Cambridge Assessment International Education – 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.

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	Guidance
1(a)	work done per unit mass (work done) moving mass from infinity (to the point)	**B1** **B1**	Ratio must be clear. **Allow** 'energy' for 'work done'. **Ignore** symbols unless they are defined. **Ignore** references to units. Direction of movement must be clear.
1(b)(i)	**- 3.55 × 10^{7}** J kg^{-1}	**B1**	Must include minus sign
1(b)(ii)	$\varphi = -\frac{GM}{r}$ $M = \frac{--3.55\times10^{7}\times4800\ 000}{6.67\times10^{-11}} = 2.55\times10^{24}$ kg	**B1**	full substitution including *G* must be seen '- -' not necessary for the mark
1(b)(iii)	$g = \frac{GM}{r^2}$ $g = \frac{6.67\times10^{-11}\times2.55\times10^{24}}{4800\ 000^2}$ *g* = 7.4 N kg^{-1} or $g = \frac{\emptyset}{r}$ $g = \frac{3.55\times10^{7}}{4800\ 000}$	**C1** **A1** **(C1)**	ECF from **(b)(i)** Correct to at least 2 s.f. AFC applies.

Question	Answer	Marks	Guidance
	g = **7.4 N kg^{-1}**	**(A1)**	Correct to at least 2 s.f. AFC applies.
1(b)(iv)	r = 26 800 km	**C1**	Tolerance to be decided at STM.
	$\frac{mv^2}{r} = \frac{GMm}{r^2}$ and $v = \frac{2\pi r}{T}$	**C1**	
	$T^2 = \frac{4\pi^2 r^3}{GM} = \frac{4 \times \pi^2 \times (26800 \times 10^3)^3}{6.67 \times 10^{-11} \times 2.55 \times 10^{24}}$ $= 4.47 \times 10^9$	**C1**	
	T = 66800 s T = **19 hours**	**A1**	18.6 Correct to at least 2 s.f. AFC applies.
1(c)	<u>similarity – any one point from</u>: • inversely proportional to distance (from point) • points of equal potential lie on concentric spheres • zero at infinite distance	**B1**	List Rules apply. **Allow** ‘decreases with distance’. **Do not allow** ‘distance squared’ for ‘distance’. **Allow** ‘equipotentials are concentric spheres’. **Allow** ‘circles’ for ‘spheres’ (??)
	<u>difference – any one point from</u>: • gravitational potential is (always) negative • electric potential can be positive or negative	**B1**	List Rules apply. **Do not allow** if also has gravitational potential always positive.

Question	Answer	Marks	Guidance
2(a)	gas for which $pV \propto T$ where T is thermodynamic temperature	**M1** **A1**	**Allow** 'gas for which pV / T is constant'. **Allow** 'gas for which pV = constant × T' provided it is clear that the 'constant' is constant. **Allow** 'absolute' or 'Kelvin' for 'thermodynamic'.
2(b)(i)	two calculations, one for each state e.g. $\frac{1.10\times10^{5}\times540}{(273+27)}$ = 198 000 <u>and</u> $\frac{6.70\times10^{6}\times30}{(273+742)}$ = 198 000 same values / constants are the same so ideal gas	**B1** **B1**	
2(b)(ii)	work is done on the gas as its volume decreases internal energy increases so temperature increases	**B1** **B1**	
2(b)(iii)	$pV = NkT$ e.g. $N = \frac{1.10\times10^{5}\times540\times10^{-6}}{1.38\times10^{-23}\times300}$ $= 1.435 \times 10^{22}$ $\Delta E_k = 3/2\ k\ \Delta T\ N$ $= 3/2 \times 1.38 \times 10^{-23} \times (742 - 27) \times \frac{1.10\times10^{5}\times540\times10^{-6}}{1.38\times10^{-23}\times300}$	**C1** **C1** **A1**	Correct to at least 3 s.f.

Question	Answer	Marks	Guidance
	= **212 J**		AFC applies. Alternative approach: $\Delta E_k = 3/2\ k\ \Delta T \times pV / kT$ C1 $= 3/2\ \ \Delta T \times pV / T$ $= 3/2 \times (742 - 27) \times 1.10 \times 10^5 \times 540 \times 10^{-6} / 300$ C1 = 212 J A1
2(c)	$E = mc\Delta T$ and $E = mL$ $\Delta T = (27 + 196)$ $E = 0.024 \times 1.04 \times (27 + 196) + 0.024 \times 199$ = **10.3 kJ**	**C1** **C1** **C1**	 Correct to at least 3 s.f. AFC applies.
3(a)	P: total energy Q: potential energy R: kinetic energy	**B2**	All correct 2 marks, 1 correct 1 mark.
3(b)	$E = {}^{1}/_{2}\, m\omega^2 x_o{}^2$	**C1**	

