OCR
Oxford Cambridge and RSA

A Level Physics A

H556/01 Modelling physics

MARK SCHEME

Duration: 2 hours 15 minutes

MAXIMUM MARK 100

This document consists of 21 pages

PREPARATION FOR MARKING ON-SCREEN

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

2. Make sure that you have read and understood the Instructions for On-Screen Marking and 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 and the **required number** of standardisation responses.

PREPARATION FOR PAPER BASED MARKING

1. Make sure that you have accessed and completed the relevant training for paper based marking.

2. Make sure that you have read and understood the Instructions for Specialist Marking and the mark scheme and the question paper for this unit.

3. Before the Standardisation meeting you must mark at least 10 scripts from several centres. Use **pencil** and follow the **mark scheme**. Bring these **marked scripts** to the meeting

MARKING INSTRUCTIONS – FOR MARKING ON-SCREEN AND FOR PAPER BASED 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 40% 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 or the scoris messaging system, or by email.

5. **Crossed Out Responses**
   Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.

Rubric Error Responses – Optional Questions
Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple Choice Question Responses
When a multiple-choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).
When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses
When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only **one mark per response**)
Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth **two or more marks**)
If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

Longer Answer Questions (requiring a developed response)
Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

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. Award No Response (NR) if:
   - there is nothing written in the answer space

   Award Zero '0' if:
   - anything is written in the answer space and is not worthy of credit (this includes text and symbols).

   Team Leaders must confirm the correct use of the NR button with their markers before live marking commences and should check this when reviewing scripts.

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. **Level of response (LoR)**

   Read through the whole answer from start to finish, concentrating on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance.

   Using a 'best-fit' approach based on the science content of the answer, first decide which set of level descriptors, Level 1 (L1), Level 2 (L2) or Level 3 (L3), **best** describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme.

   Once the level is located, award the higher or lower mark.

   The higher mark should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met. **The lower mark** should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.

   In summary:
   - the **science** content determines the **level**
   - the **communication statement** determines the **mark within a level**.

10. Here are the subject specific instructions for this question paper.

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.

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.

11. Annotations available in RM Assessor

Annotation		Meaning
	Correct response	Used to indicate the point at which a mark has been awarded (**one tick per mark awarded**).
	Incorrect response	Used to indicate an incorrect answer or a point where a mark is lost.
AE	Arithmetic error	Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors.
BOD	Benefit of doubt given	Used to indicate a mark awarded where the candidate provides an answer that is not totally satisfactory, but the examiner feels that sufficient work has been done.
BP	Blank page	Use BP on additional page(s) to show that there is no additional work provided by the candidates.
CON	Contradiction	No mark can be awarded if the candidate contradicts himself or herself in the same response.
ECF	Error carried forward	Used in numerical answers only, unless specified otherwise in the mark scheme. Answers to later sections of numerical questions may be awarded up to full credit provided they are consistent with earlier incorrect answers. Within a question, ECF can be given for AE, TE and POT errors but not for XP.
L1	Level 1	L1 is used to show 2 marks awarded and L1^ is used to show 1 mark awarded.
L2	Level 2	L2 is used to show 4 marks awarded and L2^ is used to show 3 marks awarded.
L3	Level 3	L3 is used to show 6 marks awarded and L3^ is used to show 5 marks awarded.
POT	Power of 10 error	This is usually linked to conversion of SI prefixes. Do not allow the mark where the error occurs. Then follow through the working/calculation giving ECF for subsequent marks if there are no further errors.
SEEN	Seen	To indicate working/text has been seen by the examiner.
SF	Error in number of significant figures	Where more SFs are given than is justified by the question, do not penalise. Fewer significant figures than necessary will be considered within the mark scheme. **Penalised only once in the paper.**
TE	Transcription error	This error is when there is incorrect transcription of the correct data from the question, graphical read-off, formulae booklet or a previous answer. Do not allow the relevant mark and then follow through the working giving ECF for subsequent marks.
XP	Wrong physics or equation	Used in numerical answers only, unless otherwise specified in the mark scheme. Use of an incorrect equation is wrong physics even if it happens to lead to the correct answer.
^	Omission	Used to indicate where more is needed for a mark to be awarded (what is written is not wrong but not enough).

