OCR
Oxford Cambridge and RSA

GCE

Physics A

Unit **H556/01:** Modelling physics

Advanced GCE

Mark Scheme for June 2017

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations available in RM Assessor

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
	Incorrect response
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3
TE	Transcription error
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
SF	Error in number of significant figures
	Correct response
	Wrong physics or equation

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
reject	Answers which are not worthy of credit
not	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

MARKING INSTRUCTIONS

Generic version as supplied by OCR Sciences

CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as independent 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 method 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 compensatory 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 answer 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 more significant figures.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.
Any exception to this rule will be mentioned in the Additional Guidance.

SECTION A

Question	Answer	Marks	Guidance
1	B	1	
2	B	1	
3	C	1	
4	A	1	
5	C	1	
6	B	1	
7	B	1	
8	D	1	
9	C	1	
10	B	1	
11	A	1	
12	B	1	
13	A	1	
14	C	1	
15	C	1	
	Total	15	

SECTION B

Question			Answer	Marks	Guidance
16	(a)		work done = 400 × 0.80 work done = 320 (J)	C1 A1	
	(b)		ratio of speeds = ratio of distances (since same time) **or** ratio = 80 / 2 ratio = 40	 C1 A1	 **Allow** 40:1 **Allow** 2 marks for ratio 29.4 (assuming p same) **Not** 1:40 for A1
	(c)		work done = 1200 × 9.81 × 0.02 (= 235.4) efficiency = 235.4 / 320 × 100 efficiency = 74 %	C1 A1	**Note**: Using g =10 N kg^{-1} gives 75%: allow 1 mark max Possible ECF from **(a)** **Note**: 0.74 scores 1 mark **Allow** 2 marks for using 235/320 × 100 = 73% **Allow** use of 9.8 N kg^{-1} gives 73.5% for 2 marks **Allow** 1 mark for 71%, force = (1200g – 400) N used **Allow** 1 mark for 76%, force = (1200g + 400) N used
			Total	6	

Question			Answer	Marks	Guidance
17	(a)		Use a thermometer (with ± 1 ^{o}C)	B1	**Allow** 'temperature sensor/gauge'
			Stir water bath / avoid parallax (for glass thermometer)	B1	**Allow** 'avoid touching sides of water bath with thermometer' **Allow** 'take temperature in several places/times and average' **Allow** idea of 'leave thermometer for long time (to reach thermal equilibrium)' **Not** idea of 'use thermometer with finer resolution'
	(b)	(i)	Smaller (spacing between) divisions / increments (AW)	B1	**Ignore** any reference to accuracy or precision **Allow** 'less uncertainty' **Allow** better or smaller or greater or higher resolution
		(ii)	$p = 37.0 \times 4.448 / (1000 \times 0.0254^2)$ 255 (kPa) uncertainty = 3 (kPa)	 B1 B1	**Allow** clearly identified correct answer in table or in working area. Must be 3sf Must be 1sf **Allow** 255.1 ± 3.4 scores mark 1
	(c)	(i)	Point plotted at (44, 255)	B1	ECF from **(b)(ii)** Plot to with ± half a small square **Ignore** checking error bars

		(ii)*	**Level 3 (5–6 marks)** Clear explanation, description **and** determination *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)** Some explanation, description **and** determination Or Some explanation and clear determination *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 explanation or description or determination *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× 6**	**Indicative scientific points may include:** **Explanation and Description** • Absolute zero is the minimum possible temperature / at absolute zero KE is zero • At absolute zero *p* is zero • At absolute zero, the internal energy is minimum (allow 0) • Absolute zero should be (about) -273 °C • Reference to *p*V = *nRT* or *pV* = *NkT* or p ∝ T • A graph of *p* against θ is a straight line / straight line drawn on graph • Intercept of straight line with *x*- axis or θ-axis is absolute zero calculated by using y= mx + c **Determination** • Gradient in the range 0.7 to 0.9 (kPa K^{-1}) • *y* = *mx* + *c* used to determine the intercept *c* or absolute zero • Absolute zero in the range -320 ^{o}C to -240 ^{o}C Use only L1, L2 and L3 in RM Assessor.