Question	Answer	Marks	Guidance
	$6.4 \times 10^{-3} = {}^{1}/_{2} \times 0.130 \times \omega^2 \times 0.015^2$ ω^2 = 438 ω = 20.9 T = 2π / ω = 2π / 20.9 = **0.30 s**	C1 C1 A1	Check at STM for tolerance in E and x_o. 0.300 Correct to at least 2 s.f. AFC applies.
3(c)(i)	force in opposite direction to motion	B1	
3(c)(ii)	$(0.92)^6$ = 0.606 energy lost = 6.4 – (6.4 × 0.606) = **2.5 mJ**	C1 A1	0.08 × 6 × 6.4 = 3.1 mJ is XP
3(c)(iii)	light damping because the amplitude of oscillations gradually reduces or light damping because the system still oscillates	B1	
4(a)	(electric) force is (directly) proportional to product of charges force (between point charges) is inversely proportional to the square of their separation	B1 B1	**Ignore** any symbols unless they are defined. **Ignore** any symbols unless they are defined. **Do not allow** just 'distance' for 'separation' unless it is clear that the distance is between the charges.

Question	Answer	Marks	Guidance
			Do not allow 'radius' for 'separation'.
4(b)(i)	tension, electric force and weight correct and labelled	**B1**	
4(b)(ii)	angle to vertical = $\sin^{-1}$ 0.08/1.2 = 3.82° $F_E = \frac{96\times10^{-9}\times64\times10^{-9}}{4\times\pi\times8.85\times10^{-12}\times0.08^2}$ = 8.63 × 10^{-3} N weight = F_E / tan 3.82 = 8.63 × 10^{-3} / tan 3.82 = 0.129 N mass = 0.129 / 9.81 = 0.013 kg	**C1** **C1** **C1** **A1**	**Allow** angle to the horizontal, 86.2° **Allow** weight = F_E × tan 86.2 = 8.63 × 10^{-3} × tan 86.2 0.0132 Correct to at least 2 s.f. AFC applies.
4(b)(iii)	$E_p = \frac{Q_1Q_2}{4\pi\varepsilon_o r}$ $= \frac{96\times10^{-9}\times64\times10^{-9}}{4\times\pi\times8.85\times10^{-12}\times0.08}$ = **6.9 × 10^{-4} J**	 **A1**	 6.91 Correct to at least 2 s.f. AFC applies.
4(c)(i)	towards the top of the page / towards plate P	**B1**	**Allow** upwards
4(c)(ii)	$F = QE$ and $E = V/d$ F = 1.6 × 10^{-19} × 250 / 0.018	**C1**	

Question	Answer	Marks	Guidance
	= $\mathbf{2.2 \times 10^{-15}}$ **N**	**A1**	2.22 Correct to at least 2 s.f. AFC applies.
4(c)(iii)	*either* the force is not always perpendicular to the velocity *or* the force is always in the same direction / towards plate P	**B1**	
5(a)	from graph ln Q = 2.9 so Q = 18.2 μC $C = Q / V$ = $18.2 \times 10^{-6} / 12$ = 1.5 μF	**B1** **C1** **A1**	must be seen as can reverse calculate
5(b)	gradient = - 0.25 gradient = $-1 / RC$ $R = 1 / (0.25 \times 1.5 \times 10^{-6})$ = $\mathbf{2.6 \times 10^{6}\ \Omega}$	**C1** **C1** **A1**	The first two C marks are independent and can be gained in either order 2.64 Correct to at least 2 s.f. AFC applies.
5(c)	$W = ½\, Q_o V_o$ = $½ \times 18.2 \times 10^{-6} \times 12$ = $\mathbf{1.1 \times 10^{-4}}$ **J** or $W = ½\, C V_o^{2}$	**C1** **A1** **(C1)**	1.09 Correct to at least 2 s.f. AFC applies.

Question	Answer	Marks	Guidance
	$= \frac{1}{2} \times 1.5 \times 10^{-6} \times 12^2$ $=$ **1.1×10^{-4} J**	**(A1)**	Correct to at least 2 s.f. AFC applies.
5(d)	straight line with negative gradient starting from (0, 2.9)	**B1**	no tolerance
	straight line passes through through (4, 0.9) and continues for 5.0 s	**B1**	tolerance to be decided at STM
6(a)	reading is zero when plane of probe is parallel to the (magnetic) field lines	**B1**	
	reading is maximum when plane of probe is perpendicular to (magnetic) field lines	**B1**	
6(b)(i)	number density of charge carriers	**B1**	**Allow** number of charge carriers per unit volume
6(b)(ii)	Smaller value of n so greater Hall voltage / V_H	**B1**	
6(c)	36 mV corresponds to 48 mT	**C1**	The first two C marks are independent and can be gained in either order.
	use of 1.4 s	**C1**	
	$E = \Delta BAN / t$	**C1**	
	$= \dfrac{48 \times 10^{-3} \times 0.018^2 \times \pi \times 780}{1.4}$ $=$ **0.027 V**	**A1**	0.0272 Correct to at least 2 s.f. AFC applies.

