space that has been left completely blank.                                                                                                                                                                                                          |
| <b>SEEN</b> | Indicates that a page has been seen.                                                                                                                                                                                                                                                                                                                                                                |

| Question  | Answer                                                                                                                                        | Marks     |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 1(a)      | acceleration: vector<br>electrical resistance: scalar<br>momentum: vector<br><br><i>1 mark for two correct, 2 marks for all three correct</i> | <b>B2</b> |
| 1(b)      | resultant force (in any direction) is zero                                                                                                    | <b>B1</b> |
|           | resultant torque/moment (about any point) is zero                                                                                             | <b>B1</b> |
| 1(c)(i)   | upthrust = $\rho g(\Delta)h \times A$                                                                                                         | <b>C1</b> |
|           | $= (1.00 \times 10^3 \times 9.81 \times 0.190) \times 0.0230$<br>$= 42.9 \text{ N}$                                                           | <b>A1</b> |
| 1(c)(ii)  | $(T =) 43 - 28 = 15 \text{ (N)}$<br><b>or</b><br>$(T =) 42.9 - 28 = 14.9 \text{ or } 15 \text{ (N)}$                                          | <b>A1</b> |
| 1(c)(iii) | $\sigma = F/A$ <b>or</b> $T/A$                                                                                                                | <b>C1</b> |
|           | $= 15 / (3.2 \times 10^{-6})$<br>$= 4.7 \times 10^6 \text{ Pa}$                                                                               | <b>A1</b> |
| 1(c)(iv)  | upthrust (on cylinder) increases (and weight constant)                                                                                        | <b>B1</b> |
|           | tension/stress increases and (so) strain energy increases                                                                                     | <b>B1</b> |

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| Question  | Answer                                                                                                                | Marks     |
|-----------|-----------------------------------------------------------------------------------------------------------------------|-----------|
| 2(a)      | $v^2 = u^2 + 2as$<br>$u^2 = 8.7^2 - (2 \times 9.81 \times 1.5)$                                                       | <b>C1</b> |
|           | $u = 6.8 \text{ m s}^{-1}$                                                                                            | <b>A1</b> |
| 2(b)      | (magnitude of) force on ball (by ground) equal to force on ground (by ball)                                           | <b>B1</b> |
|           | (direction of) force on ball (by ground) opposite to force on ground (by ball)                                        | <b>B1</b> |
| 2(c)(i)   | $(p = ) 0.059 \times 8.7 \text{ or } 0.059 \times 5.4$                                                                | <b>C1</b> |
|           | change in momentum = $0.059 (8.7 + 5.4)$<br>$= 0.83 \text{ N s}$                                                      | <b>A1</b> |
| 2(c)(ii)  | resultant force = $0.83 / 0.091 \text{ or } 0.059 [(8.7 + 5.4) / 0.091]$<br>$= 9.1 \text{ N}$                         | <b>A1</b> |
| 2(c)(iii) | $(W =) 0.059 \times 9.81$                                                                                             | <b>C1</b> |
|           | $(W =) 0.58 \text{ (N)}$<br>force = $9.1 + 0.58$<br>$= 9.7 \text{ N}$                                                 | <b>A1</b> |
| 2(d)      | straight line with a positive gradient and starting from a non-zero value of speed at $t = 0$ and ending when $t = T$ | <b>B1</b> |
| 2(e)      | air resistance increases                                                                                              | <b>B1</b> |
|           | resultant force/acceleration decreases so gradient (of curve) decreases                                               | <b>B1</b> |

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| Question | Answer                                                   | Marks     |
|----------|----------------------------------------------------------|-----------|
| 3(a)     | $(\Delta)E = mg(\Delta)h$ <b>or</b> $W(\Delta)h$         | <b>C1</b> |
|          | $= 330 \times (4.0 - 1.1)$                               | <b>A1</b> |
|          | $= 960 \text{ J}$                                        |           |
| 3(b)     | (work =) $960 - 540$                                     | <b>C1</b> |
|          | (= $420 \text{ J}$ )                                     |           |
|          | distance moved = $(960 - 540) / 52$<br>$= 8.1 \text{ m}$ | <b>A1</b> |
| 3(c)(i)  | $E = \frac{1}{2}mv^2$                                    | <b>C1</b> |
|          | $540 = \frac{1}{2} \times (330 / 9.81) \times v^2$       | <b>A1</b> |
|          | $v = 5.7 \text{ m s}^{-1}$                               |           |
| 3(c)(ii) | speed = horizontal component of velocity                 | <b>C1</b> |
|          | $= 5.7 \times \cos 41^\circ$                             |           |
|          | $= 4.3 \text{ m s}^{-1}$                                 | <b>A1</b> |