	(d)		Draw the worst fit line (through all the error bars) (AW). Determine the new value for absolute zero and find the <u>difference</u> between the value in **(c)(ii)** and this new intercept. (AW)	**B1** **B1**	
	(e)		Cooling gas value of absolute zero is lower than **(c)(ii)** (Whilst cooling, the) temperature of gas lags behind the temperature of water (AW, ORA) Graph is shifted to the left Stir water / <u>wait</u> for temperatures to be the same / attempt at measuring temperature of gas directly (AW)	**B1** **B1** **B1** **B1**	**Allow**: gradient is too shallow **Allow**: *p* measured is higher than expected for incorrect measurement of *T* (so affects the graph) (AW, ORA) **Not** insulation of water bath **Not** heat losses
			Total	**18**	

Question			Answer	Marks	Guidance
18	(a)	(i)	volume = $7.0 \times 10^{-2} \times \pi \times (0.5 \times 10^{-2})^2$ or 5.5×10^{-6} (m^3)	C1	No ecf for incorrect volume.
			$\rho = 5.0 \times 10^{-3} / (7.0 \times 10^{-2} \times \pi \times (0.5 \times 10^{-2})^2)$		
			density = 910 (kg m^{-3})	A1	Answer to 3 s.f. is 909 **Allow** 1 mark for 230 ($r = 1.0 \times 10^{-2}$ m used)
		(ii)	The density (of wood is) similar to human (AW)	B1	
			Less than density of water / it needs to float / otherwise it will sink	B1	**Allow** 'greater upthrust than weight when fully submerged'
	(b)		($v^2 = 2as + u^2$); $v = (2 \times 9.81 \times 0.30)^{½}$ (Allow any subject)	C1	**Allow** ($s = ½ a t^2$) to give t = 0.247 and (v = at) gives 2.42
			speed = 2.4 (m s^{-1})	A1	
	(c)	(i)	weight / *W* / *mg* **and** downward arrow	B1	**Allow** labels used in **(c)(i)** throughout
			upthrust / *U* **and** upward arrow	B1	**Ignore** arrow sizes.
			drag / *D* / friction **and** upward arrow	B1	**Allow** '(water) resistance' for drag
		(ii)	Resultant force decreases (with time or as cylinder descends)	B1	
			Upthrust remains constant / drag decreases (as speed decreases) / resultant force is upwards / At lowest point, drag is zero	B1	**Allow** 'At lowest point, upthrust > weight' **Note**: Any incorrect answer from the list will not score this point
			At lowest point, resultant force is upwards	B1	**Not** 'resultant force = 0' **Note**: Resultant force is <u>always</u> upwards' scores B1x2
	(d)		Doubling the depth is too much / d is not (directly) proportional to h	B1	
			Qualifying statement using evidence from graph e.g. decreasing gradient, use of numbers to show not proportional, comment about non-zero intercept etc	B1	
			Total	14	

Question			Answer	Marks	Guidance
19	(a)	(i)	$\omega^2 = g/L$ $\omega = \frac{2\pi}{T}$ Correct substitution $\frac{4\pi^2}{T^2} = \frac{g}{L}$ and rearranging to give correct expression	M1 M1 A1	**Note:** Both M1 marks are required to score this A1 mark
		(ii)	Transfer of **energy** to air / retort stand (because of air resistance / friction) No effect on *T* (as *T* is independent of amplitude in SHM for small amplitude oscillations of pendulum)	B1 B1	**Allow** 'loss of energy from pendulum (due to friction)' **Allow** 'work done' for 'energy' **Allow** 'isochronous'

Question	Answer	Marks	Guidance
(b)*	**Level 3 (5–6 marks)** Clear description including steps to obtain high quality data **and** analysis *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)** Clear description **and** some analysis *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 description **and** analysis **Or** limited description *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 × 6**	**Indicative scientific points may include:** **Experiment** **Description** • Pendulum string clamped / fixed (can be shown on diagram) • Use a stopwatch to determine time period *T* • Time multiple oscillations to determine *T* • Use a ruler to measure *L* • Vary length *L* and determine *T* **Quality of Data** • Method used to ensure small oscillations • Small angles i.e. <10 degrees • Idea of fiducial mark • Start/stop timing at the centre of the oscillation • Measure from the fixed point to the centre of the bob **Analysis** • Correct plotting of graph, e.g. T^2 against *L* or *T* against $\sqrt{L}$ or lg*T* against lg*L* • Analysis of data table showing T^2/L = constant

Question			Answer	Marks	Guidance
					• Expect a straight line through the origin • Correct gradient of the line e.g. $4\pi^2/g$ Use only L1, L2 and L3 in RM Assessor.
	(c)	(i)	Correct substitution of T = 2(.0 s) into $T^2 = \frac{4\pi^2}{g}L$ length = 0.99 (m)	C1 A1	**Note**: 1 (m) here cannot score this A1 mark
		(ii)	Lower g / gravitational field strength / acceleration (of free fall) on Moon. T is longer (on Moon) **and** justified by $T^2 = \frac{4\pi^2}{g}L$ or $T^2 \propto 1/g$ or $\frac{4\pi^2}{g}$ is larger	B1 B1	**Accept** 'g is a sixth of g on Earth' AW **Not** gravity (is less)
			Total	**15**	