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

SECTION A

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

SECTION B

Question			Answer	Marks	Guidance
16	(a)	(i)	vertical component =30.0 sin(70°) or 30.0 cos(20°) vertical component = 28.2 (m s^{-1})	 A1	 **Allow** 2 SF answer of 28
		(ii)	Evidence of $v^2 = u^2 + 2as$ and $v = 0$ or $gh = ½ u^2$ $h = \frac{28.2^2}{2\times9.81}$ (Any subject) h = 40.5 (m)	C1 M1 A0	**Allow** v and u interchanged; a and g interchanged **Allow** use of candidate's answer for (a)(i) at this point **Ignore** sign **Allow** $h = \frac{28^2}{2\times9.81}$ or (30 sin(70))^2/(2 x 9.81) **No ECF from (a)(i) for the second mark**
		(iii)	The ball has horizontal motion / velocity (AW)	B1	**Allow** idea of horizontal e.g. sideways, forwards **Not:** 'moving' unqualified
		(iv)	(horizontal velocity =) 30.0 cos 70° or 10.2…. (m s^{-1}) or 30.0 sin 20°. E_k = ½ × 0.057 × 10.26^2 E_k = 3.0 (J)	C1 A1	 **Allow** 1 SF answer **Not** 22 (J), v = 28 used **Not** 23 (J), v = 28.2 used **Not** 140 (J), v = 70 used

	(b)*		**Level 3 (5–6 marks)**
			Clear description 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)
			Some 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 limited analysis
			or limited description
			or limited analysis
			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 (NR) or no response worthy of credit (0).
				B1× 6	**Indicative scientific points may include:**
					Description
					• Ruler used to determine *x*
					• Average readings to determine *x*
					• *x* recorded for various *v*
					• Suitable method for consistent *v* or varying *v* e.g.
					  • Released from same point on a track
					  • Ejected from a spring device with different compressions
					• Suitable method of determining point of impact e.g.
					  • trial run to get eye in approximate correct position
					  • carbon paper so that ball makes a mark on paper
					  • scale in frame of video recording
					  • tray of sand to catch ball
					• Suitable instrument used to determine *v* (light-gate / motion sensor / video techniques) or suitable description of inference of v from other measurements such as energy released from spring of known *k* and *x*
					• Ensuring the initial velocity of ball is horizontal
					
					Analysis
					• Horizontal velocity is constant
					• Time of fall is independent of *v*/horizontal velocity
					• Suggested relationship: e.g. $x \propto v$,x d.p. to v^2, etc
					• Plot a graph of *x* against *v* or graph consistent with candidate's suggested relationship
					• If relationship is correct, then a **straight line** through the **origin**.
					• Suggested relationship supported by correct physics or algebra.
					• Correct relationship supported by physics.
					Note:
					L1 is used to show 2 marks awarded and L1^ is used to show 1 mark awarded.

			Total	**12**	

Question			Answer	Marks	Guidance
17	(a)	(i)	Horizontal arrow pointing to the right.	B1	Judgement by eye
		(ii)	$2.14 \times 10^3 = \frac{2\times\pi\times9380\times10^3}{T}$ (Any subject) $T = 2.75 \times 10^4$ (s)	C1 A1	 **Allow** 2SF answer **Note**: 2.75… x 10^n scores 1 mark.
		(iii)	$\frac{GMm}{r^2} = \frac{mv^2}{r}$ or $v^2 = \frac{GM}{r}$ $(2.14 \times 10^3)^2 = 6.67 \times 10^{-11} \times M/9380 \times 10^3$ $M = 6.44 \times 10^{23}$ (kg)	C1 C1 A1	 **Allow** ecf of answer for T from (a)(ii) **Allow** 2 SF answer **Note:** Use of 2.8 x 10^4 seconds gives 6.3 x 10^{23} (kg) for 3 marks. **Alternative Method for C1C1** • $M = 4\pi^2R^3/(T^2G)$ (Databook formula re-arranged with M as subject) • $M = 4\pi^2(9380 \times 10^3)^3/((2.75 \times 10^4)^2 \times 6.67 \times 10^{-11})$ (i.e. *M* as subject) **Note:** In alternative method, PoT error forgetting km->m conversion gives 6.46 x 10^{14} (kg) for 2 marks.
	(b)	(i)	- 0.060 and 3.85 (Both to 2 sf after the decimal point)	B1	**Allow -** 0.06 or -0.0605 (the minus sign is required) **Not: 0.06** **Allow:** 3.845(1) **Note:** Use of ln gives -0.14 and 8.854 for 0 marks.
		(ii)1	Missing data point plotted to ± half small square consistent with candidate's value.	B1	**Allow** ECF from (b)(i)

