GCE

Physics B

H157/02: Physics in depth

Advanced Subsidiary GCE

Mark Scheme for June 2019

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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.

Annotations available in Scoris

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
	Incorrect response
ECF	Error carried forward
FT	Follow through
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
	Correct response
AE	Arithmetic error
	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
(1)	Separates marking points
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
(1)m	a method mark, awarded if a correct method is used
(1)e	an evaluation mark, awarded for correct substitution and evaluation

All questions with mark totals > 1 should be annotated with ticks to show where marks have been awarded in the body of the text. Ticks must NOT be used in 6(b) or 8(e), just L3, L3^, L2, L2^, L1, L1^ and X for 6 to 0 marks respectively.

Question	Answer	Marks	Guidance
Section A			
1 (a)	Strain = 0.45 % = 0.0045 ✓ Extension = 0.0045 × 31 cm = 0.1395 cm So length = 31 cm + 0.1395 cm = 31.1 cm [3 s.f.] ✓	**2**	Ecf own strain, but must be to 3 s.f.: strain = 0.45% misinterpreted as 0.45 leads to extension = 13.95 cm giving length = 44.95 cm = 44.9/45.0 cm to 3 s.f.
(b)	$A = \pi[13 \times 10^{-3}\,\text{m}/2]^2 = 1.3(3) \times 10^{-4}\,\text{m}^2$ ✓ At 0.1% strain, stress σ = 161 MPa ✓ $F = \sigma A = 1.61 \times 10^8\,\text{Pa} \times 1.33 \times 10^{-4}\,\text{m}^2 = 21000/21400$ N ✓	**3**	ACCEPT stress in range 160 – 165 MPa Ecf own value A
(c)	Choice of suitable σ & ε values, e.g. 100 MPa, 0.05% ✓ $E = \sigma/\varepsilon = 100 \times 10^6\,\text{Pa}/0.05\% = 1.0 \times 10^8\,\text{Pa}/0.00005$ ✓ $= 2.0 \times 10^{11}\,\text{Pa}$ ✓	**3**	Needs $\sigma \leq$ 100 MPa unless correctly extrapolated e.g. to (0.115%, 225 MPa) Correct conversions and substitution. ALLOW $E = FL/Ae$ Typical values: F 13 000N, e 1.55×10^{-4} m
	Total	**8**	
2 (a)	490 nm < λ < 500 nm converted to m, e.g. 4.97×10^{-7} m ✓ THEN $f = c/\lambda = [3.00\times10^8\,\text{m s}^{-1}]/[4.97 \times 10^{-7}\,\text{m}] = 6.04 \times 10^{14}$ Hz ✓ $E = hf = 6.63 \times 10^{-34}\,\text{J s} \times 6.04 \times 10^{14}\,\text{Hz} = 4.00\times10^{-19}$ J ✓ OR recall of $E=hc/\lambda$ ✓ evaluation of E ✓	**3**	
(b)	$P = 12 \times 4.00\times10^{-19}\,\text{J}/0.1\,\text{s}$ ✓ $= 4.8 \times 10^{-17}$ W ✓	**2**	e.c.f. own E from (a) or use of 5×10^{-19} J ⇒ 6×10^{-17} W
	Total	**5**	
3	$d = 5.0 \times 10^{-2}\,\text{m}/52 = 9.62 \times 10^{-4}\,\text{m} = 9.6 \times 10^{-4}\,\text{m}$ ✓ $\lambda = d \sin\theta \Rightarrow \theta = \arcsin[\lambda/d] = \arcsin[630\times10^{-9}\,\text{m}/9.6\times10^{-4}\text{m}]$ $= 0.0376°$ ✓ $x/L = \tan\theta \Rightarrow x = 3.6\,\text{m} \times \tan(0.0376°) = 2.36\times10^{-3}$ m ✓	**3**	ALLOW 53 gaps ⇒ $d = 9.43 \times 10^{-4}$ m 53 gaps ⇒ $\arcsin(6.68 \times 10^{-4}\,\text{m}) = 0.382°$ or recall of $x/L=\lambda/d$ ✓ evaluation of λ ✓ no ecf from m.p.2 53 gaps ⇒ $x = 2.41 \times 10^{-3}$ m
	Total	**3**	