Question			Answer	Marks	Guidance
20	(a)		power × time = 2200 × 4.0 × 60 energy = 5.3×10^5 (J)	C1 A1	 **Note**: Answer to 3 s.f. is 5.28×10^5 (J)
	(b)		Energy used to heat water to 100 ^oC = 0.60 × 4200 × 80 (= 201.6 kJ) Energy remaining to vaporise water = 528 (kJ) – 201.6 (kJ) (= 326.4 (kJ) mass vaporised = 326.4×10^3 / 2.3×10^6 = 0.1419 (kg) mass of water left = 0.60 – 0.1419 mass of water left = 0.46 (kg)	C1 C1 C1 A1	 Possible ecf from **(a)**
			Total	**6**	

Question			Answer	Marks	Guidance
21	(a)	(i)	electron bound to nucleus / represents energy electron must gain to leave the atom / total energy of electron in atom is less than that of a free electron	B1	**Allow** ionisation level defined as zero as AW for 'represents electron must gain energy to leave atom / move up energy level' **Allow** potentials for attractive forces are negative.
		(ii)1	energy = 2.55 (eV)	B1	Ignore sign
		(ii)2	energy = $2.55 \times 1.60 \times 10^{-19}$ (J) $\lambda = \frac{6.63\times10^{-34}\times3.0\times10^{8}}{2.55\times1.60\times10^{-19}}$ (Allow any subject) wavelength = 4.9×10^{-7} (m) wavelength = 490 (nm)	C1 C1 A1	Possible ECF from **(ii)1** **Note:** wavelength = 488 (nm) to 3 sf
	(b)	(i)	Electron(s) makes a transition to a lower (energy) level / loses energy **and** emitting a photon(s) / EM radiation	B1	
		(ii)	Reduce grating separation / increase distance between grating and screen	B1	**Allow** 'use finer grating' or 'use grating with more lines mm^{-1}' **Not** 'smaller slit size'
		(iii)	wavelength (of peak) = 661.5 nm $v = 3.0 \times 10^{8} \times (661.5 - 656.3) /$ **656.3** recession velocity = 2.4×10^{6} (m s^{-1})	C1 C1 A1	**Allow:** between 661 and 662 nm **Note:** check divided by 656.3 nm Range of acceptable answers. 2.1(5)-2.6(1) x 10^{6}
		(iv)	(Relative) abundance of hydrogen (AW)	B1	**Allow** 'Hydrogen commonly found in stars' (AW)
	(c)		Less intense Galaxy is moving faster **and** therefore greater / longer wavelength (AW) Periodic shift in wavelength (if plane of orbit is in line of sight) (ORA)	B1 B1 B1	 **Allow** 'greater red shift' / 'greater Doppler shift' / 'to the right' for longer wavelength **Allow** argument referring to splitting of line because of relative velocities of two component stars. **Not** idea of blue shift.
			Total	14	

Question			Answer	Marks	Guidance
22	(a)		The sum of (the random distribution of) the KE and PE of (its) molecules	B1	**Not** if no clear indication of particulate nature, i.e. allow particles or atoms for molecules
	(b)		No change in KE	M1	**Allow** 'KE is not changing' **Not** 'KE is not increasing'
			because temperature is constant (during melting)	A1	
			PE of (the molecules) increases (during melting)	M1	
			The internal energy increases	A1	**Note:** This A1 mark can only be scored if both M1 marks have been awarded.
			Total	5	

Question			Answer	Marks	Guidance
23	(a)		$V_{(g)} = -\frac{GM}{r}$	B1	
	(b)	(i)	KE = ½mv^2 **and** GPE = GMm/r ½mv^2 = GMm/r then a valid step to $v = \sqrt{(2GM/r)}$	C1 A1	 **Allow** m = 1 (kg) if clearly defined
		(ii)	($v^2 = 2 \times 6.67 \times 10^{-11} \times 0.131 \times 10^{23} / 1.19 \times 10^6$) v = 1200 (m s^{-1})	 A1	 Answer to 3.s.f. is 1210
		(iii)	Mercury has a higher escape velocity than Pluto (ORA) Mercury is closer to sun **and** Mercury is hotter (ORA) Molecules on Mercury (are more likely to) have **speed** higher than the escape velocity	B1 M1 A1	**Allow** a supporting calculation (speed is about 4.2 km s^{-1}) **Allow** 'required speed' for 'escape velocity' **Allow** 'fast enough to escape'
			Total	7	

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