GCE

Physics B

Unit **H557A/01:** Fundamentals of physics

Advanced GCE

Mark Scheme for June 2017

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.

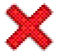
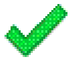
This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

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.

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 (in copying data from root of question – **ALLOW** method mark(s) if no further error but zero credit for evaluation)
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

Section A: MCQs

Question	Answer	Marks	Guidance

Question			Answer	Marks	Guidance
1	D		D	1	
2	B		B	1	
3	A		A	1	
4	A		A	1	
5	B		B	1	
6	B		B	1	
7	A		A	1	
8	B		B	1	
9	C		C	1	
10	C		C	1	
11	A		A	1	
12	D		D	1	
13	C		C	1	
14	C		C	1	
15	D		D	1	
16	B		B	1	
17	D		D	1	
18	B		B	1	
19	D		D	1	
20	D		D	1	
21	A		A	1	
22	D		D	1	
23	C		C	1	
24	D		D	1	
25	B		B	1	
26	C		C	1	
27	B		B	1	
28	A		A	1	
29	B		B	1	
30	A		A	1	
			Total	**30**	

Section B

Question			Answer	Marks	Guidance
31	(a)		(usually air is not a conductor) having no charge carriers (to support a current) / ✓ the ions and / or electrons provide charge carriers (for the air to conduct)	1	**expect** concept of charged particles free to move **not** just air is an insulator or non-conductor / just ions are charged / just charges can conduct **allow** charge carriers / delocalised or free electrons or charges / charges available to carry current / charges can flow
31	(b)		($\Delta Q = I\,\Delta t$) = $30 \times 10^{3} \times 250 \times 10^{-6}$ ✓ = 7.5 (C) ✓	1 1	bare correct value scores both marks **ignore** units
			Total	**3**	

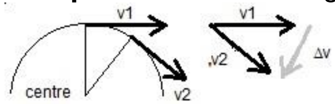
Question			Answer	Marks	Guidance
32	(a)		$\frac{c / c_{\text{glass}}}{c / c_{\text{water}}}$ ✓	1	
32	(b)		${}_{g}n_{w}$ = 1.3 / 1.6 = 0.81(3) ✓ r = $\sin^{-1}$(sin30º/0.813) = 38º ✓ OR $n_1 \sin\theta_1 = n_2 \sin\theta_2$ method r = $\sin^{-1}$(sin 30° x 1.6 / 1.3) ✓ = 38° ✓	1 1	first mark for evaluating / using correct index **not** 24 º have inverted the index **only** if this method is clear **allow** n_1 / n_2 = 1.6 / 1.3 = 1.2(3) for first mark
			Total	**3**	

Question			Answer	Marks	Guidance
33	(a)	(i)	$\Delta E = m\,c\,\Delta\theta$ ✓ = 4200 x 17 = 71.4 (kJ) ✓	1 1	method evaluation **accept** 71 (kJ)
33	(a)	(ii)	$\Delta t = m\,c\,\Delta\theta / I\,V$ or = 71.4 x 10^3 / (230 x 46) ✓ = 6.7(5) (s) ✓	1 1	method in rearranged algebra or numbers **accept** $t = E / P$ evaluation **not** 6.74 (s) RE **allow** ecf on value from (a)
33	(b)		$\Delta\theta$ doubled ✓ so flow (rate) or $\Delta m / \Delta t$ will have to halve ✓	1 1	**accept** mass flow rate drops from 0.15 to 0.075 kg s^{-1} **not** ΔE doubles so time doubles / other time reasoning **max 1** for just flow (rate) less or slower
			Total	6	

Question			Answer	Marks	Guidance
34	(a)		(4.5 x 1 /10) = **0.45** ✓ (4.5 – 0.45) = **4.05** ✓	1 1	 **ignore** 4.1
34	(b)	(i)	$\Delta Q \approx I\,\Delta t = V\,\Delta t / R$ ✓ and $V = Q / C$ (⇨ $\Delta Q \approx Q\,\Delta t / R\,C$) ✓	1 1	**accept** algebra expressed in words / = or ≈ symbols **not** credit for any exponential type reasoning
34	(b)	(ii)	assumes current / voltage / charge (on capacitor) is constant during Δt (instead of continuously decaying) ✓ overcome by making Δt smaller / as small as possible (as needed for better approximation) **not** just make Δt small ✓	1 1	assumption **not** just rate is constant **accept** rate of charge flow is constant or rate of discharge is constant how overcome for 1 standalone mark if no answer to assumption
			Total	6	