Question	Answer	Marks	Guidance
4 (a)	Currents at 3.0 V are 25 mA & 46.5 mA ✓ Total current drawn = 25 mA + 46.5 mA = 71.5 mA = 0.0715 A ✓ THEN $G = I/V$ = 0.0715 A/3.0 V = 0.0283 S = 0.024 S (2 s.f.) ✓ OR $R = V/I$ =3.0 V/0.0715 A = 42.0 Ω and $G = 1/R$ ✓	3	Needs 46 mA < I_B < 47 mA. Ecf own I_B Can calculate both G_1= 0.0083 S, G_2=0.0155 S separately for marking point 2 and add for marking point 3 or R_1 = 120 Ω & R_2 = 64.5 Ω for m.p.2 ⇒ R_{tot}= 42.0 Ω, G = 0.024 S for m.p.3 If wrong V chosen, can get mp2 & mp3 ecf. No ecf for mp3 if two errors preceded it.
(b)	p.ds. across the two components must add to give 6.0 V ✓ at 36 mA, V_A = 4.4 V and V_B = 1.6 V (which add to give 6.0 V) ✓	2	e.g. V = 6.0 V is shared (in a series circuit) allow tolerance of 0.1 V on each V but must add to 6 V. m.p. 2 may subsume m.p.1 or R_1+R_2 = 119 Ω + 47 Ω ⇒ I = 6 V/166 Ω = 0.0361 A
	Total	**5**	
5 (a)	F = 8.2 N × sin(35°) = 4.70 N ✓ m = 8.2 N/9.81 N kg^{-1} = 0.836 kg ✓ $a = F/m$ = 4.70 N/0.836 kg = 5.6(2) m s^{-2} ✓ OR Vertical acceleration in absence of the ramp would be g ✓ Component of g along slope = g sin 35° / g cos 55° ✓ = 9.81 m s^{-2} × 0.574 = 5.62 m s^{-2} = 5.6 m s^{-2} (2 s.f.) ✓	3	Alternative methods possible Mp1 is resolution, mp2 is finding m, mp3 = evaluation of a Can be implied by resolution, or even just a correct use of g anywhere
(b)	ΔE_k = work done = 4.70 N × 0.68 m = 3.2 J ✓	1	a bald answer of 3.2 J (ecf own F or a) is enough. Other approaches possible, e.g. $\Delta E_{gpe} = mgh$ where h = 0.68 m sin(35°) = 0.390 m
	Total	**4**	
	Section A total	**25**	

Question	Answer	Marks	Guidance
Section B			
6 (a) (i)	d =2.04 nm/8 = 0.255 nm so r = 0.1275 nm ✓ $V = (4/3)\pi r^3 = (4/3)\pi[1.275\times 10^{-10}\,\text{m}]^3$ ✓ $= 8.682 \times 10^{-30}\,\text{m}^3$ ($\approx 9 \times 10^{-30}\,\text{m}^3$) ✓	**3**	Unit conversion and substitution Evaluation
(a) (ii)	m = 63.5 g/N_A ✓ $= 0.0635\,\text{kg}/6.02 \times 10^{23} = 1.055\times 10^{-25}\,\text{kg} = 1.05/6 \times 10^{-25}\,\text{kg}$ ✓	**2**	
(a) (iii)	$\rho = m/V = 1.05 \times 10^{-25}\,\text{kg} / 8.682 \times 10^{-30}\,\text{m}^3 = 12100\,\text{kg m}^{-3}$ ✓	**1**	$V = 9 \times 10^{-30}\,\text{m}^3$ gives 11700 kg m^{-3} e.c.f. own m Ignore s.f.e.
(a) (iv)	In the real solid here are spaces between the atoms ✓ So a real solid has a smaller mass per unit volume/ so a given mass takes up more space✓	**2**	