| Question  | Answer                                                                                                                                                                                                         | Marks     |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 4(a)      | time for one oscillation/vibration/cycle<br><b>or</b><br>time between <u>adjacent</u> wavefronts (passing the same point)<br><b>or</b><br><u>shortest</u> time between two wavefronts (passing the same point) | <b>B1</b> |
| 4(b)      | (when two or more) waves meet/overlap (at a point)                                                                                                                                                             | <b>B1</b> |
|           | (resultant) displacement is sum of the individual displacements                                                                                                                                                | <b>B1</b> |
| 4(c)(i)   | microwave(s)                                                                                                                                                                                                   | <b>B1</b> |
| 4(c)(ii)  | $v = \lambda / T$<br><b>or</b><br>$v = f\lambda$ <b>and</b> $f = 1/T$                                                                                                                                          | <b>C1</b> |
|           | $T = 0.040 / 3.00 \times 10^8$                                                                                                                                                                                 | <b>C1</b> |
|           | $= 1.33 \times 10^{-10} \text{ (s)}$<br>$= 1.33 \times 10^{-10} / 10^{-12} \text{ (ps)}$<br>$= 130 \text{ ps}$                                                                                                 | <b>A1</b> |
|           |                                                                                                                                                                                                                |           |
| 4(c)(iii) | $(1.380 - 1.240) / 0.040 = 3.5$<br><b>or</b><br>$1.380 / 0.040 - 1.240 / 0.040 = 3.5$                                                                                                                          | <b>A1</b> |
| 4(c)(iv)  | phase difference = $1260^\circ$ <b>or</b> $180^\circ$                                                                                                                                                          | <b>A1</b> |
| 4(c)(v)   | (always) zero                                                                                                                                                                                                  | <b>A1</b> |
| 4(c)(vi)  | increase in distance between (adjacent intensity) maxima/minima                                                                                                                                                | <b>A1</b> |

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| Question  | Answer                                                                     | Marks     |
|-----------|----------------------------------------------------------------------------|-----------|
| 5(a)      | volt / ampere                                                              | <b>B1</b> |
| 5(b)      | $R = \rho L / A$                                                           | <b>B1</b> |
|           | $(A = V / L)$                                                              | <b>B1</b> |
|           | (so) $R = \rho L^2 / V$ (with $\rho$ and $V$ constant so $R \propto L^2$ ) |           |
| 5(c)(i)   | $E = 2.4 \text{ V}$                                                        | <b>A1</b> |
| 5(c)(ii)  | $P = VI$ <b>or</b> $I^2R$ <b>or</b> $V^2/R$                                | <b>C1</b> |
|           | $= 1.3 \times 5.0$ <b>or</b> $5.0^2 \times 0.26$ <b>or</b> $1.3^2 / 0.26$  | <b>C1</b> |
|           | $= 6.5 \text{ W}$                                                          | <b>A1</b> |
| 5(c)(iii) | (–) internal resistance <b>or</b> (–) $r$                                  | <b>B1</b> |

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| Question | Answer                                                                      | Marks     |
|----------|-----------------------------------------------------------------------------|-----------|
| 6(a)     | the nucleus is charged                                                      | <b>B1</b> |
|          | the majority of the mass (of atom) is in the nucleus                        | <b>B1</b> |
| 6(b)     | made up of quarks (so) not a fundamental particle                           | <b>B1</b> |
| 6(c)     | $(Q =) 6.9 \times 10^{-9} \times 60$                                        | <b>C1</b> |
|          | number = $(6.9 \times 10^{-9} \times 60) / (2 \times 1.60 \times 10^{-19})$ | <b>C1</b> |
|          | = $1.3 \times 10^{12}$                                                      | <b>A1</b> |
| 6(d)     | (magnitude of electric) force is constant                                   | <b>B1</b> |
|          | (so magnitude of) acceleration is constant                                  | <b>B1</b> |
| 6(e)     | (nuclei have) same charge/same number of protons                            | <b>B1</b> |
|          | (so) same (magnitude of) force                                              | <b>B1</b> |



