Oxford Cambridge and RSA

…day June 20XX – Morning/Afternoon

A Level Physics B (Advancing Physics)
H557/02 Scientific literacy in physics

SAMPLE MARK SCHEME

Duration: 2 hours 15 minutes

MAXIMUM MARK 100

This document consists of 20 of pages

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

SCORIS

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *scoris assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to scoris and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

   YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the scoris 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the scoris messaging system.

5. Work crossed out:

    a. where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks

    b. if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)

    - if there is nothing written at all in the answer space
    - OR if there is a comment which does not in any way relate to the question (e.g. ‘can’t do’, ‘don’t know’)
    - OR if there is a mark (e.g. a dash, a question mark) which isn’t an attempt at the question.

    Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The scoris **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

    If you have any questions or comments for your Team Leader, use the phone, the scoris messaging system, or e-mail.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response:

- Read through the whole answer from start to finish.

- Decide the level that **best fits** the answer – match the quality of the answer to the closest level descriptor.

- To select a mark within the level, consider the following:

  Higher mark: A good match to main point, including communication statement (in italics), award the higher mark in the level
  Lower mark: Some aspects of level matches but key omissions in main point or communication statement (in italics), award lower mark in the level.

Level of response questions on this paper are **5(c) and 7(a).**

11. Annotations

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

12. **Subject-specific Marking Instructions**

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Question			Answer	Marks	Guidance
1	(a)	(i)	$h_{image} = (v/u) \times h_{object}$ **or** = (26 / 35) × 2.5 ✓ = 1.9 (cm) ✓	2	1.9 (cm) gains both marks
		(ii)	*($P = 1/f = 1/v – 1/u$)* = 1/(0.35) – 1/(-0.26) ✓ (= 2.86 + 3.85) = 6.7 (D) ✓	2	method mark for adopting the correct method and evaluation mark for getting the correct answer. 6.7 (D) gets both marks
		(iii)	Justifies ignoring Δu as Δv is much greater ✓ uses v = 26.5 **or** 25.5 ✓ evaluation ΔP = 0.08 (D) from 25.5 **or** 0.07 (D) from 26.5 ✓	3	allow $\Delta P / P = \Delta v / v$ giving ΔP = 0.1 (D) *alternative method* This method makes no simplifying assumption Attempt to find P_{max} or P_{min} using Δu = 0.1 & Δv = 0.5 ✓ in same direction, both to increase P or both to decrease P (e.g. 35.1 cm & 26.5 cm or 34.9 cm & 25.5 cm) ✓ evaluation ΔP = 0.09 (D) ✓
	(b)	(i)	New P = 1/0.35 – 1/-(0.26 – 0.027) = 7.2 D ✓ Percentage increase = [(7.2 D – 6.7 D)/6.7 D] × 100% = 7.5 % (≈ 7 %) ✓	2	Allow use of unrounded figures for both Ps, gives 6.6% 7.46 or 7.5 gains both marks
		(ii)	different colours will be imaged at different places ✓ so objects emitting/reflecting light of several colours will not be seen sharply/will be fuzzy/ will have coloured edges✓	2	
			Total	11	

Question			Answer	Marks	Guidance
2	(a)	(i)	$V = 0.20 \times \pi \times 0.025^2 = 3.9 \times 10^{-4}$ (m^3) ✓ $N = pV/kT$ **or** $N = (1.0 \times 10^5 \times 3.9 \times 10^{-4})/(295 \times 1.38 \times 10^{-23})$ ✓ $= 9.7 \times 10^{21}$ ($\approx 10^{22}$) ✓	3	1st mark for getting the volume of the jar; marks 2 and 3 are method and evaluation marks for calculation of the number of molecules. Correct answer gains 3 marks
		(ii)	V per molecule $= 3.9 \times 10^{-4} / 9.5 \times 10^{21} = 4.1 \times 10^{-26}$ (m^3) ✓ $x = \sqrt[3]{(4.1 \times 10^{-26})} = 3.4 \times 10^{-9}$ (m) ($\approx$ 3 nm) ✓	2	Can use 10^{22} to get 3.9×10^{-26} m^3 (gives the same x) Correct answer gains 2 marks
	(b)	(i)	$pV = \frac{1}{3}Nm\overline{c^2} = NkT$ ✓ $\overline{c^2} = 3kT/m \Rightarrow$ r.m.s. speed $= \sqrt{\overline{c^2}}$ ✓	2	
		(ii)	$\text{r.m.s. speed} = \sqrt{\dfrac{3 \times 1.38 \times 10^{-23} \times 295}{2.1 \times 10^{-25}}} = 240$ (m s^{-1}) ✓ distance travelled in the 5 minutes = 240 × 300 = 72 000 m ✓ random walk due to multiple collisions (with air molecules) ✓	3	
			Total	**10**	