Question	Answer	Marks	Guidance
6 (b)*	**(Level 3) (5 – 6 marks)** Identifies lack of dislocation movement in the alloy. Recognises that the looser structure implies reduced density for similar atoms. Links crystal changes/lack of dislocation movement correctly to differences in at least one physical property (density, hardness, stiffness) with justification **OR** correctly links lack of dislocation movement to two physical properties. Links changed alloy properties to desirable properties of coins, e.g. hardness, stiffness. *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)** Identifies lack of dislocation movement in the alloy. Attempts to link to differences in at least one physical property but does not link to a desirable property for coins. *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 simple comparisons between the crystal structures in terms of regularity but unlikely to mention dislocations or to use to predict differences in physical properties relevant for coins *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.	**[6]**	**Indicative scientific points may include:** **Difference between individual atoms:** • Zinc atoms are larger than copper atoms • so lattice will be disrupted/include gaps **Discussion of crystal structure and bonding** • Alloy has larger inter-atomic gaps • Resulting in lower overall density (even ignoring atom density differences) • Crystal structure is not a regular lattice • Larger Zn atoms will 'pin' dislocations • So dislocations cannot readily move **Discussion of different physical properties and suitability for coins** • Lack of dislocation movement will make the metal harder • So coins will not easily scratch • Lack of dislocation movement will make the metal stiffer • So coins will not easily bend • Coins need to be malleable to be formed **Use the L1, L2, L3 annotations in Assessor; do not use ticks.**
	Total	**14**	

Question	Answer	Marks	Guidance
7 (a)	Mass m of air displaced = ρV = 1.2 kg m^{-3} × 3.4 × 10^{-5} m^3 = 4.08 × 10^{-5} kg ✓m ✓e So weight of air = mg = 4.08 × 10^{-5} kg × 9.81 N kg^{-1} = 4.00 × 10^{-4} N ✓ Compared with W: 4.00 × 10^{-4} N/ 0.026 N = 0.0154 = 1.54 % (which ≈1%) ✓	4	One-stage calculation of W = 4.00 × 10^{-4} N can get marking points 1 to 3 in one stage, even without working. Requires a clear comparison with 0.026 N
(b)	$A = \pi r^2 = \pi(0.020\text{ m})^2 = 1.2566 \times 10^{-3}\text{ m}^3 = 1.26 \times 10^{-3}\text{ m}^3$ ✓ $D = ½\ \rho A\ C_d v^2$ = 0.5 × 1.2 kg m^{-3} ×1.26 × 10^{-3} m^3 × 0.4 × (9.3 m s^{-1})^2 = 0.026 N ✓ $D = W$ (- U) as it is not accelerating ✓	3	1.25 × 10^{-3} m^3 is a rounding error (RE) Must have evidence of evaluation of this, e.g. by substitution of correct values into the equation e.g. $D = W$, possibly in words
(c) (i)	Tangent drawn at t = 1 s ✓ $v = \Delta s/\Delta t$ = (22.4 m – 0 m)/(4.0 s – 0.42 s) ✓ = 6.3 m s^{-1}✓	3	line should be tangent at t = 1 s and cut t = 4 s between 22.0 m and 28 m. Award this mark only if $\Delta t \geq 1.0$ s. e.c.f. own triangle: range of readings acceptable. Must have 2 or 3 s.f. for marking point 3.(evaluation)
(c) (ii)	Curve becomes a straight line (by t = 3 s) (1)	1	NOT directly proportional
(d)	Denser gas so increased upthrust ✓ larger ρ **AND** C_d ✓ so greater drag D at any v **OR** smaller v to give same drag ✓ produces lower terminal velocity / reaches terminal velocity sooner due to greater D ✓	4	
	Total	**15**	
	Section B total	**29**	

