Cambridge Pre-U

PHYSICS **9792/02**

Paper 2 Written Paper 2 **May/June 2023**

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	<u>Calculation specific guidance</u> 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	<u>Guidance for chemical equations</u> 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)(i)	u_{vert} = speed × sin θ = 210 m s^{-1} × sin(23°) = 82.0535 m s^{-1} = **82 (m s^{-1})**	**1**
1(a)(ii)	vertically, $a = g = (v–u) / t = (0–u) / t$	**1**
	⇒ $t = –u / g$ = 82.05 m s^{-1} / (–9.81 m s^{-2})	**1**
	= 8.364 s **= 8.4 s** (≈ 8 s)	**1**
1(b)(i)	u_{horiz} = speed × cos θ = 210 m s^{-1} × cos(23°) = 193.306 m s^{-1} = **190 (m s^{-1})**	**1**
1(b)(ii)	Any use of correct numbers in suvat equation representing projection e.g. $–160 = 82t – 4.9t^2$; height above launch $s = \big((u+v) / 2\big) \times t = \big((82.1+0) / 2\big) \times 8.36$ s = 343 m	**1**
	Height above sea level = 343 m + 160 m = 503 m Time to fall = √(2 × height / g) = √(2 × 503 m / 9.81 m s^{-2}) = 10.13 s	**1**
	Total time of flight = 8.36 s + 10.13 s = 18.5 s	**1**
	horizontal distance travelled = $u_{\text{horiz}} t$ = 193 m s^{-1} × 18.5 s **= 3600 (m)**	**1**
1(c)	it will stop rising sooner / time less	**1**
	it will not go as far / distance less	**1**
	any sensible suggestion, e.g. • air resistance slows the projectile at a greater rate than 9.81 m s^{-2} / adds to the weight • (mean) horizontal speed will drop • falls from a lower height ⇒ drop in a shorter time (ignoring other factors)	**1**

Question	Answer	Marks
2(a)	Weight is the (gravitational) force	**1**
	Gravitational field strength / *g* is the (gravitational) force per unit mass	**1**
2(b)	at least four equally spaced (by eye) straight lines perpendicular to the lunar surface	**1**
	Arrows on lines pointing downwards	**1**
2(c)	Weight of spacecraft = mg = 4500 kg × 1.6 N kg^{-1} = 7200 N	**1**
	Resultant force F on spacecraft = 16 000 N – 7200 N = 8800 N	**1**
	$a = F / m$ = 8800 N / 4500 kg = 1.96 m s^{-2} = **2.0 (m s^{-2})**	**1**

Question	Answer	Marks
3(a)	Performance is not elastic **and** **Either** Band does not return to its original length (after relaxation) **Or** Work done in extension is greater than energy returned on relaxation	**1**
3(b)	any value of gradient calculated	**1**
	46 (N m^{-1}) (± 3 N m^{-1})	**1**
3(c)	Clear method to find area under upper line (Answer in range 0.55 (J) – 0.68 (J) **……..1**)	**1**
	Answer in range 0.59 (J) – 0.64 (J)	**2**

Question	Answer	Marks
3(d)	Greyed area = work done in stretching – energy released on relaxation **or** energy transferred that is not returned / energy absorbed	**1**
	This is increase in internal energy of rubber band	**1**

Question	Answer	Marks
4(a)	$v = 62 \times 0.45\ \text{m s}^{-1}$ **or** $v = 27.9\ \text{m s}^{-1} = 28\ \text{m s}^{-1}$	**1**
	$a = (v\text{-}u) / t = 28\ \text{m s}^{-1} / 8.9\ \text{s} = 3.1\ \text{m s}^{-2}$	**1**
	$F = ma = 1900\ \text{kg} \times 3.1\ \text{m s}^{-2}$ (= **6000 N)**	**1**
4(b)	$P = Fv \Rightarrow F = P / v$	**1**
	$(F = 0.90 \times)\ 110 \times 10^3 / 45$	**1**
	$0.90 \times 110 \times 10^3 / 45$ (= **2200 N ≈ 2 kN)**	**1**

Question	Answer	Marks
4(c)	energy delivered by battery through motor = 0.90 × 55 = 49.5 kW h	**1**
	converting an energy in kW h to J, e.g. $49.5 \times 10^3 \times (60)^2$ J = 1.78×10^8 J	**1**
	Any one of: • *calculating the driving force for range of 270 km,* e.g. mean driving force $F_m = (1.78 \times 10^8\ \text{J}) / (270 \times 10^3\ \text{m}) = 660$ N • *calculating the energy required to travel 270 km* e.g. (E) = Fd = 2000 × 270 × 1000 = 5.4×10^8 (J) • *calculating the distance covered using the energy in the battery* e.g. (d =) 1.78×10^8 / 2000 = 89 km • *calculating the time taken before the battery runs out* e.g. (t =) 1.78×10^8 / 110 000 × 0.9 = 1800 s and car takes 6060 s	**1**
	The driving force required is larger / energy required is more than in battery / distance covered is too small / time taken is too small for journey **or** comment on difference, e.g. can’t be travelling at top speed, not doing much accelerating / changing direction	**1**