Question			Answer	Marks	Guidance
35	(a)		$v = 0.24 \times 60 \times 3 \times 10^8 / \{60 \times 60 \times 24\}$ ✓ $= 5.0 \times 10^4$ (m s^{-1}) ✓	1 1	**accept** $\{4.32 \times 10^9$ m $\div$ 8.64×10^4 s$\}$
35	(b)		range $R = 44.444 \times 60 \times 3 \times 10^8 =$ (8.0×10^{11} m) ✓ $v_{perp.} = R\omega = 8.0 \times 10^{11} \times 1.8 \times 10^{-3} / (24 \times 3600)$ ✓ $= 1.66 \times 10^4$ (m s^{-1}) ✓ OR alternative method **for last 2 marks** $s_{perp.} \approx R\theta = 8 \times 10^{11} \times 1.8 \times 10^{-3} =$ (1.44×10^9 m) $v_{perp} = s_{perp} / t = 1.44 \times 10^9 / (24 \times 3600) = 1.66 \times 10^4$ (m s^{-1})	1 1 1	**accept** ranges based on either time or mean time of signal travel **all** give range = 8.0×10^{11} m (2 S.F.) method evaluation method **accept** $\sin\theta \approx \tan\theta \approx \theta$ for small angle θ **n.b.** $s_{perp.}$ = 0.08 light minutes can be credited more method & evaluation **allow** answers close to 280 m s^{-1} to score 2/3 marks because light mins treated as light secs so 1/60 of correct answer so one small eror
			Total **Total section B**	**5** **23**	

Section C

Question			Answer	Marks	Guidance
36	(a)		velocity vector is changing direction constantly towards the centre of the orbit (magnitude / speed remains constant) ✓ and acceleration = rate of change of velocity so there is an acceleration ✓ OR (circular motion) requires a force towards the centre of the circle (otherwise the mass will move in a straight line at a tangent to the circle) ✓ and acceleration $\propto$ force so there is an acceleration (towards the centre) ✓	1 1	**accept** in annotated diagram form  dependent on the first mark **accept** (circular motion) requires centripetal force **ignore** references to gravitational force of Earth on Moon cause Moon to accelerate towards earth dependent on the first mark **accept** $a = F / m$ so there is an acceleration (towards the centre)
36	(b)	(i)	$a = v^2 / R = \{2\pi R\}^2 / \{T^2 R\} =$ …… ✓ OR $a = R\,\omega^2 = R\,\{2\pi/T\}^2 =$ ……..	1	algebraic reasoning **accept** using forces and $F = ma = m\,v^2 / R$ and cancelling m and completing
36	(b)	(ii)	$4\pi^2 \times 3.84 \times 10^8 / (2.35 \times 10^6)^2 = 0.0027$ m s^{-2} ✓	1	evaluation **accept** 2.74 mm s^{-2} / 2.75 mm s^{-2} ($\pi \approx$)
36	(b)	(iii)	$g_{\text{at moon orbit}} = g_{\text{Earth surface}} / 60^2$ ✓ = 9.8 / 3600 = 2.7(2) x 10^{-3} m s^{-2} ✓ same value as **(ii)** ✓	1 1 1	method using inverse square law reasoning in numbers / words / algebra evaluation **accept** g = 9.81 m s^{-2} / correct use of $a = G\,M / D^2$ comparison **allow** ecf from **(ii)** if compared sensibly to 3 mm s^{-2}
			Total	**7**	

Question			Answer	Marks	Guidance
37	(a)		v_{terminal} = 0.65 (m s^{-1}) ✓ ± 0.02 (m s^{-1}) ✓	1 1	v_{terminal} read from graph **accept** in range 0.64 to 0.66 (m s^{-1}) uncertainty estimate apply SF penalty for 2 or 3 SF e.g. 0.019 or 0.0195 (m s^{-1}) scores 0
37	(b)		(at t = 0.5 s) ball is accelerating (and a is decreasing) ✓ because downwards weight is larger than upwards drag force ✓	1 1	**credit** numerical estimates of acceleration ≈ 0.55 m s^{-2} **accept** in algebra $W > D$ or $> (D + U)$ **accept** if upthrust U is overlooked / air resistance or friction for drag **not** U confused with D **not** just because net force is downwards
37	(c)	(i)	temperature should be monitored or held constant ✓ since the viscosity / drag force will depend on T ✓	1 1	**accept** density of the glycerol ; as it will affect upthrust **accept** viscosity of the glycerol ; as it will affect drag **accept** purity of the glycerol ; as moisture affects viscosity **accept** density of ball bearing ; as it will affect the weight **accept** mass of ball bearing ; as it will affect the weight **not** height drop or air bubbles in glycerol or keep same liquid **ignore** edge effect
37	(c)	(ii)	D^2 / v_T = constant **OR** v_T / D^2 = constant ✓ D^2 / v_T values: 144, 145, 144, 204, 221 (mm^2 m^{-1} s) ✓✓ OR v_T / D^2 values (6.9, 6.9, 6.9, 4.9, 4.5) x 10^{-3} (m s^{-1} mm^{-2}) ✓✓	1 2	proposal **if** v_T / D^2 = constant **accept** log / log graph **allow** v_T = k D^2 working **expect** at least **2 data** tests for credit 1 mark and all **5 data** tested for 2 marks **accept** table of D^2 values (for v_T vs D^2 sketch graph) **accept** calculated log v_T and log D values same rule on data