Question			Answer	Marks	Guidance
3	(a)		Narrow hole to collimate **or** ensure all alpha particles following same track to start with **or** create a parallel beam ✓ air removed because it would absorb alpha particles before they reached detector ✓	2	
	(b)	(i)	All arrows radially outward from the nucleus✓ arrows 1 and 3 of equal length and shorter than arrow 2✓ arrow 2 is 4 × longer than the others ✓	3	
		(ii)	At closest approach, PE = initial alpha KE ✓ PE (= VQ_{He}) = $kQ_{Au}Q_{He}/R$ ✓ $9.0\times10^{9} \times (79e)\times (2e)/R = 4.8 \times 10^{6} \times e$✓ ($R = 9.0\times10^{9} \times 158e^{2}/(4.8 \times 10^{6} \times e)$ $= 9.0\times10^{9} \times 158 \times (1.6 \times 10^{-19})/(4.8 \times 10^{6})$) $= 4.7 \times 10^{-14}$ (m) ✓	4	1st mark is for applying conservation of energy 2nd mark is for choice of the appropriate equations 3rd mark is for correct substitution into energy equation 4th mark is for correct evaluation. Correct answer gains 4 marks
			Total	**9**	

Question			Answer	Marks	Guidance
4	(a)	(i)	$G = I/V = 0.18/1.4 = 0.129$ (S) ✓ $G = \sigma A/L \Rightarrow \sigma = GL/A = 0.129 \times 0.5/(\pi\times[½\times0.213\times10^{-3}]^2)$ ✓ $= 1.8 \times10^{6}$ (S m^{-1}) ✓ *alternative method* $R = V/I = 0.18/1.4 = 7.8$ (Ω) ✓ $R = \rho L/A \Rightarrow \rho = RA/L = 7.8 \times(\pi\times[½\times0.213\times10^{-3}]^2)/0.5 = 5.54\times10^{-6}$ (Ω m) ✓ $\sigma = 1/\rho = 1/(5.54\times10^{-6}) = 1.8\times10^{6}$ (S m^{-1}) ✓	3	If done through resistance, the method mark for finding σ must include inversion of ρ. correct answer gains 3 marks
		(ii)	(σ too low means that is G also too low so) either I should be larger or V should be smaller ✓ there are p.d. losses across ammeter **or** croc clips/places where clips grip wire ✓ *alternative* Resistance R increases or G decreases ✓ current heats wire due to increased atomic vibrations hindering electron transport ✓	2	1st mark is for the suggestion and the 2nd for the explanation
	(b)	(i)	Three complete continuous loops through core, air gap and plate (not crossing) ✓ Flux lines tend to contract or straighten ✓	2	
		(ii)	Air has a much lower permeability than steel or the core ✓ Overall permeance of the magnetic circuit is much lower when air is present ✓ Giving smaller flux and so less force with air gap ✓	3	allow suitable alternative terms
	(c)		Power supply ~ current carrying coil ✓ emf ~ NI ✓ I ~ flux or ϕ ✓ conductance ~ permeance ✓ value for circuit leads/electromagnet core is greater than that for the alloy wire /steel plate ✓	5	award 1 mark for each correct row
			Total	15	