Question			Answer	Marks	Guidance
			Straight best fit line drawn	**B1**	**Allow** ECF for incorrectly plotted point or data point from **(i)** omitted
		(ii)2	(Triangle used to determine gradient and) gradient calculation is shown to be within range -1.90 to -2.20	**B1**	
		(ii)3	lg(g) = lg(GM) – 2lg(r) or lg(g) = – 2lg(r) + lg(GM) seen **Compared** with $y = mx + c$, and hence gradient = - 2	**M1** **A1**	**Allow:** incorrect handling of negative g.
	(c)	**(i)**	Any <u>two</u> from: • Direction of g for Earth and Mars are in opposite directions • For small values of r / r < about 4.4 ($\times 10^{10}$ m) g for Earth is greater or resultant g is towards the Earth • At r about 4.4 ($\times 10^{10}$ m) the g values are the same/AW • Inverse square law for g for either planet causes curve near to either planet's surface/AW • Zero point for (resultant) g is further from the Earth (than the midpoint) since Earth has a larger mass than Mars • g at Earth's surface is larger than g at surface of Mars because Earth has a larger mass than Mars	**B1×2**	**Allow** field / (gravitational) force for g **Allow** for r values larger than 4.4 (x 10^{10} m) g for Mars is greater or resultant g is towards Mars
		(ii)	Any valid equation relating g_{Earth} and g_{Mars} e.g. $GM_{Earth}/r_E^2 = GM_{Mars}/r_M^2$	**C1**	

Question			Answer	Marks	Guidance
			ratio consistent with values above	**A1**	**Note:** the correct ratio is in the range 8.2 to 12 allowing for values of r of 4.4 ± 0.1 ($\times 10^{10}$ m) when $g = 0$
			Total	**16**	

Question			Answer	Marks	Guidance
18	(a)		$1.2 \times 10^6 = ½ \times$ (mass per second) $\times 8.0^2$ mass per s = 3.8×10^4 (kg s^{-1})	C1 A1	 Answer is 3.75×10^4 (kg s^{-1}) to 3sf **Note:** 3.8×10^n (kg s^{-1}) scores 1 for PoT error.
	(b)	(i)	$A \rightarrow$ m^2 and $\rho \rightarrow$ kg m^{-3} $P \rightarrow$ kg m^2 s^{-3} Clear working to show units are equivalent on either side of equation	M1 M1 A1	**Note**: No mark for $v \rightarrow$ m s^{-1} since units are in **(a)** **Allow** $P \rightarrow$ kg m s^{-2} m s^{-1} (from $P = Fv$ or P=Work done/t) **Note:** clear working includes m^3s^{-3} seen.
		(ii)	$1.2 \times 10^6 = ½ \times 1.3 \times A \times 8.0^3$ or A = 3600 (m^2) seen L = 34 (m)	C1 A1	**Allow** volume s^{-1} = 28846 (m^3) using 3.75×10^4 (kg s^{-1}) or 29231 (m^3) using 3.8×10^4 (kg s^{-1}) **Allow** ECF from (a) **Note:** 3.4×10^n (m) scores 1 for PoT error.
		(iii)	(output power =) 0.42×1.2 / 0.504 (MW) (*N* = 50/0.504 = 99.2) *N* = 100	C1 A1	**Allow:** 50×10^6 / 0.42 = 119 MW and then 119 / 1.2 **Not** 99 **Note**: answer of 99.2 scores 1 mark max
			Total	9	

