Practice paper– Set 2

H 556/03 *Unified physics*

MARK SCHEME

Duration: 1 hour 30 minutes

MAXIMUM MARK 70

Final

This document consists of 10 pages

MARKING INSTRUCTIONS

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CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as <u>independent</u> marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are <u>method</u> marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are <u>compensatory</u> method marks which can be scored 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 it. 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 given.

A marks: These are accuracy or <u>answer</u> marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Note about significant figures:

If the data given in a question is to 2 sf, then allow to 2 or <u>more</u> significant figures.
If an answer is given to fewer than 2 sf, then penalise once only in the <u>entire</u> paper.
Any exception to this rule will be mentioned in the Additional Guidance.

Question			Answer	Marks	AO element	Guidance
1	a		$p = \rho gh = 1.3 \times 9.81 \times h = 1.0 \times 10^5$ h = 7.8 km	B1 B1	2.2	
	b	(i)	$-mV_g = ½mv^2$ or $½mv^2 + mV_g = 0$ $V_g = -GM/R = -gR$ $v = \sqrt{(2gR)}$	B1 B1 B1	1.1 2.1	 Working must be shown
		(ii)	$v = \sqrt{(2 \times 9.81 \times 6.4 \times 10^6)} = 11 \times 10^3$ m s^{-1}	B1	2.6	allow 11(.2) km s^{-1}
		(iii)	$½mc^2 = 3/2\ kT$ where $m = (M/N_A) = 6.6 \times 10^{-27}$ kg $T = 6.6 \times 10^{-27} \times 121 \times 10^6 / 3 \times 1.38 \times 10^{-23}$ $T = 1.9 \times 10^4$ (K)	B1 C1 A1	1.2 2.6	**ecf b(ii); allow** m = 4u or $4 \times 1.67 \times 10^{-27}$ **allow** 2 or 2.0
		(iv)	1 random motion and elastic collisions of particles 2 lead to distribution of kinetic energies/velocities among particles 3 a very few will have very high velocities at top end of distribution 4 a long way from mean /r.m.s. velocity at 300 K 5 hence some able to escape	B1 B1 B1 B1	1.1 1.2	**max** 4 out of 5 marking points where answer is a logical progression
		(v)	helium nucleus is an α-particle so helium is generated by radioactive decay helium is found in (natural gas) deposits underground	B1 B1	1.1 2.1	**max** 2 out of 3 marking points
			Total	**15**		

Question			Answer	Marks	AO element	Guidance
2	(a)		gradient = b and *y*-intercept = lg a	B1	3.1	
	(b)	(i)	1.70; 0.41 ± 0.03	B1 B1	2.8	both values for the mark **allow ecf** to find uncertainty value
		(ii)	two points plotted correctly; line of best fit	B1 B1	3.2	**ecf** value and error bar of first point **allow ecf** from points plotted incorrectly
	c	(i)	b = gradient = 1.60 y = 0.86 (± 0.01); x = 1.98 so *y*-intercept = 0.86 – 1.6 x 1.98 = -2.3(1) a = $10^{-2.3}$ = 0.005	B1 B1 B1	3.2	**allow** 1.56 to 1.64; **allow** 1.6 **ecf** gradient in finding y-intercept
		(ii)	worst acceptable straight line b = gradient of steepest line = 1.75 giving uncertainty ± 0.15	B1 B1	3.2	steepest or shallowest possible line that passes through the error bars; should pass from top of top error bar to bottom of bottom error bar **or** bottom of top error bar to top of bottom error bar **allow (**1.6) ± 0.1 or 0.2 where plausible working is shown
			Total	**10**		

Question			Answer	Marks	AO element	Guidance
3		(i)	acceptable pattern with lines touching but not entering spheres lines perpendicular to spheres and arrows from plus ion to minus ion	B1 B1	2.5	adequate drawing for 1 mark award second mark for detail/quality
		(ii)	$E = kQ/r^2$ where $k = 1/4\pi\varepsilon_0$ $E = 9 \times 10^9 \times 1.6 \times 10^{-19}/6.25 \times 10^{-20}$ $E = 2.3 \times 10^{10}$ $2E = 4.6 \times 10^{10}$ (N C^{-1})	C1 C1 C1 A1	1.1 2.6	correct formula with Q = e correct substitution evaluation fields of charges add, **allow ecf** for E
	(b)	(i)	$a = 4\pi^2 f^2 x$ so $k = (m4\pi^2 f^2) = 1.7 \times 10^{-27} \times 4 \times 9.87 \times 43.7 \times 10^{26}$ $k = 292$ (N m^{-1})	C1 B1 A1	1.2 2.6	condition for SHM substitution **ecf** if incorrect mass used
		(ii)	(N2 gives) $F_H = m_H a_H$ and $F_I = m_I a_I$ (N3 gives) $F_H = F_I$ *can be implicit* SHM gives $a \alpha (-)x$ hence $x_H/x_I = a_H/a_I = m_I/m_H = 127$	B1 B1 B1 B1	1.2 2.1 2.2	**allow** total momentum = 0 at all times SHM gives $v = 2\pi f x_{max}$ so $m_H x_H = m_I x_I$ **accept** $127 = x_H/x_I \approx 10/0.08 = 125$
			Total	**13**		

