



Cambridge International AS & A Level

PHYSICS

9702/21

Paper 2 AS Level Structured Questions

May/June 2022

MARK SCHEME

Maximum Mark: 60

Published

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This document consists of **13** printed pages.

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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 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 <u>independent</u> 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 <u>method</u> 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 <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 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. 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 <u>answer</u> marks. They may depend on an M mark or allow a C 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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ECF	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 not after XP.
AE	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.
POT	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.
TE	Indicates incorrect transcription of the correct data from the question, a graph, data sheet or a previous answer. For example, the value of 1.6×10^{-19} has been written down as 6.1×10^{-19} or 1.6×10^{19} . 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.
SF	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.
BOD	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').
CON	Indicates that a response is contradictory.
I	Indicates parts of a response that have been seen but disregarded as irrelevant.
M0	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.
^	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.
SEEN	Indicates that a page has been seen.

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Question	Answer	Marks
1(a)	change in displacement / time (taken)	B1
1(b)(i)	(displacement =) area under graph	C1
	(at $t = 4.0$ s) $v = (-) 2.4$	C1
	height = $\frac{1}{2} \times 2.5 \times 4.0 - \frac{1}{2} \times 1.5 \times 2.4$ = 3.2 m	A1
1(b)(ii)	change in momentum = $7.5 (-4.0 - 2.4)$	C1
	= $(-) 48$ N s	A1
1(b)(iii)	$W = \Delta p / (\Delta)t$ or $\Delta mv / (\Delta)t$	C1
	= $48 / 4.0$	A1
	= 12 N	
	or	
	$W = ma$ or mg or $m(v - u) / t$	(C1)
	= 7.5×1.6 or $7.5 \times (4 + 2.4) / 4.0$ = 12 N	(A1)
1(c)	speed/velocity decreases so viscous force decreases	B1
	viscous force decreases (and weight constant) so resultant force decreases	B1

Question	Answer	Marks
2(a)	point where (all) the weight (of the object) is taken to act	B1
2(b)(i)	moments about P are: $(F \times 1.10)$, (44.0×0.60) and (3.0×2.90) <i>1 mark for any one correct moment and 2 marks for two correct moments</i>	C2
	$(F \times 1.10) = (44.0 \times 0.60) + (3.0 \times 2.90)$ $F = 32 \text{ N}$	A1
2(b)(ii)	force = $32 + 44 + 3$ $= 79 \text{ N}$	A1
2(c)(i)	$(F = \rho g V)$ $V = 2.5 / (1100 \times 9.81) (= 2.32 \times 10^{-4})$	C1
	$V = (4/3)\pi r^3$	C1
	$r = [(3 \times 2.32 \times 10^{-4}) / 4\pi]^{1/3}$ $r = 0.038 \text{ m}$	A1
2(c)(ii)	resultant moment = 2.5×2.9 $= 7.3 \text{ N m}$ or resultant moment = $F \times 1.1 - (44 \times 0.6 + 0.5 \times 2.9)$ $= 7.3 \text{ N m}$ (allow 7.2 N m or 7.4 N m from rounded values of F)	A1
	direction: anticlockwise	A1

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Question	Answer	Marks
3(a)(i)	work (done) / time (taken)	B1
3(a)(ii)	$W = Fx$ or $E = Fx$	B1
	$(P =) Fx / t = Fv$ or $P = Fvt / t = Fv$	B1
3(b)(i)	$T = 430 \sin 11^\circ$ or $430 \cos 79^\circ$	C1
	$= 82 \text{ N}$	A1
3(b)(ii)	speed = $56 / 82$ $= 0.68 \text{ m s}^{-1}$	A1
3(b)(iii)	no change in kinetic energy (of block)	B1
3(b)(iv)	(input power) = $56 / 0.80$ $(= 70 \text{ W})$	C1
	time taken = $1.2 \times 10^3 / 70$ $= 17 \text{ s}$	A1
	or	
	(useful energy) = $1200 \times 80 / 100$ $(= 960 \text{ J})$	(C1)
	time taken = $960 / 56$ $= 17 \text{ s}$	(A1)

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Question	Answer	Marks
4(a)	$k = F / \Delta L$ or F / x or gradient	C1
	= e.g. $30 / (0.60 - 0.20)$	A1
	= 75 N m^{-1}	
4(b)	$E = \frac{1}{2} F \Delta L$ or $\frac{1}{2} Fx$ or $\frac{1}{2} k (\Delta L)^2$ or $\frac{1}{2} kx^2$ or area under graph	C1
	= $\frac{1}{2} \times 15 \times 0.20$ or $\frac{1}{2} \times 75 \times 0.20^2$	C1
	= 1.5 J	A1