Question	Answer	Marks	Guidance
Section C			
8 (a)	Correct explanation of systematic error ✓ (For any pair of readings), Δu will be the same size as Δv ✓ Δu & Δv will be in opposite directions ✓	**3**	Must have the idea that it is built into the system of measurement used i.e. not measuring from the (optical) centre but from some point to one side of it. May refer to calibration or zero error. e.g. if $\|u\|$ is too small, v will be too big by the same amount
(b)	Taking all 8 values, range of v is (34 cm, 42 cm) Δv = (42 cm - 34 cm)/2 = 4 cm ✓ mean v = (34 cm + 42 cm)/2 = 38 cm ✓ OR mean v = (34+35+34+36+41+41+40+42)/8 = 38 cm rounded to nearest cm✓	**2**	Correct answer is 38 cm ± 4 cm and can be obtained in different ways. If mean quoted as 37.9 cm, accept either 42 cm - 37.9 cm = 4.1 cm or 37.9 cm – 34cm =3.9 cm for Δv ALLOW mean = (mean v_{max} – mean v_{min}) = 37.8 cm
(c)	$\frac{1}{v} = \frac{1}{u} + \frac{1}{f} = \frac{1}{u} + P$ ✓ $y = mx + c$ so $m = 1$ and $c = P$ if $y = 1/v$ and $x = 1/u$ ✓	**2**	Rewriting the lens equation in terms of u, v and P Identifying m and c from the lens equation
(d)	$1/v$ values of 13.9 m^{-1} **AND** 15.9 m^{-1} respectively ✓ At least one uncertainty in $1/v$ correctly found ✓ Points and uncertainty bars correctly plotted with e.c.f. ✓	**3**	ALLOW 13.89 m^{-1} AND 15.87 m^{-1}. See table below. Allow 1 m^{-1} or 2 m^{-1} Tolerance ± half a small square.

v	Δv	v_{min}	v_{max}	$1/v$	$1/v_{min}$	$1/v_{max}$	diff/2	$1/v-1/v_{max}$	$1/v_{min}-1/v$	$\Delta(1/v)$
0.072	0.008	0.064	0.08	13.889	15.625	12.5	1.5625	1.389	1.736	1, 2, 2
0.063	0.007	0.056	0.07	15.873	17.857	14.286	1.786	1.587	1.984	2, 2, 2

Question	Answer	Marks	Guidance
8 (e)*	**(Level 3) (5 – 6 marks)** Maximum and minimum gradients and at least one intercept value found with sensible comparison of gradient with 1 and intercept with 20 m^{-1}. Realises that data contradicts expected results, even though graph looks good. Recognises that systematic errors may be responsible for incorrect gradient and intercept. *There is well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **(Level 2) (3 – 4 marks)** Two reasonable lines drawn and at least one value each of values of gradient and intercept found correctly. Other evaluation superficial, as level 1. *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)** At least one acceptable line drawn through data. Gradient found, possibly with too small a triangle. Intercept read correctly. Unlikely to refer to expected values, and evaluation may be simplistic, e.g. repeat experiment. *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. .	**[6]**	**Indicative scientific points may include:** **Analysis of graph** • Max gradient found (I get 2.4) • Min gradient found (I get 1.7) • Max *y*-axis intercept found (I get 32.0 m^{-1}) • Min *y*-axis intercept found (I get 25.7 m^{-1}) **Comparison with expected results** • Expected gradient = 1 is lower than the minimum found • Expected *y*-axis intercept = power of lens with 50 mm focal length • $1/(50\times10^{-3}$ m) = 20 D • Expected *y*-axis intercept is lower than the minimum found **Evaluation of the graph** • Data all fall within a reasonable straight line with no obvious outliers • Uncertainty decreases with larger $\|1/u\|$ • i.e. when object is closer to lens, results are more uncertain **Evaluation of the procedure followed** • systematic error (as in part (a)) could explain the 'wrong' gradient and intercept • random uncertainties would create greater spread of data but should not make gradient and intercept so wrong. • Need to have more data to clarify, e.g. more data points, or trying a different zero of measurements on the lens body. **Use the L1, L2, L3 annotations in Assessor; do not use ticks.**
	Section C Total	**16**	

OCR (Oxford Cambridge and RSA Examinations)
The Triangle Building
Shaftesbury Road
Cambridge
CB2 8EA

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored

Oxford Cambridge and RSA Examinations
is a Company Limited by Guarantee
Registered in England
Registered Office; The Triangle Building, Shaftesbury Road, Cambridge, CB2 8EA
Registered Company Number: 3484466
OCR is an exempt Charity

OCR (Oxford Cambridge and RSA Examinations)
Head office
Telephone: 01223 552552
Facsimile: 01223 552553