Cambridge Assessment International Education

Cambridge Pre-U

PHYSICS **9792/02**

Paper 2 Written **May/June 2022**

MARK SCHEME

Maximum Mark: 100

Published

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

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

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

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This syllabus is regulated for use in England, Wales and Northern Ireland as a Cambridge International Level 3 Pre-U Certificate.

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.

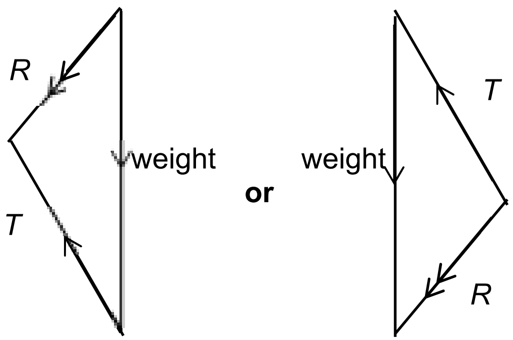
GENERIC MARKING PRINCIPLE 1: Marks must be awarded in line with: • the specific content of the mark scheme or the generic level descriptors for the question • the specific skills defined in the mark scheme or in the generic level descriptors for the question • the standard of response required by a candidate 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 ***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.

Question	Answer	Marks
1(a)	(Γ =) $Wx_{\perp r}$ **or** 850 × (2.50 – 0.80) cos (30°) **or** 850 × 1.70 cos (30°)	**1**
	1.25 × 10^3 (Nm)	**1**
1(b)(i)	(trigonometry that leads to) (5.00 – 0.80) sin (30°) **or** 4.20 sin (30°)	**1**
1(b)(ii)	(anticlockwise) moment (about P) due to weight (of beam) = clockwise) moment (about P) due to rope **or** 1.25 × 10^3 = T × 2.10	**1**
	596 (N)	**1**
1(c)(i)	diagram of form:  **or** equivalent parallelogram	**1**
	length of weight arrow to scale	**1**
	445 (N) ⩽ magnitude ⩽ 455 (N)	**1**
	38(°) ⩽ angle to PQ ⩽ 45(°)	**1**
1(c)(ii)	candidate's magnitude from **(c)(i) and** comment that the direction is opposite to that of R	**1**

Question	Answer	Marks
2(a)(i)	can undergo significant plastic deformation	**1**
2(a)(ii)	can absorb / requires significant amount of energy (before breaking)	**1**
2(b)(i)	strain is directly proportional to stress	**1**
2(b)(ii)	(E =) $4Fl_0 / \pi D^2 x$ **or** $4 \times 1.47 \times 2.50 / (\pi \times (3.76 \times 10^{-4})^2 \times 2.8 \times 10^{-4})$	**1**
	1.2×10^{11} (Pa)	**1**
2(b)(iii)	(external force pulls) atoms further apart / bonds stretching, owtte	**1**
	(interatomic) force increases (uniformly) with (interatomic) separation **or** dislocations do not move	**1**

Question	Answer	Marks
3	any **eight** from: weight of capsule = 95 × 9.81 = 932 N **or** calculation showing the initial acceleration is 9.81 m s^{-2} capsule hits surface of sea at 6.3 s $\leqslant t \leqslant$ 6.4 s **or** with a speed of 44 m s^{-1} capsule hits surface of sea with KE (= ½m40^2) of 92.0 kJ **or** capsule hits seabed with KE of 1.71 kJ capsule hits seabed at t = 9.4 s reaches terminal velocity in water = 6.0 m s^{-1} **or** at 6.9 s $\leqslant t \leqslant$ 7.0 s **or** distance travelled at terminal velocity = 14.4 m resistive force in water = 932 N acceleration (in air) decreases (with time) **or** <u>resultant</u> force (on capsule in air) decreases with time **or** deceleration in water decreases with time (to 7 s then constant) **or** <u>resultant</u> force (on capsule) <u>in water</u> decreases with time (to 7 s then constant) air resistance increases (with increasing speed) **or** drag in water decreases (with decreasing speed) distance travelled (height or depth or their sum) = area under graph height of bridge (above surface of sea) from 155 m to 170 m **or** depth of sea is from 20 m to 26 m **or** height of bridge above seabed / total distance travelled from 179 m to 191 m GPE lost (between bridge and surface) from 147 kJ to 162 kJ **or** GPE lost (between surface and seabed) from 18.0 kJ to 25.0 kJ **or** GPE lost (between bridge and seabed) from 167 kJ to 178 kJ	**8**