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Question	Answer	Marks
5(a)	wave(s) (travel along string and) reflect at fixed point / A / B / end	B1
	incident and reflected waves superpose / interfere or two waves travelling / with speed in opposite directions superpose / interfere	B1
5(b)	line has an approximate sinusoidal shape with maximum downward displacement at P and zero displacement at each node	B1
5(c)	$v = \lambda / T$ or $v = f\lambda$ and $f = 1 / T$	C1
	$\lambda = 35 \times 0.040$ or $35 / 25$ (= 1.4 m)	C1
	distance = 1.4×2.5 = 3.5 m	A1
5(d)	(number of periods / cycles) ($= t / T$) = $0.060 / 0.040$ (= 1.5)	C1
	amplitude = $72 / 6$ = 12 mm	A1

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Question	Answer	Marks
6(a)	sum of current(s) into junction = sum of current(s) out of junction or (algebraic) sum of current(s) at a junction is zero	B1
6(b)(i)	same potential difference (across X and Y as in parallel)	B1
	power = V^2 / R (and $R_X > R_Y$) or power = VI and $I_X < I_Y$	M1
	(so) Y (dissipates more power)	A1
6(b)(ii)	$R = \rho L / A$ (and $R_X > R_Y$)	M1
	(so) Y (has the larger (cross-sectional) area)	A1
6(c)(i)	current = $5.4 / 1800$ $= 3.0 \times 10^{-3} \text{ A}$	A1
6(c)(ii)	$5.4 / 9.0 = 1800 / (1800 + R_L)$ or $R_L = (9.0 - 5.4) / 3.0 \times 10^{-3}$	C1
	$R_L = 1200 \Omega$	A1
6(c)(iii)	resistance of LDR / R_L decreases	B1
	current (in the circuit) increases (so) voltmeter reading increases	B1

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Question	Answer	Marks
7(a)(i)	change in $A = 0$	A1
	change in $Z = (+)1$	A1
7(a)(ii)	(electron) <u>anti</u> neutrino	B1
7(b)(i)	up / u (charge) = $(+)\frac{2}{3}e$ or antidown / $\bar{d} = (+)\frac{1}{3}e$ or $(q) = \frac{2}{3}e + \frac{1}{3}e$	M1
	$q = (+)1e$	A1
7(b)(ii)	hadron(s)	B1
	meson(s)	B1



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Question	Answer	Marks
1(a)	only ampere and kilogram underlined	B1
1(b)(i)	percentage uncertainty = $2.1 + 0.6 + (1.5 \times 2)$	C1
	= 5.7%	A1
1(b)(ii)	absolute uncertainty = $(5.7 / 100) \times 8.245 \times 10^9$ (= 4.7×10^8 Pa or 0.47×10^9 Pa)	C1
	$E = (8.2 \pm 0.5) \times 10^9$ Pa	A1

Question	Answer	Marks
2(a)	$T \sin 68^\circ + 32 = 280$	C1
	$T = 270$ N	A1
2(b)(i)	$F = \rho g V$ $V = 280 / (1.0 \times 10^3 \times 9.81)$ = 0.029 m ³	A1
2(b)(ii)	$\rho = (32 / 9.81) / 0.029$	C1
	= 110 kg m ⁻³	A1

Question	Answer	Marks
2(c)	$(\Delta)E = mg(\Delta)h$ or $(\Delta)E = W(\Delta)h$	C1
	$(\Delta)h = (-) 77 / 32$	C1
	$(\Delta)h = (-) 2.4$ final height = $6.2 - 2.4$ $= 3.8 \text{ m}$	A1
2(d)(i)	$T = kx$ where k is a constant or $T = (EA / L)x$ where A is (cross-sectional) area, E is Young modulus, L is (original/unstretched) length	B1
2(d)(ii)	$E = \frac{1}{2} kx^2$ or $E = \frac{1}{2} Fx$ and $F = kx$	C1
	$E = 0.65 \times 2^2$ $= 2.6 \text{ J}$	A1
	or	
	$E = \frac{1}{2} Fx$ $0.65 = \frac{1}{2} \times 270 \times x$ and so $x = 4.8 \times 10^{-3} \text{ m}$ $k = F / x = 270 / 4.8 \times 10^{-3}$ $= 5.6 \times 10^4$	(C1)