Question			Answer	Marks	AO element	Guidance
4	a *		**see page 7**	**B1 x 6**	3	
	b	(i)	$E = hc/\lambda$; $\Delta\varepsilon = E_1 - E_2 = hc\Delta\lambda/\lambda^2$ $\Delta\varepsilon = 6.63 \times 10^{-34} \times 3 \times 10^{8} \times 0.6 \times 10^{-9} / 5.9^2 \times 10^{-14}$ $\Delta\varepsilon = 3.4 \times 10^{-22}$ (J)	**C1** **C1** **A1**	1.1 2.6	**allow** calculation of $E = hc/\lambda$ twice and difference taken
		(ii)	$\sin\theta = n\lambda/d$; $1/d = 3 \times 10^{5}$ (m^{-1}) $\theta_1 - \theta_2 = \sin^{-1}(2 \times 589.6 \times 3 \times 10^{-4}) - \sin^{-1}(2 \times 589 \times 3 \times 10^{-4})$ $\theta_1 - \theta_2 = 20.717 - 20.695 = 0.022^0$	**C1** **M1** **A1**	1.2 2.6	**or** similar **allow** 20.72 – 20.70
			Total	**12**		

Question			Answer	Marks	Guidance
4	(a)		**Level 3 (5–6 marks)** Clear methods of measurement, statement of uncertainties **and** how to minimise them *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)** Adequate methods of measurement, statement of uncertainties **and** how to minimise them *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)** Limited methods of measurement, statement of uncertainties **or** how to minimise them *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.	B1 x 6	**Indicative scientific points may include:** **M measurement** **D** measured with metre rulers **y** measured using mm graticule on glass screen observed with hand lens **U uncertainty** **D** maximum ±2 mm in 1.5 to 2.0 m 0.1% **y** ±0.5 mm in the position of the centre of each maximum, giving an uncertainty of ±1 mm x = 600 x 10^{-9} x 2/5 x 10^{-4} = 2.4 mm so we have y = 5x with ±1/(2.4 x 5) so of order of 8 to 10% in value of x. **a** vernier to ±0.05 mm in 0.5 mm gives uncertainty of order of 10% **total** uncertainty of about 20% or ± 100 nm to 120 nm **A minimising uncertainties** **D** maximise distance available on bench **y** measuring across the maximum number of x possible **a** suggesting that a more sensitive method is needed, e.g. using slide projector to display enlarged image of slits on screen compared to millimetre scale projected on screen or similar

Question			Answer	Marks	AO element	Guidance
5	**a** *		**see page 9**	**B1x6**	3	
	b	**(i)**	$I = I_0/r^2$ or $I = kr^{-2}$ (k = 20) so $I = 20/(0.25)^2 = 20 \times 16 = 320$	**B1** **B1**	1.1 2.6	**allow** inverse square law statement
		(ii)1	640	**B1**	1.2	
		(ii)2	$640 = 20/r^2$ so $r = \sqrt{(20/640)} = 0.18$ (m)	**C1** **A1**	2.6	**ecf b(ii)1** **accept** 0.177 (m)
			Total question 5	**11**		

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>5</td><td>(a)</td><td></td><td>Level 3 (5–6 marks)
Clear set up and description of chosen experiment(s) and clear interpretation of observations

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)
Limited set up and description of chosen experiment and limited interpretation of observations

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)
Very basic description of chosen experiment and limited interpretation of observations

The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.

0 marks
No response or no response worthy of credit.</td><td>B1 x 6</td><td>Indicative scientific points may include:

1. range/penetration/absorption/deflection experiment suggested

2. suitable arrangement and choice of apparatus e.g. on diagram; allow GM tube as detector for all particles

3. description of range/penetration/absorption experiment:

a. α place detector very close/ 2cm from source; measure count rate, use paper screen or move back to 10 cm or more, measure count rate, interpret result; contrast to background count level and/or other emissions from same source

b. β place detector e.g. 10 cm from source measure count rate, add thin sheets of Al until count drops to very low or almost constant value e.g. γ present; interpret result;

c. γ place detector e.g. 10 cm from source measure count rate, add thin sheets of Pb until count drops to very low/background level; interpret result

4. deflection experiment:
needs vacuum for α experiment;
source for radiation passes through region of E- or B- field;
deflection or not of particles detected by detector to distinguish emissions;
detail of directions;
amount of curvature determines energy of emission; and nature of particle</td></tr>
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Question			Answer	Marks	AO element	Guidance
6	a		Time constant of charging = 10 s maximum current = 10/100k = 100 μA statements about adequate sensitivity of meter and stopwatch	**B1** **B1** **B1** **B1**	3.3	**allow** alternative but equivalent statements **e.g.** current falls to 37 mA in 10 s **e.g.** readings can be taken every 3 to 5 s so can collect at least 8 sets of values before approaching change of less than 2 μA; sensitivity of 0.5 s adequate
	(b)	**(i)**	1 the (total stored) charge is constant 2 capacitors in parallel must come to the same voltage 3 capacitors are identical so each stores half/same charge so final V is 5 V	**B1** **B1** **A0**		**max** 2 out of 3 marking points **allow** mathematical argument, e.g. initial Q = 1 mC final Q on each is 0.5 mC as identical Cs in parallel so V = 0.5 x 10^{-3} x 1.0 x 10^{-4} = 5.0 V **or** total C x total Q gives 5 V
	(ii)		C_1 curve : exponential decay curve from 10 V to 5 V C_2 curve: 10 – C_1 curve time axis: curves to be horizontal at 5V about 25 s	**B1** **B1** **B1**	3.2	 time constant of 5 s
			Total	**9**		