## Cambridge International AS & A Level

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**PHYSICS**

**9702/23**

Paper 2 AS Level Structured Questions

**May/June 2021**

**MARK SCHEME**

Maximum Mark: 60

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|                  |
|------------------|
| <b>Published</b> |
|------------------|

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.

Cambridge International is publishing the mark schemes for the May/June 2021 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

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This document consists of **12** printed pages.

**PUBLISHED****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 descriptors 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.

**GENERIC MARKING PRINCIPLE 5:**

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:**

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

For questions that require ***n*** responses (e.g. State **two** reasons ...):

- The response should be read as continuous prose, even when numbered answer spaces are provided.
- Any response marked *ignore* in the mark scheme should not count towards ***n***.
- Incorrect responses should not be awarded credit but will still count towards ***n***.
- 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.
- Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

**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.

**Abbreviations**

|     |                                                                                                                                                                                                                                                                     |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| /   | 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 <b>context</b> 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>B</b> marks | These are <u>independent</u> marks, which do not depend on other marks. For a <b>B</b> mark to be awarded, the point to which it refers must be seen specifically in the candidate's answer.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>M</b> marks | These are <u>method</u> marks upon which <b>A</b> marks later depend. For an <b>M</b> 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 <b>M</b> mark, then the later <b>A</b> mark cannot be awarded either.                                                                                                                                                                                                                                                                                                                                                                              |
| <b>C</b> marks | These are <u>compensatory</u> 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 <b>C</b> mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the <b>C</b> mark is awarded.<br>If a correct answer is given to a numerical question, all of the preceding <b>C</b> marks are awarded automatically. It is only necessary to consider each of the <b>C</b> marks in turn when the numerical answer is not correct. |
| <b>A</b> marks | These are <u>answer</u> marks. They may depend on an <b>M</b> mark or allow a <b>C</b> mark to be awarded by implication.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

**Annotations**

|    |                                                                                                                                                                     |
|----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ✓  | Indicates the point at which a mark has been awarded.                                                                                                               |
| X  | Indicates an incorrect answer or a point at which a decision is made not to award a mark.                                                                           |
| XP | Indicates a physically incorrect equation ('incorrect physics'). No credit is given for substitution, or subsequent arithmetic, in a physically incorrect equation. |

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|             |                                                                                                                                                                                                                                                                                                                                                                                                     |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>ECF</b>  | Indicates ‘error carried forward’. Answers to later numerical questions can always be awarded up to full credit provided they are consistent with earlier incorrect answers. <u>Within</u> a section of a numerical question, ECF can be given after AE, TE and POT errors, but <b>not</b> after XP.                                                                                                |
| <b>AE</b>   | Indicates an arithmetic error. Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors.                                                                                                                                                                                                                 |
| <b>POT</b>  | Indicates a power of ten error. Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors.                                                                                                                                                                                                                |
| <b>TE</b>   | Indicates incorrect transcription of the correct data from the question, a graph, data sheet or a previous answer. For example, the value of $1.6 \times 10^{-19}$ has been written down as $6.1 \times 10^{-19}$ or $1.6 \times 10^{19}$ .<br>Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors. |
| <b>SF</b>   | Indicates that the correct answer is seen in the working but the final answer is incorrect as it is expressed to too few significant figures.                                                                                                                                                                                                                                                       |
| <b>BOD</b>  | Indicates that a mark is awarded where the candidate provides an answer that is not totally satisfactory, but the examiner feels that sufficient work has been done (‘benefit of doubt’).                                                                                                                                                                                                           |
| <b>CON</b>  | Indicates that a response is contradictory.                                                                                                                                                                                                                                                                                                                                                         |
| <b>I</b>    | Indicates parts of a response that have been seen but disregarded as irrelevant.                                                                                                                                                                                                                                                                                                                    |
| <b>MO</b>   | Indicates where an A category mark has not been awarded due to the M category mark upon which it depends not having previously been awarded.                                                                                                                                                                                                                                                        |
| <b>^</b>    | Indicates where more is needed for a mark to be awarded (what is written is not wrong, but not enough). May also be used to annotate a response space that has been left completely blank.                                                                                                                                                                                                          |
| <b>SEEN</b> | Indicates that a page has been seen.                                                                                                                                                                                                                                                                                                                                                                |