Question	Answer	Marks	Guidance
7(a)	photon absorbed (by electron) and electron excited	B1	**Allow** ‘jump to higher energy level’ for ‘excited’ **Ignore** ‘atom’ and ‘gas’ for ‘electron’
	(photon) energy equal to difference in (energy of two) energy levels	B1	Can be for excitation or de-excitation
	photon energy relates to a single wavelength / single frequency	B1	
	electron de-excites and emits photon in any direction	B1	**Allow** ‘falls to lower energy level’ for ‘de-excites’ **Ignore** ‘atom’ and ‘gas’ for ‘electron’ **Allow** ‘all’ for ‘any’ **Allow** ‘re-radiated’ for ‘emitted’
7(b)	$\frac{hc}{\lambda} = E_1 - E_2$	C1	
	uses 656 nm	C1	
	$\frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{658 \times 10^{-9}} = -E_1 - -3.40 \times 1.6 \times 10^{-19}$		
	E_1 = **- 2.42 × 10^{-19} J**	A1	Must include minus sign Correct to at least 3 s.f. (2.417) AFC applies.
8(a)	4, 2 for the alpha particle	B1	

Question	Answer	Marks	Guidance
	234, 92 for the uranium nucleus	B1	
8(b)(i)	$N_o = 0.874 / (238 \times 1.66 \times 10^{-27})$ $= \mathbf{2.21 \times 10^{24}}$	A1	2.212 Correct to at least 3 s.f. AFC applies.
8(b)(ii)	$A = \lambda N$ $= \frac{\ln 2}{87.7 \times 365 \times 24 \times 3600} \times 2.21 \times 10^{24}$ $=$ **5.54 × 10^{14} Bq**	C1 A1	ECF from (b)(i) 5.544 Correct to at least 3 s.f. Unit required with answer. **Allow** ‘s^{-1}’ for ‘Bq’
8(b)(iii)	power $= 5.54 \times 10^{14} \times 5.59 \times 10^{6} \times 1.6 \times 10^{-19}$ = **496 W**	C1 A1	495.9 Correct to at least 3 s.f. AFC applies. Unrounded *A* leads to 495 W, AFC.
8(b)(iv)	$A = A_o e^{-\lambda t}$ $\ln 0.653 = -(\ln 2 / 87.7)\, t$ t = **53.9 years**	C1 A1	Correct to at least 3 s.f. AFC applies.
8(c)	advantage: less mass so less energy needed to get probe into space disadvantage: half-life shorter, will not provide power for long enough	B1 B1	**List rules apply.**

Question	Answer	Marks	Guidance
9(a)	piezo-electric crystal sound wave causes shape change / vibrations shape change / vibrations causes emf which is detected	**B1** **B1** **B1**	 causality needed causality needed
9(b)(i)	**93 V**	**A1**	
9(b)(ii)	**2.7×10^7 rad s^{-1}**	**A1**	**Allow** $8.6 \times 10^6\ \pi$ rad s^{-1}
9(c)(i)	kg m^{-2} s^{-1}	**B1**	
9(c)(ii)	$\rho = Z / c = 1.7 \times 10^6 / 1600$ = **1100 kg m^{-3}**	 **A1**	1060 Correct to at least 2 s.f. AFC applies.
9(c)(iii)	calculation of intensity reflection coefficient (= 0.999 or 1.0) coefficient ≈ 1 so almost all / all ultrasound reflected	**B1** **B1**	 **Allow** Z_1 and Z_2 are very different so almost all / all ultrasound reflected **Allow** coefficient ≈ 1 so almost no / no ultrasound transmitted
10(a)	 brighter star could be closer	 **B1**	**List rules apply.** **Allow** reverse argument if clear

Question	Answer	Marks	Guidance
	brighter star could have a greater luminosity in the visible wavelengths	B1	**Allow** reverse argument if clear **Allow** ‘emit more power’ for ‘have a greater luminosity’ **Allow** brighter star is hotter
10(b)	object with known luminosity	B1	**Allow** ‘star’ or ‘galaxy’ for ‘object’
10(c)(i)	$\frac{660.9-656.3}{656.3} \approx \frac{v}{3.0\times10^8}$ leading to 2.1×10^6 m s^{-1}	B1	
10(c)(ii)	$v = H_0 d$	C1	
	$d = 2.1 \times 10^6 / 2.3 \times 10^{-18}$		
	$=$ **9.1×10^{23} m**	A1	Correct to at least 2 s.f. (9.13) AFC applies.
10(c)(iii)	wavelength has increased / light is redshifted	B1	
	galaxy is moving away (from Earth)	B1	
	universe is expanding	B1	