Question			Answer	Marks	Guidance
5	(a)	(i)	(upthrust = weight so) $Ad\rho_w g = mg$ ✓ $d = mg/A\rho_w g = m/A\rho_w$ ✓	2	
		(ii)	maximum upthrust = $LA\rho_w g$ and weight of rod = $LA\rho_{rod} g$ ✓ if $\rho_{rod} > \rho_w$ then weight > upthrust so it will sink ✓	2	can be done without algebraic treatment by referring to the maximum upthrust being the weight of a volume of water equal to the volume of the rod ✓which must be less than the rod's weight if the density of water is greater than that of the rod ✓
	(b)		upwards force = $\rho_w(d+s)Ag$ and downwards force is still $mg = \rho_w Adg$ ✓ so resultant force $F = \rho_w Asg$ and acceleration = $F/m = \rho_w Asg/m$ ✓ $a \propto -s$ so this is simple harmonic motion ✓ $a = -\omega^2 s$ so $\omega^2 = \rho_w Ag/m$ ✓ $T = 2\pi/\omega$ ✓ (= $2\pi\sqrt{(m/\rho_w Ag)}$)	5	allow reference to additional weight of water displaced when moved from equilibrium. accept in the opposite direction for (-) sign Full credit for corresponding alternative with $2\pi f$ for ω
	(c)*		**Level 3 (5–6 marks)** Both methods compared and advantages of SP and disadvantages of FR identified. Qualitative comparison of uncertainties of the different methods made, even if not completely successful, linking to value for *g*. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Compares both methods and identifies some advantages of SP method. Partial attempt to quantify differences.	6	**Indicative scientific points may include:** **floating rod method** • Method is indirect • Rod may oscillate in different directions • Damping will stop oscillations • Difficult to time a large number of oscillations to reduce ΔT • Water surface will move making it hard to judge position of rod • Use of the formula in the form $g = \frac{4\pi^2 m}{T^2 \rho_w A}$ • Percentage uncertainty in *m* and *A* are small compared with *T*

Question			Answer	Marks	Guidance
			There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence. **Level 1 (1–2 marks)** Makes direct comparison between at least one shortcoming of FR method and an advantage of SP method. No attempt to quantify uncertainty. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or no response worthy of credit.		• T will be of the order of 1 s • $\Delta T/T$ significantly larger than for pendulum • logical argument linking uncertainties in measurement through to value of g **simple pendulum method** • Method is indirect • Can time a large number of oscillations to reduce ΔT • May be systematic error in measuring L • Use of dense bob and light, flexible thread minimises frictional losses • Easy to judge position of bob e.g. passing though centre • Use of the formula in the form $g = \frac{4\pi^2 l}{T^2}$ • T will be of the order of 2s • $\Delta T/T$ significantly smaller than for floating rod • logical argument linking uncertainties in measurement through to value of g
			Total	**15**	

Question			Answer	Marks	Guidance
6	(a)	(i)	Conservation of momentum requires that vector addition of $m_\alpha v_1$ & $m_{\mathrm{He}} v_2$ will give $m_\alpha u$ ✓ For the masses to cancel $m_\alpha = m_{\mathrm{H}\varepsilon}$ ✓	2	allow suitable alternative wording
		(ii)	Pythagoras' theorem gives $(v_1)^2 + (v_2)^2 = (u)^2$ ✓ As $m_\alpha = m_{\mathrm{He}} = m$: $\frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 = \frac{1}{2}mu^2$ ✓	2	
	(b)		Straight line diagonally up to point of pair creation roughly bisecting the 'V' ✓ Gamma is uncharged/not very ionising ✓ e^- and e^+ have opposite charges (so qvB has opposite sign) so they curve in opposite directions ✓ paths are spirals **or** radius of paths becomes less as they go on ✓ (because) the positron and electron are slowing down ✓ due to energy loss through ionising the air particles (which is why you can see the tracks) ✓	6	3rd marking point needs both the observation (paths curve opposite ways) and the inference (particles have opposite charges) allow $r = mv / Bq$
	(c)	(i)	total charge before = 0 (p^+ and p^-) ✓ 4 hadron tracks curve clockwise and 4 anticlockwise, so for every + charge there is a - charge✓	2	

Question			Answer	Marks	Guidance
		(ii)	$mv^2/R = Bqv$ ✓ so $v = BqR/m$ ✓ $= (2.2 \times 1.6 \times 10^{-19} \times 4.6 \times 10^{-3})/2.5 \times 10^{-28}$ $= 6.5 \times 10^{6}$ (m s^{-1}) ✓	**3**	
			Total	**15**	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>7</td><td>(a)*</td><td></td><td>Level 3 (5–6 marks)
Relates desirable and undesirable properties of aluminium during the launch and in the space environment with explanation in terms of physics principles.

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)
Recognises some desirable qualities of aluminium and some disadvantages with some details relating to the launch or space environment but lacks explanation of either.