Question	Answer	Marks
3	energy transferred to thermal energy between bridge and sea is (GPE lost – KE at sea) = (147 to 162) – 92.0 **or** 55.0 kJ to 70.0 kJ **or** energy lost in sea is 90 kJ terminal speed in air would have been 48 to 54 m s^{-1} momentum on hitting water 4180 kg m s^{-1} / N s **or** momentum at terminal velocity is 570 kg m s^{-1} / N s momentum change / impulse between hitting water and reaching terminal velocity is 3610 kg m s^{-1} / N s (average resultant) force in air 4180 ÷ 6.3 to 6.4 = 663 to 653 N **or** (average resultant) force between hitting the water and terminal velocity in water (3610 ÷ 0.6 to 0.7) = 6017 to 5157 N **or** (average resultant) force between speed of 44 m / s and a lower value e.g. 20 m / s gradient of the graph is the acceleration one value of acceleration calculated at known time / speed (e.g. at t = 2.0 s, a = 8.62 m s^{-2}) **or** one value of an average acceleration one value of (resultant) force calculated at known time or speed (e.g. at t = 2.0 s, R = 819 N or in first 6.3 s, 663 N) corresponding force of air resistance calculated (e.g. at t = 2.0 s, F_R = 113 N) **two** forces of air resistance calculated **and** at known speed; e.g.: when v = 10 m s^{-1}, a = 9.47 m s^{-2} and F_R = 32 N when v = 11 m s^{-1}, a = 9.40 m s^{-2} and F_R = 39 N when v = 20 m s^{-1}, a = 8.46 m s^{-2} and F_R = 128 N when v = 22 m s^{-1}, a = 8.18 m s^{-2} and F_R = 155 N when v = 30 m s^{-1}, a = 6.78 m s^{-2} and F_R = 288 N when v = 40 m s^{-1}, a = 4.42 m s^{-2} and F_R = 512 N when v = 44 m s^{-1}, a = 3.28 m s^{-2} and F_R = 620 N	

Question	Answer	Marks
3	evidence **and** so $F_R \propto v^2$ / $F = kv^2$ hence k = 0.32 N s^2 m^{-2}	

Question	Answer	Marks
4(a)	($\Delta E = mc\Delta\theta$ and $m = \rho V$) $\Delta E = 1.69 \times 10^3 \times 1.36 \times 10^4 \times 1.52 \times 10^3 \times (621 - 260)$	**1**
	1.26×10^{13} (J)	**1**
4(b)(i)	$\dfrac{\text{useful energy output}}{\text{(total) energy input}} \times 100$ **or** $\dfrac{\text{useful power output}}{\text{(total) power input}} \times 100$	**1**
4(b)(ii)	(P =) $\eta\Delta E / \Delta t$ or $37.6 \times 1.26 \times 10^{13} / (100 \times 8.00 \times 3600)$	**1**
	1.65×10^8 (W)	**1**
4(b)(iii)	(P =) VI and $P = I^2R$ **or** $\left(\dfrac{1.65 \times 108}{2.75 \times 105}\right)^2 \times 10.4$	**1**
	3.73×10^6 (J s^{-1}) **or** 3.74×10^6 (J s^{-1})	**1**
4(c)	no change (in pressure) **and** (as the density increases) the height of the liquid decreases (in inverse proportion)	**1**