Question	Answer	Marks
5(a)(i)	(current in 18 Ω resistor =) 4.7 V / 18 Ω = 0.26 A	**1**
	current in battery X = **1.1 A – 0.26 A** = 0.84 A	**1**
	Or Kirchhoff 2 round left loop, 4.7 = 18(1.1 – I)	**(1)**
	I = **15.1 / 18** = 0.84 A	**(1)**

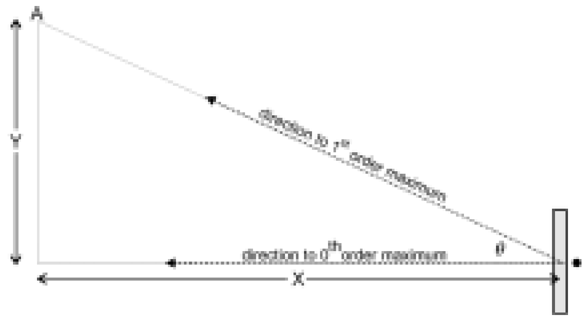
Question	Answer	Marks
5(a)(ii)	$Q = It \Rightarrow$ time = 9000 C / 0.84 A = 10 714 s = 10 714 / 3600 = 2.98 hours = **3.0 (hours)**	**1**
5(b)	Applying Kirchhoff II round outer loop, 4.7 – 4.5 = 0.84 × r	**1**
	r = 0.2 V / 0.84 A = **0.24** (Ω)	**1**
	Or	
	Applying Kirchhoff II round RHS loop, 4.5 = (18 × 0.26) – 0.84 r	**(1)**
	r = (4.68 – 4.5) / 0.84 = **0.21 (Ω)** (or **0.24** Ω using 0.261 A)	**(1)**
5(c)	(as r falls) I will rise	**1**
	(as r falls) X will be charged more rapidly / in less time	**1**

Question	Answer	Marks
6(a)	n_p = sin(45.0°) / sin(28.3°) = **1.49**	**1**
6(b)	n_g = sin(45.0°) / sin(24.6) = 1.70	**1**
	$n_g = c / v_g \Rightarrow v_g = c / n_g$ = 3.00 × 10^8 m s^{-1} / 1.70 = **1.76 × 10^8 (m s^{-1})**	**1**
6(c)	All three correct: (speed) decreases (frequency) stays the same (wavelength) decreases	**1**

Question	Answer	Marks
7(a)	the path difference / phase difference between direct and reflected waves changes	**1**
	one of: • constructive interference / superposition and destructive interference / superposition mentioned • in phase and out of phase mentioned / phase difference changes • path diff = odd number of ½λ intensity is a minimum and when path difference = whole number of λ intensity is a maximum	**1**
7(b)	Length of reflected path = $2 \times \sqrt{\left(d^2 + (½L)^2\right)}$	**1**
	First reflected path = 90.54 cm or 1st path difference = 10.54 cm	**1**
	Second reflected path = 87.48 cm or 2nd path difference = 7.48 cm	**1**
	λ = 3.06 cm = **3.1 × 10⁻² (m)**	**1**
7(c)	Path difference / phase difference between direct and reflected waves is very small	**1**
	which would produce a maximum, so phase change from reflection required	**1**
	Or	
	Phase change of π (at reflection) gives a minimum	**(1)**
	Since path difference / path difference too small to cause a minimum / waves should be in phase	**(1)**

Question	Answer	Marks
8	Any eight points from:	**8**
	Initial beta-count = 0 only alpha emission, so sample is 100% X at time t = 0.	**(1)**
	No / negligible evidence of background radiation	**(1)**
	Finding $T_{½}$ from beginning of α-plot / end of β-plot: Uses 2, 3 or 4 half-lives	**(1)**
	X has half-life 6 minutes	**(1)**
	Y has half-life 12–14 minutes	**(1)**
	decay constant for X: 1.9×10^{-3} / s, 0.12 / min	**(1)**
	decay constant for Y: $9.6 \text{ x } 10^{-4} – 8.3 \times 10^{-4}$ / s; 0.058 – 0.050 / min	**(1)**
	After 50–60 minutes, alpha rate is ≈ 0 so X is virtually depleted	**(1)**
	After 110–120 minutes, beta rate is ≈ 0 so Y is virtually depleted / sample all Z	**(1)**
	At time 11–12 minutes, beta rate is a maximum / Y is at a maximum	**(1)**
	At peak / 11–12 minutes, rate of decay of X = rate of decay of Y	**(1)**
	At peak / 11–12 minutes, number of nuclei $N_X \approx ½ N_Y$	**(1)**
	Area under either graph clearly used to find total number of counts	**(1)**
	from graph, total number of alpha decays = 20 000 – 21 000 **or** number of beta decays = 85 000 – 87 000	**(1)**
	total number of alpha decays measured = 40 / lambda = 21 000	**(1)**
	Because the areas are not equal, the efficiency of the counters are different	**(1)**

Question	Answer	Marks
8	Up to two marks for any two correct comparisons between X, Y and Z of their: • proton number / charge on nucleus • neutron number • mass number / nucleon number	**(2)**