Question			Answer	Marks	Guidance
19	(a)		**A** = white dwarf and **B** = red giant	**B1**	**Allow:** red supergiant for B **Not:** neutron star for A
	(b)	(i)	(λT = constant) $550 \times 5800 = 370 \times T$ T = 8600 (K)	 **C1** **A1**	 **Allow** however expressed Answer is 8620 to 3 sf
		(ii)	**P** on the main sequence and to LEFT of Sun.	**B1**	**Allow:** ECF from **(b)(i)** **Note:** temperature of Sun is 5800 K.
			Total	**4**	

Question			Answer	Marks	Guidance
20	(a)		$E_k = ½ mv^2$ and $p = mv$ (Correct manipulation leading to) $E_k = ½ p^2/m$	M1 A1	**Allow:** any subject **Allow:** $E_k = p^2/(2m)$
	(b)	(i)	From t = 0 to t = 2.0 s: a non-zero horizontal line From t = 2.0 to t = 3.5 s: line showing v = 0 From t = 3.5 to t = 4.0 s: non-zero horizontal line showing v is opposite in direction and magnitude larger than that of line drawn at t = 0 to t = 2.0.	B1 B1 B1	 Judgement by eye
		(ii)	KE is constant. GPE increases linearly / proportional to t	B1 B1	 **Allow**: 'at constant rate' for 'linear' **Not:** unqualified 'constantly'
		(iii)1	$V^2 = 0.80^2 + 2 \times 9.81 \times 0.40$ V = 2.9 (m s^{-1})	C1 A1	 **Allow** 1 mark for $(2 \times 9.81 \times 0.40)^{1/2}$ = 2.8 (m s^{-1})
		(iii)2	$F = 0.12 \times 2.9/0.025$ F = 14 (N)	C1 A1	 Possible ECF from **(iii)1** **Note:** use of 2.8 m s^{-1} gives F = 13(.44 N) **Note:** 1.4 x 10^n (N) scores 1 mark
			Total	11	

Question			Answer	Marks	Guidance
21	(a)		Both forces act on the same object (AW) The types of forces are different / one force is gravitational and the other force is electrostatic	B1 B1	 **Allow:** one force is gravitational (and the other is not)
	(b)		T = 60/1600 or $T = 3.75 \times 10^{-2}$ (s) ($v = \pi \times 0.50/3.75 \times 10^{-2}$) speed = 42 (m s^{-1}) uncertainty = 3 (m s^{-1})	C1 A1 A1	**Allow:** f = 26.7 or $\frac{1600}{60}$ (Hz) or ω = 168 (s^{-1}) **Note:** v must be to 2 or more SF **Note:** uncertainty must be to 1 SF **Allow:** ecf on candidate's value for speed i.e. uncertainty = candidate's value / 16 (to 1 SF) **Allow for 2 marks max: 84 ± 5 (m s^{-1})**
	(c)		$mv^2/r = mg$ or $v^2/r = g$ $v^2 = 9.81 \times 0.25$ v = 1.6 (m s^{-1})	C1 C1 A1	**Allow:** $v^2/r = a$ and $a = g$ or $mv^2/r = ma$ and $a=g$ **Allow:** any subject **Allow:** any subject **Note:** qualified 2.21 (ms^{-1}) scores 2 marks.
			Total	**8**	

Question			Answer	Marks	Guidance
22	(a)	(i)	KE is conserved (as well as momentum)	B1	**Allow:** No KE lost
		(ii)	Attempt at conservation of momentum in x- or y- direction	C1	**Allow** confusion of sin and cos at this stage **Allow** attempt at conservation of KE
			Correct expression of conservation of momentum in x- or y-direction / correct determination for velocity of Y of 55(3) m s^{-1}	C1	**Allow** any subject e.g. p cos(25°) + m x 258cos(65°) = m x 610 or p sin(25°) = m x 258sin(65°) or $(p)^2 + (m \times 258)^2 = (m \times 610)^2$ or ½ mv^2 + ½ m $(258)^2$ = ½ $m(610)^2$
			$p = 3.7 \times 10^{-24}$ (kg m s^{-1})	A1	Answer is 3.67 x 10^{-24} (kg m s^{-1}) to 3 sf