Question	Answer	Marks
5(a)(i)	(electrical) energy (transferred) / work done (between two points)	**1**
	per unit charge	**1**
5(a)(ii)	energy is dissipated in the battery / internal resistance **or** potential difference exists across internal resistance	**1**
	emf, some of, used within the battery **or** lost volts in the battery	**1**
5(b)(i)	(by symmetry) B, C, D and E are at equal potentials **or** four horizontal resistors can be ignored / carry no current **or** $\frac{1}{13.4} = \frac{1}{2R} + \frac{1}{2R} + \frac{1}{2R} + \frac{1}{2R}$	**1**
	$\frac{1}{13.4} = \frac{1}{2R} + \frac{1}{2R} + \frac{1}{2R} + \frac{1}{2R}$	**1**
	26.8 (Ω)	**1**
5(b)(ii)	(V =) $ER_1 / (R_1 + R_2)$ **or** 18.0 × 13.4 / (13.4 + 1.6) **or** 18.0 × 13.4 / 15.0 **or** (I =) 18.0 / 15.0 = 1.20 (A)	**1**
	16.1 (V)	**1**

Question	Answer	Marks
6(a)	electromagnetic waves are transverse	**1**
	there are many (mutually perpendicular) directions / planes of oscillation at right angles to the transmission direction	**1**
6(b)(i)	$I_{max} < I_0$	**1**
	sinusoidal curve **and** peaks separated by 180°	**1**
	$\cos^2$ graph **and** peaks separated by 180°	**1**
6(b)(ii)	plane of polarisation of light from F_1 is at 45° / not perpendicular to: the plane of polarisation of F_3(and some light emerges from F_3)	**1**
	plane of polarisation of light from F_3 is at 45° / not perpendicular to: the plane of polarisation of F_2	**1**

Question	Answer	Marks
7(a)	(in addition to the their thermal motion) the vibration (of air molecules) parallel to propagation / travel direction (of sound)	**1**
7(b)	(f =) c / λ **or** 330 / 0.600	**1**
	550 (Hz)	**1**
7(c)(i)	(both loud speakers) produce compressions / rarefactions at the same time / moment	**1**

Question	Answer	Marks
7(c)(ii)	(path difference =) 4.080 – 3.930 **or** 0.150 **or** 4.080 / 0.600 **or** 3.930 / 0.600 **or** 6.800 (λ) **or** 6.550 (λ)	**1**
	(phase difference =) path difference / wavelength ($\times$ 360 or $\times$ 2π) **or** 0.150 / 0.600 ($\times$ 360 or $\times$ 2π) **or** (path difference =) 6.800 λ – 6.550 λ **or** 0.250 λ	**1**
	90.0(°) **or** 90.0(°)	**1**
7(c)(iii)	(phasor diagram with) a line labelled 0.0120 (Pa) at right angles to a line labelled 0.0050 (Pa) **or** $0.0120^2 + 0.0050^2$	**1**
	diagonal of phasor / hypotenuse diagram drawn **or** amplitude^2 / $A^2 = 0.0120^2 + 00050^2$ or $\sqrt{0.01202 + 0.00502}$	**1**
	0.0130 (Pa)	**1**

Question	Answer	Marks
8(a)(i)	α-particle source	**1**
	thin gold sheet **or** gold foil **or** gold leaf	**1**
	diagram **and** vacuum **or** movable detector **or** at least three detectors in different positions **or** (fluorescent) wrap-around screen / detector	**1**
8(a)(ii)	overwhelming majority pass straight through showing that most of the atom is empty space / nucleus is very small (compared with atom)	**1**
	some α-particles are deflected through large angles showing that charged particles are repelled / have same charge as by the nucleus	**1**

Question	Answer	Marks
8(b)(i)	3	**1**
8(b)(ii)	52	**1**
8(b)(iii)	neutrons produced are absorbed by / hit other (uranium-235) nuclei	**1**
	these <u>nuclei</u> split / undergo fission / produce more neutrons (and so on)	**1**
8(b)(iv)	(thin rods so) neutrons are very likely to escape / pass through the sides of the rod	**1**

Question	Answer	Marks
9(a)(i)	(electron) diffraction	**1**
9(a)(ii)	(this is) superposition (which is a wave property)	**1**
	(electrons have) wavelike property **or** (electrons) behave like waves **or** wave-particle duality mentioned	**1**
9(b)	rings become smaller **or** pattern more compressed	**1**
	momentum increases **or** brighter **or** $n\lambda = d \sin\theta$ **or** $\lambda = h / mv$	**1**
	(de Broglie) wavelength decreases	**1**