| Question  | Answer                                                                         | Marks     |
|-----------|--------------------------------------------------------------------------------|-----------|
| 1(a)(i)   | two correct scalar quantities e.g. time, mass, distance, temperature           | <b>B1</b> |
|           | two correct vector quantities e.g. force, acceleration, velocity, displacement | <b>B1</b> |
| 1(a)(ii)  | magnitude                                                                      | <b>B1</b> |
|           | unit                                                                           | <b>B1</b> |
| 1(b)(i)   | north component of velocity = $11 \text{ m s}^{-1}$                            | <b>A1</b> |
|           | east component of velocity = $7.5 \text{ m s}^{-1}$                            | <b>A1</b> |
| 1(b)(ii)  | velocity = $7.5 - 2.7$<br>$= 4.8 \text{ m s}^{-1}$                             | <b>A1</b> |
| 1(b)(iii) | velocity = $\sqrt{11^2 + 4.8^2}$                                               | <b>C1</b> |
|           | $= 12 \text{ m s}^{-1}$                                                        | <b>A1</b> |
| 1(b)(iv)  | angle = $\tan^{-1} (4.8 / 11)$                                                 | <b>C1</b> |
|           | $= 24^\circ$                                                                   | <b>A1</b> |

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| Question  | Answer                                                                                                                                                                          | Marks     |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 2(a)      | change in velocity / time (taken)                                                                                                                                               | <b>B1</b> |
| 2(b)(i)   | air resistance increases (with speed/with time)                                                                                                                                 | <b>B1</b> |
|           | resultant force decreases (as speed increases/with time) so acceleration decreases (as speed increases/with time)                                                               | <b>B1</b> |
|           | when air resistance equals the weight the speed/velocity/ $v$ becomes constant                                                                                                  | <b>B1</b> |
| 2(b)(ii)  | speed = $36 \text{ m s}^{-1}$                                                                                                                                                   | <b>A1</b> |
| 2(b)(iii) | height given by area under the curve                                                                                                                                            | <b>C1</b> |
|           | height = 950 m<br><br><i>Round to two significant figures and award 2 marks for a value in the range 920–980 m and 1 mark for a value in the range 900–910 m or 990–1000 m.</i> | <b>A2</b> |
| 2(b)(iv)  | line starting at (0, 9.8)                                                                                                                                                       | <b>B1</b> |
|           | curve with negative gradient between $t = 0$ and $t = 20 \text{ s}$                                                                                                             | <b>B1</b> |
|           | line showing zero acceleration between $t = 20 \text{ s}$ and $t = 30 \text{ s}$                                                                                                | <b>B1</b> |

| Question  | Answer                                                                                                                                                                                                     | Marks     |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 3(a)      | force $\times$ distance                                                                                                                                                                                    | <b>M1</b> |
|           | perpendicular distance of (line of action of) force from the point                                                                                                                                         | <b>A1</b> |
| 3(b)(i)   | distance moved by pointer = $123 - 86 (= 37 \text{ mm})$                                                                                                                                                   | <b>C1</b> |
|           | (extension =) $37 \times (1.8 / 52.6) = 1.3 \text{ (mm)}$<br><br><b>or</b><br><br>sin or tan $\theta = 37 / 526$ (so $\theta = 4.0^\circ$ so extension =) sin or tan $\theta \times 18 = 1.3 \text{ (mm)}$ | <b>A1</b> |
| 3(b)(ii)  | moment = $0.472 \times 9.81 \times 6.2 \times 10^{-2}$                                                                                                                                                     | <b>C1</b> |
|           | = $0.29 \text{ N m}$                                                                                                                                                                                       | <b>A1</b> |
| 3(b)(iii) | $(\Delta)F \times 1.8 \times 10^{-2} = 0.29$                                                                                                                                                               | <b>C1</b> |
|           | $\Delta F = 16 \text{ N}$                                                                                                                                                                                  | <b>A1</b> |
| 3(b)(iv)  | $k = F / x$                                                                                                                                                                                                | <b>C1</b> |
|           | = $16 / (1.3 \times 10^{-3})$<br><br>= $1.2 \times 10^4 \text{ N m}^{-1}$                                                                                                                                  | <b>A1</b> |