Question	Answer	Marks
2(d)(ii)	final $E = \frac{1}{2} \times 540 \times 9.6 \times 10^{-3}$ or $E = \frac{1}{2} \times (270 \times 2) \times (4.8 \times 10^{-3} \times 2)$ or $E = \frac{1}{2} \times 5.6 \times 10^4 \times (9.6 \times 10^{-3})^2$ $= 2.6 \text{ J}$	(A1)

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Question	Answer	Marks
3(a)	$v^2 = u^2 + 2as$ $s = 5.6^2 / (2 \times 9.81)$	C1
	(max height =) $3.1 + 5.6^2 / (2 \times 9.81) = 4.7$ (m)	A1
3(b)	$s = ut + \frac{1}{2}at^2$ $4.7 = \frac{1}{2} \times 9.81 \times t^2$	C1
	$t = 0.98$ s	A1
3(c)	line drawn from a non-zero speed at $t = 0$ to a greater speed at $t = T$	B1
	a single sloping straight line drawn from $t = 0$ to $t = T$	B1
	line starts with a positive non-zero value of v and ends with a negative non-zero value of v	B1
3(d)	acceleration (of the ball)	B1
3(e)(i)	(magnitudes of accelerations are) equal / same	B1
3(e)(ii)	(speeds are) equal / same	B1

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Question	Answer	Marks
4(a)	<u>sum/total</u> momentum before = <u>sum/total</u> momentum after or <u>sum/total</u> momentum (of a system of objects) is constant	M1
	<u>if no (resultant) external force/for a closed system</u>	A1
4(b)(i)	$(3.0 \times 4.0 \times \cos \theta)$ or $(2.5 \times 4.8 \times \cos \theta)$ or (5.5×3.7)	C1
	$(3.0 \times 4.0 \times \cos \theta) + (2.5 \times 4.8 \times \cos \theta) = (5.5 \times 3.7)$	C1
	$\theta = 32^\circ$	A1
4(b)(ii)	(initial $E_K = \frac{1}{2} \times 3.0 \times 4.0^2 + \frac{1}{2} \times 2.5 \times 4.8^2 =$) 53 (J) or (final $E_K = \frac{1}{2} \times 5.5 \times 3.7^2 =$) 38 (J)	C1
	values of initial E_K and final E_K both correct and inelastic stated	A1

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Question	Answer	Marks
5(a)	constant phase difference (between the waves)	B1
5(b)(i)	path difference = 1.5×660 = 990 nm	A1
5(b)(ii)	phase difference = $360^\circ \times 1.5$ = 540°	A1
5(c)	$\lambda = ax / D$	C1
	$x = (660 \times 10^{-9} \times 1.8) / 0.44 \times 10^{-3}$	C1
	= 2.7×10^{-3} m	A1
5(d)	bright fringes are brighter	B1
	no change to dark fringes	B1
	no change to (fringe) separation / (fringe) spacing	B1
5(e)	(blue light has) shorter wavelength	M1
	(so) decrease (slit) separation	A1

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Question	Answer	Marks
6(a)	$V = V_1 + V_2 + V_3$	B1
	$IR = IR_1 + IR_2 + IR_3$ or $(V/I) = (V_1/I) + (V_2/I) + (V_3/I)$ and $R = R_1 + R_2 + R_3$	B1
6(b)(i)	$V/8.0 = 6.0 \times 10^3 / (4.0 \times 10^3 + 6.0 \times 10^3)$ or $I = 8.0 / (4.0 \times 10^3 + 6.0 \times 10^3) = 8.0 \times 10^{-4}$ $V = 8.0 \times 10^{-4} \times 6.0 \times 10^3$	C1
	$V = 4.8 \text{ V}$	A1
6(b)(ii)	total resistance in parallel = $3.0 \times 10^3 (\Omega)$ or $3.0 (\text{k}\Omega)$	C1
	current = $8.0 / (3.0 \times 10^3 + 6.0 \times 10^3)$ $= 8.9 \times 10^{-4} \text{ A}$	A1
6(c)	<u>thermistor</u> resistance increases	B1
	(thermistor resistance increases so total resistance increases so) current decreases (in battery)	M1
	($P = EI$ and E constant so) power decreases	A1

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Question	Answer	Marks
7(a)(i)	P = 0 and Q = 137	A1
	R = -1 and S = 56	A1
7(a)(ii)	lepton(s)	B1
7(b)(i)	(charge of ddd / Y =) $-\frac{1}{3}(e) - \frac{1}{3}(e) - \frac{1}{3}(e) = -1(e)$	B1
	(charge of $\bar{u}d$ / Z =) $-\frac{1}{3}(e) - \frac{2}{3}(e) = -1(e)$	B1
7(b)(ii)	meson: Z / $\bar{u}d$ because consists of a quark and an antiquark	B1
	baryon: Y / ddd because consists of three quarks	B1



Cambridge International AS & A Level

PHYSICS

9702/23

Paper 2 AS Level Structured Questions

May/June 2022

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.

