Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/04**

Paper 4 A Level Structured Questions **For examination from 2022**

MARK SCHEME

Maximum Mark: 100

Specimen

This document has **14** pages. Blank pages are indicated.

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> (see examples below) 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.

Abbreviations used in the Mark Scheme

/	alternative answers for the same marking point
underline	actual word given must be used by candidate (grammatical variants accepted)
(brackets)	the word or phrase in brackets is not required, but sets the context

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.

Examples of how to apply the list rule

State **three** reasons ... [3]

A

1. Correct	✓	**2**
2. Correct	✓	
3. Wrong	✗	

B (4 responses)

1. Correct, Correct	✓, ✓	**3**
2. Correct	✓	
3. Wrong	ignore	

C (4 responses)

1. Correct	✓	**2**
2. Correct, Wrong	✓, ✗	
3. Correct	ignore	

D (4 responses)

1. Correct	✓	**2**
2. Correct, CON (of 2.)	✗, (discount 2)	
3. Correct	✓	

E (4 responses)

1. Correct	✓	**3**
2. Correct	✓	
3. Correct, Wrong	✓	

F (4 responses)

1. Correct	✓	**2**
2. Correct	✓	
3. Correct CON (of 3.)	✗ (discount 3)	

G (5 responses)

1. Correct	✓	**3**
2. Correct	✓	
3. Correct Correct CON (of 4.)	✓ ignore ignore	

H (4 responses)

1. Correct	✓	**2**
2. Correct	✗	
3. CON (of 2.) Correct	(discount 2) ✓	

I (4 responses)

1. Correct	✓	**2**
2. Correct	✗	
3. Correct CON (of 2.)	✓ (discount 2)	

Question	Answer	Marks
1(a)	gravitational force (of attraction between satellite and planet)	**B1**
	causes centripetal acceleration (of satellite about the planet)	**B1**
1(b)	$M = (4/3) \times \pi R^3 \rho$	**B1**
	$\omega = 2\pi / T$ **or** $v = 2\pi nR / T$	**B1**
	$GM / (nR)^2 = nR\omega^2$ **or** v^2 / nR	**M1**
	completion of algebra to give $\rho = 3\pi n^3 / GT^2$	**A1**
1(c)	$n = (3.84 \times 10^8) / (6.38 \times 10^6) = 60.19$ or 60.2	**C1**
	$\rho = 3\pi \times 60.19^3 / [(6.67 \times 10^{-11}) \times (27.3 \times 24 \times 3600)^2]$	**C1**
	$\rho = 5.54 \times 10^3\ \text{kg m}^{-3}$	**A1**

Question	Answer	Marks
2(a)	$pV = nRT$	**C1**
	$T = (5.60 \times 10^5 \times 3.80 \times 10^{-2}) / (5.12 \times 8.31)$ $T = 500\ \text{K}$	**A1**
2(b)(i)	$V = (3.80 \times 10^{-2}) \times (500 + 125) / 500 = 4.75 \times 10^{-2}\ \text{m}^3$	**A1**
2(b)(ii)	(for ideal gas,) change in internal energy is change in (total) kinetic energy (of molecules)	**B1**
	$\Delta U = (3/2) \times 1.38 \times 10^{-23} \times 125 \times 5.12 \times 6.02 \times 10^{23}$	**C1**
	$\Delta U = 7980\ \text{J}$	**A1**
2(c)(i)	$W = p\Delta V$	**C1**
	$W = 5.60 \times 10^5 \times (4.75 - 3.80) \times 10^{-2}$ $W = 5320\ \text{J}$	**A1**

Question	Answer	Marks
2(c)(ii)	work done on the gas is negative **or** work is done by the gas	**B1**
	increase in internal energy = thermal energy transferred to gas + work done on gas so thermal energy transferred to gas = 7980 – (–5320) = 13 300 J	**A1**