	(b)*		**Level 3 (5–6 marks)** Clear explanation and correct calculation. *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 and limited calculation, or limited explanation and correct calculation. *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 and missing or incomplete calculation. *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 (NR) or no response worthy of credit (0).	**B1x6**	**Indicative scientific points may include:** **Explanation** • At a certain temperature all atoms have the same <u>average</u> kinetic energy • Helium behaves as an ideal gas • $E_K = \frac{3}{2}kT$ • Mean / r.m.s speed of atoms is less than the escape velocity • Atoms have range of speeds / velocity or mention of Maxwell-Boltzmann distribution • Faster atoms have escaped the Earth (over long period of time) • Earth was significantly hotter in the (ancient) past **Calculation** • T = 283 K • $\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$ • $c_{r.m.s.} = \sqrt{\frac{3kT}{m}}$ • $c_{r.m.s.}$ = 1.3 km s^{-1}
			Total	**10**	

23	**(a)**		Uniform distribution of matter (everywhere in the Universe)	**B1**	**Allow:** density of Universe (approximately) constant throughout **Not:** references/idea of isotropic/"looks the same in all directions"
	(b)	**(i)**	$v = 68 \times 200 = 13600$ (km s^{-1}) or 13.6 x 10^6 m s^{-1} $(\Delta\lambda = \frac{v}{c} \times \lambda)$ (change in λ =) $13600 \times 10^3 \times 280/3.00 \times 10^8$ or 13 (nm) or 13 x 10^{-9} (m) (λ = 280 + 13) λ = 290 (nm)	**C1** **C1** **A1**	**Allow:** Any correct velocity if unit matches. **Allow:** ECF for incorrect v **Answer to 3 sf is 293 (nm)** **Allow:** ECF for incorrect $\Delta\lambda$
		(ii)	Any suitable <u>one</u> from: • Very/infinitely dense • Idea that escape velocity ≥ c or 'light cannot escape it'	**B1**	**Allow:** singularity **Allow:** physical radius ≤ event horizon radius **Allow:** Distorts space(time) **significantly** / bends light **significantly** **Allow:** Emits Hawking radiation
	(c)		Any three from: 1. At the Big Bang the Universe is a singularity / very dense / very hot 2. Expansion / inflation / high energy (gamma) photons but no matter 3. Quarks and leptons form / Quark-Gluon Plasma phase 4. Quarks combine to form neutrons / protons / hadrons 5. **Hadrons / neutrons <u>and</u> protons / nucleons combine** to make nuclei All candidate's points in the correct sequence	**M1x3** **A1**	**Allow for point 1:** fundamental forces unified **Ignore:** Any phase after nuclei phase e.g. recombination era /formation of atoms/formation of CMBR
			Total	**9**	

Question			Answer	Marks	Guidance
24	(a)		y = sin (θ) $\sqrt{x^2 + y^2}$ compared with "y=mx+c"	B1	**Allow:** gradient = $\frac{\Delta y}{\Delta(\sqrt{x^2+y^2})}$ with sin (θ) = O/H **Not:** gradient = $\frac{y}{(\sqrt{x^2+y^2})}$ **unless** "c=0" seen.
	(b)	(i)	(Straight line of best fit showing) gradient = 0.73 ($d\sin\theta = n\lambda$) $\frac{1.0 \times 10^{-3}}{600} \times 0.73 = 2 \times \lambda$ λ = 6.1 × 10^{-7} (m)	C1 C1 A1	**Allow:** gradient in range 0.70-0.76. **Allow:** evaluation of θ = 44-50 (degrees) in place of gradient **Allow:** any subject **Note**: Gradient in range 0.70-0.76 gives λ in range (5.8 - 6.4) × 10^{-7} m
		(ii)	(Scales/distances are large compared with the absolute uncertainty so) **absolute uncertainty is too small** to be shown (reasonably on this graph's scale) (AW)	B1	**Ignore**: **error** too small
		(iii)	(The values for λ or θ will be) less precise (as independent measurements less likely to agree) (AW)	B1	
			Total	6	