There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.

Level 1 (1–2 marks)
Recognises that toughness, strength and low density are advantageous as these qualities make it durable and light but does not relate properties to details of the context.

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks
No response or no response worthy of credit.</td><td>6</td><td>Indicative scientific points may include:

Properties of aluminium
• Low density so light
• Strong to withstand stresses e.g. in launch
• Tough so will not crack easily
• May conduct charge from solar wind into sensors
• Changing magnetic field induce emfs in the satellite body which may damage electronics

Demands of environment
• Vacuum of space
• Exposed directly to solar storms or solar wind
• Changing magnetic fields
• Irradiated by UV etc. from Sun
• Cannot be repaired once in position
• Need to manoeuvre easily
• Great stresses during launch</td></tr>
<tr><td></td><td></td><td></td><td align="right">Total</td><td>6</td><td></td></tr>
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Question			Answer	Marks	Guidance
8	(a)		$hc/\lambda = kT \Rightarrow T = hc/k\lambda$ ✓ $T = 6.6 \times 10^{-34} \times 3\times10^{8} / (\lambda \times 1.4 \times 10^{-23})$ Gives range of 1.4×10^{6} K to 1.4×10^{8} K✓ Compares with T of photosphere, e.g. at least 200 × higher temperature ✓	3	Accept other sensible Boltzmann approximations e.g. 3/2 kT Accept Boltzmann factor considerations leading to lower temperatures
	(b)		Must consider 'worst case scenario', i.e. 3200 km s^{-1} speed✓ time to reach Earth = 150×10^{9} m/ 3200×10^{3} m s-1 = 46875 s = 13 hours ✓ Action taken: any one from shut down satellites facing Sun/prepare for power cuts/shield sensitive circuits/disconnect grid circuit breakers ✓	3	ecf wrong choice of speed must convert to hours or days (to have realistic view of time left) allow other reasonable suggestion
			Total	**6**	

Question			Answer	Marks	Guidance
9	(a)		SOHO orbital radius = $(1.50\times10^{11} - 1.5\times10^{9})$ $= 1.485 \times 10^{11}$ (m) ✓ $\omega = 2\pi/T$ ✓ $= 2\pi/(3.2 \times 10^{7}$ s) (= 1.96×10^{-9} rad s^{-1}) ✓ $a = (-)r\,\omega^2 = (1.485 \times 10^{11}$ m) × (1.96×10^{-9} rad s$^{-1})^2$ = (-)5.7×10^{-3} m s^{-2} ✓	4	*Alternative* SOHO orbital radius = $(1.50\times10^{11} - 1.5\times10^{9})$ $= 1.485 \times 10^{11}$ (m) ✓ Speed of SOHO = orbital circumference / time $= 2\pi \times (1.485 \times 10^{11}$ m) / 3.2×10^{7} s) ✓ = 29000 m s^{-1} ✓ $a = v^2/r$ = (29000 m s$^{-1})^2/(1.485 \times 10^{11}$ m) = 5.7×10^{-3} m s^{-2} ✓
	(b)		Net F_{grav} on SOHO = $(-)Gm(M_S/r_S^2 - M_E/r_E^2)$ ✓ = (-)11 N ✓ From (c) centripetal force = mass SOHO x centripetal acceleration = 1900 kg x ((-)5.7×10^{-3}) ✓ = (-)11 N ✓ net gravitational force provides the centripetal force required to enable SOHO to orbit in 1 Earth year ✓	5	ecf from (c) as necessary. ORA
			Total	**9**	

Question			Answer	Marks	Guidance
10			Conservation of energy i.e. ΔGPE = ΔKE ✓ $GMm\,(1/r_{closest} - 1/r_{furthest}) = ½\,m\,(v_{closest}^2 - v_{furthest}^2)$ 3.29×10^{23} J = $(1.1\times10^{14})(v_{closest}^2 - 880^2)$ ✓ $V_{closest}$ = 54 000 m s^{-1} ✓ which is 62 times greater than 880 m s^{-1} ✓	4	
			Total	**4**	

Summary of updates

Date	Version	Change
January 2019	2.0	Minor accessibility changes to the paper: i) Additional answer lines linked to Level of Response questions ii) One addition to the rubric clarifying the general rule that working should be shown for any calculation questions