Question	Answer	Marks
10(a)(i)	track is curved **or** track not straight	**1**
10(a)(ii)	LH rule shows resultant force is to left if particle is positive **or** deflection (in magnetic field) shows that the (electric) current is from A to B	**1**

Question	Answer	Marks
10(a)(iii)	track becomes more curved/smaller *r* **or** radius of curvature decreases	1
	v decreases because $r = mv / BQ$ **or** $r \propto v$	1
	energy absorbed by lead **or** kinetic energy decreases	1
10(b)(i)	X has nucleon number 206 and proton number 82	1
	alpha has nucleon number 4 and proton number 2 and symbol He / alpha / α	1
10(b)(ii)	sum of momenta (relative to centre of mass of system) = 0	1
	$(v_X / v_a) = 4 / 206$ which is 0.0194 **or** slightly less than 0.02 / 2%	1
10(b)(iii)	$\frac{E_\alpha}{E_X} = \frac{½m_a v_a^2}{½\,m_X v_X^2}$ **or** (k.e. =) $½mv^2$	1
	$(\frac{E_\alpha}{E_X} = \frac{½m_a v_a^2}{½\,m_X v_X^2}) = \frac{½(m_a v_a)v_a}{½\,(m_X v_X)v_X}$	1
	$(\frac{E_a}{E_X} = \frac{½m_\alpha v_\alpha^2}{½\,m_X v_X^2} = \frac{½(m_a v_a)v_a}{½\,(m_X v_X)v_X}) = \frac{½pv_a}{½pv_X} = \frac{v_a}{v_X}$	1
10(c)(i)	nucleon number is unchanged / both sides of the equation have 210 on top **or** baryon number of neutron and proton / nucleon = 1 (and baryon number of electron = 0)	1
10(c)(ii)	*e* is a lepton **or** right-hand side has lepton number (+) 1	1
	anti-lepton / particle with lepton of number –1 is needed (to give sum of lepton numbers of 0 on RHS)	1
10(c)(iii)	mass of alpha is much bigger than mass of beta (so *v* can be much smaller to give comparable k.e.) **or** alpha-particle is much heavier than beta-particle	1

Question	Answer	Marks
10(d)(i)	sum of momenta of positron and neutron must be 0 in the vertical direction	**1**
	(component of positron momentum in vertical direction =) m_p v_p sin(70°) **or** 9.11 × 10^{-31} kg × 2.2 × 10^8 m s^{-1} × sin(70°) = 1.88 × 10^{-22} N s	**1**
	(component of neutron momentum in vertical direction =) m_n v_n sin(20°) **or** 1.67 × 10^{-27} kg × v_p × sin(20°) **or** 5.71 × 10^{-28} × v_p	**1**
	330 000 (m s^{-1})	**1**
10(d)(ii)	($E = mc^2$ =) 9.11 × 10^{-31} kg × (3.0 × 10^8 m s^{-1})^2 **or** 8.20 × 10^{-14} J (+ ½ × ½ × 9.11 × 10^{-31} × (2.2 × 10^8)^2) (**or** + relativistic value of ke)	**1**
	($f = E / h$ = 8.20 × 10^{-14} J / 6.63 × 10^{-34} J s = 1.24 × 10^{20} Hz $\lambda = c / f$ = 3.00 × 10^8 m s^{-1}/1.24 × 10^{20} Hz =) 2.43 × 10^{-12} (m) **or** 2.14 × 10^{-12} (m)	**1**
10(e)(i)	$0.5I_0 = I_0 \exp\{-\mu t_{½}\} \Rightarrow ½ = \exp\{-\mu t_{½}\} \Rightarrow 2 = \exp\{+\mu t_{½}\}$	**1**
	$\ln(2) = \ln(\exp\{+\mu t_{½}\}) = \mu t_{½} \Rightarrow t_{½} = \ln(2) / \mu$	**1**
10(e)(ii)	($t_{½}$ = 9.5 × 10^{12} km = 9.5 × 10^{15} m $\mu = \ln(2) / t_{½} = \ln(2) / 9.5 \times 10^{15}$ m =) 7.30 × 10^{-17} (m^{-1})	**1**