Cambridge International is publishing the mark schemes for the May/June 2022 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

This document consists of **16** printed pages.

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	<u>'List rule' guidance</u> For questions that require <i>n</i> responses (e.g. State two reasons ...): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked <i>ignore</i> in the mark scheme should not count towards <i>n</i>. • Incorrect responses should not be awarded credit but will still count towards <i>n</i>. • 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 <i>n</i> 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 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 <u>independent</u> 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 <u>method</u> 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 <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 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. 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 <u>answer</u> marks. They may depend on an M mark or allow a C 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.
ECF	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 not after XP.
AE	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.
POT	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.
TE	Indicates incorrect transcription of the correct data from the question, a graph, data sheet or a previous answer. For example, the value of 1.6×10^{-19} has been written down as 6.1×10^{-19} or 1.6×10^{19} . 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.
SF	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.
BOD	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').
CON	Indicates that a response is contradictory.
I	Indicates parts of a response that have been seen but disregarded as irrelevant.
M0	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.
^	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.
SEEN	Indicates that a page has been seen.

Question	Answer	Marks
1(a)	$\rho = m / V$	C1
	$V = (4 / 3) \times \pi \times r^3$ $= (4 / 3) \times \pi \times (3.42 / 2)^3$ $(= 20.9 \text{ cm}^3)$	C1
	$\rho = 67 / 20.9$ $= 3.2 \text{ g cm}^{-3}$	A1
1(b)	$\% \rho = \%m + 3 \times \%d$ $= [(2 / 67) \times 100] + [3 \times (0.02 / 3.42) \times 100]$	C1
	$= 3.0\% + 3 \times 0.58\%$ $= 4.7\% \text{ or } 5\%$	A1

Question	Answer	Marks
2(a)	(time =) displacement / velocity	C1
	(time =) $70.0 / 65.0 \cos 4.30^\circ = 1.08 \text{ (s)}$	A1
2(b)	$s = ut + \frac{1}{2}at^2$ $= (65 \times \sin 4.30^\circ \times 1.08) - (0.5 \times 9.81 \times 1.08^2)$	C1
	$s = -0.46 \text{ (m)}$	C1
	height above ground $= 1.66 - 0.46$ $= 1.2 \text{ m}$	A1
2(c)	GPE has decreased	M1
	(total energy conserved so) KE has increased	A1

Question	Answer	Marks
3(a)	(velocity =) change in displacement / time	B1
3(b)(i)	$a = 2400 / 1200$ $= 2.0 \text{ m s}^{-2}$	A1
3(b)(ii)	straight line from the origin with positive gradient (labelled A)	M1
	ending at (20, 40)	A1
3(c)(i)	line starting at origin (with the same gradient as A) and beneath A at all points	B1
	gradient decreasing to zero	B1
	straight horizontal line from $t = 12 \text{ s}$ and ending at $t = 20 \text{ s}$ (and labelled B)	B1
3(c)(ii)	the velocity/speed will increase	B1
	to a new terminal/constant/maximum velocity/speed	B1
	or	
	the car has an acceleration	(B1)
	to a new (higher) terminal/constant/maximum velocity/speed	(B1)

Question	Answer	Marks
4(a)	work (done) = force $\times$ displacement	M1
	(force = mg and distance = Δh)	A1
	(so) work (done) = $mg\Delta h$ <u>and</u> work = $\Delta E_{(P)}$ (so $\Delta E_{(P)} = mg\Delta h$)	
4(b)	gravitational potential (energy) to heat/thermal (energy)	B1
4(c)(i)	$P = mg(\Delta)h / (\Delta)t$ or Fv	C1
	$P = (0.60 \times 9.81 \times 1.4) / 4.0$ or $0.60 \times 9.81 \times (1.4 / 4.0)$	A1
	= 2.1 W	
4(c)(ii)	$P = I^2R$ or IV or V^2 / R	C1
	= $0.09^2 \times 47$ or 0.09×4.23 or $4.23^2 / 47$	A1
	= 0.38 W	
4(c)(iii)	efficiency = $P_{\text{out}} / P_{\text{in}} (\times 100)$ or $E_{\text{out}} / E_{\text{in}} (\times 100)$	C1
	= $0.38 / 2.1 (\times 100)$ or $0.38 \times 4.0 / 2.1 \times 4.0 (\times 100)$	A1
	= 0.18 or 18%	