Question	Answer	Marks
3(a)(i)	e.g. period = 6 / 2.5	**C1**
	frequency = 0.42 Hz	**A1**
3(a)(ii)	energy = $\frac{1}{2}m\omega^2 {y_0}^2$	**C1**
	energy = $\frac{1}{2}m \times 4\pi^2 f^2 {y_0}^2$ $= \frac{1}{2} \times 0.25 \times 4\pi^2 \times 0.42^2 \times (1.5 \times 10^{-2})^2$	**C1**
	energy = 1.9×10^{-4} J	**A1**
3(b)	gradual decrease in amplitude, so light (damping)	**B1**

Question	Answer	Marks
4(a)	force proportional to product of charges and inversely proportional to the square of the separation	**B1**
	force between point charges	**B1**
4(b)(i)	(near to each sphere,) fields are in opposite directions **or** point (between spheres) where fields are equal and opposite **or** point (between spheres) where field strength is zero	**M1**
	so same (sign of charge)	**A1**
4(b)(ii)	(at x = 5.0 cm,) $E = 3.0 \times 10^3$ V m^{-1}	**C1**
	$a = qE / m$	**C1**
	$a = (1.60 \times 10^{-19} \times 3.0 \times 10^3) / (1.67 \times 10^{-27})$ $a = 2.9 \times 10^{11}$ m s^{-2}	**A1**

Question	Answer	Marks
4(c)	field strength or E is potential gradient **or** field strength is rate of change of (electric) potential	**M1**
	(field strength) maximum at x = 6 cm	**A1**

Question	Answer	Marks
5(a)(i)	$V_{r.m.s.} = V_0 / \sqrt{2}$	**C1**
	$V_{r.m.s.} = 8.0 / \sqrt{2}$ $V_{r.m.s.} = 5.7\,V$	**A1**
5(a)(ii)	half-wave (rectification)	**B1**
5(b)(i)	line from peak at t = 1.0 ms to minimum (non-zero) value where it meets the printed line after 4.0 ms	**B1**
	correct concave curvature, with gradient never positive	**B1**
	minimum potential difference 6.0 V	**B1**
5(b)(ii)	time = 3.5×10^{-3} s	**A1**
5(b)(iii)	$V = V_0 \exp(-t / RC)$ $6.0 = 8.0 \exp [(-3.5 \times 10^{-3}) / (85 \times 10^{-6} \times R)]$	**C1**
	$R = 140\,\Omega$	**A1**

Question	Answer	Marks
6(a)(i)	PSYV <u>and</u> QRXW	**B1**
6(a)(ii)	electron moving in magnetic field deflected towards face QRXW	**M1**
	so face PSYV is more positive	**A1**
6(b)(i)	PV **or** SY **or** RX **or** QW	**B1**
6(b)(ii)	negative and positive charge (carriers) would deflect in opposite directions	**M1**
	so no change in polarity	**A1**

Question	Answer	Marks
7(a)(i)	product of (magnetic) flux density and (cross-sectional) area	**M1**
	direction of flux normal to (plane of the) area	**A1**
	or (magnetic) flux density × area × sin θ	**(M1)**
	where θ is angle between direction of flux and (plane of the) area	**(A1)**
7(a)(ii)	(induced) e.m.f. proportional to rate	**M1**
	of change of (magnetic) flux linkage	**A1**
7(b)	e.m.f. = $\Delta(\Phi N) / \Delta t$ e.m.f. = $(6.8 \times 10^{-6} \times 2 \times 3.5 \times 96) / (2.4 \times 10^{-3})$	**C1**
	e.m.f. = 1.9 V	**A1**
7(c)	alternating / sinusoidal	**C1**
	with same frequency as supply **or** out of phase with the supply	**A1**