Question	Answer	Marks
9(a)	mark direction of one order e.g. with pin, mark on ruler parallel to grating measurement of two distances to find angle	**1**
	Using  calculating θ e.g. arctan(Y / X) $\lambda = d \sin\theta$ to find λ $f = c / \lambda$ to find f	**1**
	Accuracy feature: any one from	
	• Measure more than one maximum	**1**
	• Use as large values of X, Y as possible	**1**
	• Perform in darkened environment	**1**

Question	Answer	Marks
9(b)(i)	$E = eV$	**1**
	$= 1.60 \times 10^{-19}$ C $\times$ 2.8 V $= 4.48 \times 10^{-19}$ J	**1**
	$E = hf \Rightarrow h = E / f$	**1**
	$= 4.48 \times 10^{-19}$ J / 6.45×10^{14} Hz $= 6.946 \times 10^{-34}$ J s = $\mathbf{6.9 \times 10^{-34}}$ **(J s)**	**1**
9(b)(ii)	5.6 mA $\Rightarrow$ No. of electrons $= 5.6 \times 10^{-3}$ A / 1.60×10^{-19} C	**1**
	$\mathbf{3.5 \times 10^{16}}$	**1**

Section B

Question	Answer	Marks
10(a)	Wood releases its caloric	**1**
	Wood changes (into ash, carbon dioxide, water vapour, smoke etc.) **or** caloric moves to a named location	**1**
10(b)(i)	Seemingly an unlimited supply of caloric / continues to produce heat for a long period of time / supply of heat seemingly inexhaustible **OR** The cannon + the bits machined off had the same specific heat capacities, and therefore the same caloric content per kilogram/ there was no change in properties of the material	**1**
10(b)(ii)	No with explanation, e.g. although plausible, he had not definitely proved that the machining could go on for ever. **OR** Yes with explanation, e.g. caloric / heat is produced without changing the material; thermal energy can be transferred from work done; if work is done / energy transferred for ever	**1**
10(c)(i)	resultant downwards force on masses = mg – friction at pulley = (26.3 kg × 9.81 N kg^{-1}) – 1.80 N = 256.2 N	**1**
	loss of gravitation PE = F × d × n falls = 256.2 N × 3.20 m × 20 = 16 400	**1**
	numerical use of $\Delta E = mc\Delta\theta$ with data from question	**1**
	If temperature rise = $\Delta\theta$ and $mc\Delta\theta$ (for water) + $mc\Delta\theta$ (for brass) = 16 400 J $\Delta\theta$ = 16 400 J / ((6.04 × 4180 J °C^{-1}) + (3.00 × 380 J °C^{-1}))	**1**
	= 16 400 J / 26 390 J °C^{-1} = 0.62 °C	**1**

Question	Answer	Marks
10(c)(ii)	Any *two* points from: • Final $\Delta\theta$ is very small / similar to heating from external causes • Findings contradict accepted theory, so results needed to be very well supported • Many repeats allowed Joule to see that there was a consistent temperature rise / to average his temperature rise • minimising heat losses or gains reduces systematic error / answer is closer to true value / answer is more valid / answer more accurate • repeated readings reduces uncertainty / allows to account for anomalous results	**2**
10(d)(i)	Early steam engine: T_H = (100 + 273) K = 373 K & T_C = (0 + 273) K = 273 K	**1**
	efficiency $= 1 - \frac{T_c}{T_h} = 1 - \frac{273}{373}$ = 1 – 0.732 = 0.27	**1**
	Modern PS: T_H = (560 + 273) K = 833 K & T_C = (5 + 273) K = 278 K	**1**
	efficiency $= 1 - \frac{278}{833}$ = 1 – 0.334 = 0.67	**1**
10(d)(ii)	Any *two* points from: • more friction in the moving parts (pistons, levers, etc.) • leakage of steam at valves and piston • hard to get source hot enough / sink cold enough • work done to lift piston • lack of insulation / heat losses	**2**

Question	Answer	Marks
10(e)(i)	work done per day = 1.1 × 10^9 J / 365 = 3.01 × 10^6 J = **3.0 × 10^6 (J)**	**1**
10(e)(ii)	$COP = \frac{Q_c}{W}$ in any form	**1**
	So Q_C = COP × W = 3.5 × 3.0 × 10^6 J = **1.1 × 10^7 (J)**	**1**
10(f)(i)	COP = 1	**1**
10(f)(ii)	COP > 1 **and** reason more heat emitted than electrical energy used; additional source of energy; some energy comes from the cold sink Q_h > W or Q_C > 0	**1**
10(f)(iii)	Cheaper to install **Or** less construction work needed **Or** Many people don't have access to garden etc. for installation	**1**
10(f)(iv)	Any *one* from: • air is a poor conductor / has low heat capacity • ground is solid / liquid with good contact with heat exchanger • underground temperature is more constant than air source • underground temperature higher than air source (when heating is required) • underground temperature (rather than air temperature outside) closer to temperature inside house (in colder months)	**1**
	explanation (why COP is higher), e.g. W reduced / Q_C increased / $T_H - T_C$ less (for given Q_H)	**1**