Question	Answer	Marks
5(a)(i)	power = intensity $\times$ area	C1
	$= 1.3 \times 10^3 \times (\pi \times 0.055^2)$	A1
	$= 12 \text{ W}$	
5(a)(ii)	intensity = power / area $= 12 / (\pi \times 0.0015^2)$ $= 1.7 \times 10^6 \text{ W m}^{-2}$	A1
5(b)(i)	$(\lambda =) v / f \text{ or } c / f$	C1
	$(\lambda =) 3.0 \times 10^8 / 3.7 \times 10^{15} = 8.1 \times 10^{-8} \text{ (m)}$	A1
5(b)(ii)	ultraviolet	A1

Question	Answer	Marks
5(b)(iii)	$d \sin \theta = n\lambda$ or $(1/N) \times \sin \theta = n\lambda$	C1
	$d = 1/2400 \times 10^3 \text{ (m)}$ $= 4.2 \times 10^{-7} \text{ (m)}$ or $N = 2400 \times 10^3 \text{ (m}^{-1}\text{)}$	C1
	$n = 4.2 \times 10^{-7} \times \sin 90^\circ / 8.1 \times 10^{-8}$ or $\sin 90^\circ / 2400 \times 10^3 \times 8.1 \times 10^{-8}$ $n = 5.2$ or 5.1 or when $n = 5$, $\theta = 76.4^\circ$ and when $n = 6$, $\sin \theta > 1$ (so) $n = 5$	B1
	number of maxima = $(2 \times 5) + 1$ = 11	A1
5(b)(iv)	the wavelength has increased	M1
	(so) number of maxima decreases	A1

Question	Answer	Marks
6(a)(i)	line passes through (0,0) and is in first and third quadrants only	M1
	gradient of line becoming less steep in both quadrants and roughly symmetrical	A1
6(a)(ii)	(as I increases) the temperature (of the filament wire/lamp) increases	B1
	(as I / temperature / V increases) the resistance (of wire/lamp) increases	B1
	(as I / temperature / V increases the graph curves because) ratio V/I increases or ratio I/V decreases	B1
6(b)	$R = \rho L / A$	C1
	$= (5.6 \times 10^{-8} \times 5.8) / 3.4 \times 10^{-8}$	A1
	$= 9.6 \, \Omega$	

Question	Answer					Marks																														
6(c)	<table><tr><th colspan="2">position of switches</th><th colspan="3">ammeter readings</th></tr><tr><th>S₁</th><th>S₂</th><th>X / A</th><th>Y / A</th><th>Z / A</th></tr><tr><td>open</td><td>open</td><td>0</td><td>0</td><td>0</td></tr><tr><td>open</td><td>closed</td><td>1.0</td><td>0</td><td>1.0</td></tr><tr><td>closed</td><td>open</td><td>2.0</td><td>2.0</td><td>0</td></tr><tr><td>closed</td><td>closed</td><td>3.0</td><td>2.0</td><td>1.0</td></tr></table>					position of switches		ammeter readings			S ₁	S ₂	X / A	Y / A	Z / A	open	open	0	0	0	open	closed	1.0	0	1.0	closed	open	2.0	2.0	0	closed	closed	3.0	2.0	1.0	B4
	position of switches		ammeter readings																																	
	S ₁	S ₂	X / A	Y / A	Z / A																															
	open	open	0	0	0																															
	open	closed	1.0	0	1.0																															
	closed	open	2.0	2.0	0																															
	closed	closed	3.0	2.0	1.0																															
	second row: both values correct (B1)																																			
third row: all three values correct (B1)																																				
fourth row: $X = Y + Z$ (any values) (B1)																																				
all three values correct (B1)																																				

Question	Answer	Marks
7(a)(i)	${}^{18}_{9}\text{F} \rightarrow {}^{18}_{8}\text{O} + {}^{0}_{(+1)}\beta^{(+)} + {}^{(0)}_{(0)}\nu_{(e)}$ v or neutrino (B1) ${}^{0}_{(+1)}\beta^{(+)}$ (B1) ${}^{18}_{8}\text{O}$ (B1)	B3
7(a)(ii)	up quark to down quark	B1
7(b)(i)	must be three (anti)quarks as largest (negative) quark charge is $(-)\frac{2}{3}$ (e) or mesons can only have a charge of 0 or ± 1 (e)	M1
	(so hadron is) a baryon	A1
7(b)(ii)	any combination of three from: antiup (quark) / up antiquark and/or anticharm (quark) / charm antiquark and/or antitop (quark) / top antiquark	B1