Question	Answer	Marks
8(a)	two from: • there is a frequency below which electrons are not ejected • <u>maximum</u> energy of electron depends on frequency • <u>maximum</u> energy of electrons does not depend on intensity • emission of electrons is instantaneous	**B2**
8(b)(i)	(λ_0 is the) threshold wavelength **or** wavelength corresponding to threshold frequency **or** maximum wavelength for emission (of electrons)	**B1**

Question	Answer	Marks
8(b)(ii)	intercept = $1 / \lambda_0 = 2.2 \times 10^6$ m^{-1} $\lambda_0 = 4.5 \times 10^{-7}$ m	**A1**
8(b)(iii)	gradient = 2.0×10^{-25} or correct substitution into gradient formula	**B1**
	gradient = hc	**C1**
	$h = (2.0 \times 10^{-25}) / (3.0 \times 10^8)$ $h = 6.7 \times 10^{-34}$ J s	**A1**
8(c)	line with same gradient as printed line	**B1**
	straight line with positive gradient, intercept at greater than 2.2×10^6 when candidate's line extrapolated	**B1**

Question	Answer	Marks
9(a)	7^{0}_{-1}e	**B1**
9(b)(i)	$E = mc^2$	**C1**
	$E = 1.66 \times 10^{-27} \times (3.00 \times 10^8)^2$ (= 1.494×10^{-10} J)	**M1**
	division of energy by 1.60×10^{-13} shown, to give 934 MeV	**A1**
9(b)(ii)	$\Delta m = (82 \times 1.00863\text{u}) + (57 \times 1.00728\text{u}) - 138.955\text{u}$ $\Delta m = (-)1.16762$ (u)	**C1**
	energy = 1.16762×934	**C1**
	energy per nucleon = $(1.16762 \times 934) / 139$ = 7.85 MeV	**A1**
9(c)	uranium-235 has a larger nucleon number (than lanthanum-139 and than 56) **or** (fission) reaction releases energy	**M1**
	so (binding energy per nucleon is) less	**A1**

Question	Answer	Marks
10(a)(i)	<u>difference</u> in amount of blackening	**B1**
10(a)(ii)	$I = I_0 \exp(-\mu x)$	**C1**
	ratio = (exp {–1.5 × 2.9}) / (exp {–4.0 × 0.95}) (= exp {–0.55}) ratio = 0.58	**A1**
10(b)(i)	pulses are reflected (from boundaries)	**B1**
	time between transmission and detection (of reflected pulse) gives the depth (of the boundary)	**B1**
	intensity (of reflected pulse) gives information about the nature of the boundary	**B1**
10(b)(ii)	product of density and speed	**M1**
	of sound in the medium	**A1**
10(b)(iii)	coefficient (nearly) 0	**B1**
	coefficient (nearly) 1	**B1**

Question	Answer	Marks
11(a)(i)	substance introduced into the body	**B1**
	absorbed by tissues (being studied)	**B1**
11(a)(ii)	gamma photons	**B1**
11(b)	positrons (emitted) interact with electrons (in tissue)	**B1**
	positron is antiparticle of electron	**B1**
	(pair) annihilation (between the two) / matter turns into energy	**B1**
11(c)	(same mass therefore) combined momentum of electron and positron is zero	**B1**
	photons have momentum so must be two of them (to conserve momentum)	**B1**

Question	Answer	Marks
12(a)(i)	standard candle	**B1**
12(a)(ii)	$F = L / 4\pi d^2$	**C1**
	$2.6 \times 10^{-9} = 4.8 \times 10^{29} / 4\pi d^2$ distance = 3.8×10^{18} m	**A1**
12(b)(i)	(Wien's displacement law states) $\lambda_{max} \propto 1 / T$	**B1**
	so $T = (5800 \times 500) / 430 = 6700$ K (6740 K)	**A1**
12(b)(ii)	$L = 4\pi\sigma r^2 T^4$ $4.8 \times 10^{29} = 4\pi \times 5.67 \times 10^{-8} \times 6700^4 \times r^2$	**C1**
	radius = 1.8×10^{10} m	**A1**

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