| Question | Answer                                                                                | Marks     |
|----------|---------------------------------------------------------------------------------------|-----------|
| 4(a)     | (when two or more) waves meet/overlap (at a point)                                    | <b>B1</b> |
|          | (resultant) displacement is sum of the individual displacements                       | <b>B1</b> |
| 4(b)     | intensity $\propto$ amplitude <sup>2</sup>                                            | <b>C1</b> |
|          | maximum intensity = $9I$                                                              | <b>A1</b> |
| 4(c)(i)  | $x = \lambda D / a$                                                                   | <b>C1</b> |
|          | $= (550 \times 10^{-9} \times 1.2) / (0.35 \times 10^{-3})$                           | <b>C1</b> |
|          | $= 1.9 \times 10^{-3} \text{ m}$                                                      | <b>A1</b> |
| 4(c)(ii) | red light has longer wavelength (than 550 nm) so distance (between fringes) increases | <b>B1</b> |

| Question  | Answer                                                                                                                                           | Marks     |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 5(a)      | energy per unit charge                                                                                                                           | <b>B1</b> |
|           | energy transferred by source driving charge around the complete circuit<br><b>or</b><br>energy transferred from other forms to electrical energy | <b>B1</b> |
| 5(b)      | there is a p.d. across the internal resistance/ $r$                                                                                              | <b>B1</b> |
|           | change in current/ $I$ results in a change in p.d. across the internal resistance                                                                | <b>B1</b> |
|           | $V = E - \text{p.d. across internal resistance}$<br><b>or</b><br>change in p.d. across $r$ causes a change in $V$ (as e.m.f. is constant)        | <b>B1</b> |
| 5(c)(i)   | $E = 7.4 \text{ V}$                                                                                                                              | <b>A1</b> |
| 5(c)(ii)  | maximum current = 0.92 A                                                                                                                         | <b>A1</b> |
| 5(c)(iii) | $r = E / I_{\text{MAX}}$ <b>or</b> $(-)\text{gradient}$                                                                                          | <b>C1</b> |
|           | e.g. $r = 7.4 / 0.92$<br><br>$= 8.0 \Omega$                                                                                                      | <b>A1</b> |
| 5(d)      | straight line with negative gradient that is smaller in magnitude than the original line                                                         | <b>B1</b> |
|           | line which would have intercept on $V$ -axis below the original line                                                                             | <b>B1</b> |

| Question  | Answer                                                                                                                   | Marks     |
|-----------|--------------------------------------------------------------------------------------------------------------------------|-----------|
| 6(a)(i)   | up up down                                                                                                               | <b>B1</b> |
| 6(a)(ii)  | up down down                                                                                                             | <b>B1</b> |
| 6(a)(iii) | (alpha-particle is) 2 protons and 2 neutrons                                                                             | <b>C1</b> |
|           | 6 up, 6 down                                                                                                             | <b>A1</b> |
| 6(b)(i)   | most of an <u>atom</u> is empty space<br><b>or</b><br>the nucleus (volume) is (very) small <u>compared with the atom</u> | <b>B1</b> |
| 6(b)(ii)  | the nucleus is charged                                                                                                   | <b>B1</b> |
|           | the majority of the mass of atom is in the nucleus                                                                       | <b>B1</b> |
| 6(c)      | $F = Eq$ <b>and</b> $a = F / m$                                                                                          | <b>C1</b> |
|           | $a = Eq / m$<br>ratio = $(e / m) / (2e / 4m)$<br>$= 2$                                                                   | <b>A1</b> |