Question			Answer	Marks	Guidance
			noticing smallest three b.bs have almost constant k / largest two b.bs have a different sensible constant / smallest and largest b.bs k not constant ………………………………………………………………… consideration of **quantitative** uncertainty in k D^2 / v_T = 144, 145, 144 constant to ± 0.3% / = 204, 221 constant to ± 4% ………………………………………………………………… correct statement about **their test** showing proportionality or not showing proportionality ………………………………………………………………… If graphs sketched 2 marks from: sketches of log / log graph or sketches of v_T vs D^2 correct comment on gradient or linearity of **their** graph	2	conclusions **2 marks** available for **any sensible test involving 2 or more data points** **accept** any two or all three of smallest b.bs have almost constant k **accept** largest two b.bs have sensible constant k (if only 2 tested) **accept** use of 3% uncertainty based on the uncertainty in v_T from (a) OR comment on differences in their k values 144, 221 show increase in k of about 50% / decrease of about 35% **for graph method candidates**
			Total	**11**	

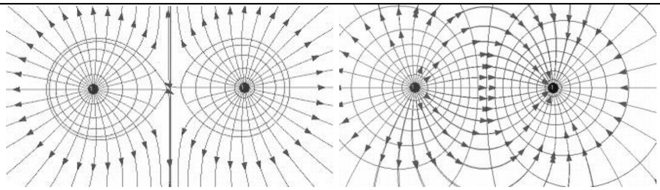
Question			Answer	Marks	Guidance
38	(a)		draw tangent and suitable large Δ at $t = 1$ or 3 s ✓ 1.1 (m s^{-1}) ✓ OR identifying $A = 0.70$ m $f = 1/4$ Hz $v_{max} = A\,\omega$; = 0.7 x 2 π x ¼ = 1.1 (m s^{-1})	1 1	method **accept** tangent and $\Delta s / \Delta t$ = 1.6 / 1.5 **ignore** signs here award magnitude evaluation **accept** in range 1.0 to 1.2 (m s^{-1}) alternative method for two marks
38	(b)		**- sin** graph of period 4 s and shape by eye ✓ scaled to amplitude of 1.1 m s^{-1} ✓	1 1	**accept** - sin graph scaled to agree with (a) ecf **ignore** shape of graph here just peak values
38	(c)	(i)	$L = T^2 g / 4\pi^2$ or equivalent using numbers ✓ = 4^2 x 9.8 / $4\pi^2$ = 3.97 m ✓	1 1	method **not** just $T = 2\pi\sqrt{\{L / g\}}$ evaluation **accept** $g = 9.81$ gives $L = 3.98$ m
			Total	**6**	

Question			Answer	Marks	Guidance
39	(a)		**X** pure β no γ at background with 5 mm lead ✓ **Y** α, β, γ large drop with paper $\therefore$ must have α ✓ **Z** β, γ (no drop with paper $\therefore$ no α) counts with lead so some γ ✓	1 1 1	all identifications correct for **first mark** even if **no** explanations **total** zero if three sources incorrect **two** correct explanations for **second mark** **three** correct explanations for **third mark** **ignore** comments on β as present in all three sources **not** credit for descriptions of data expect logical analysis
39	(b)	(i)	Δ log*C*/ Δ log*R* or e.g. (4.0 – 0.5) / (0.4 – 1.9) = ✓ = - 2.3 ✓	1 1	method evidence of sensible gradient taken or tangent drawn or Δ constructed in downward section of graph even if sign is wrong evaluation **accept** in range - 2.0 to - 2.5 must have correct sign here **allow** both marks if bare answer in this range
39	(b)	(ii)	✓ ✓ ✓ ✓ **Graph comments:** $C = k / R^2$ gives $\log C = \log k - 2 \log R$ **OR** gradient close to 2 suggests R^2 variation and **–** sign indicates inverse relation $1 / R^2$ accuracy: - 2.3 is close but not perfect fit for low range is not a good fit (log graph flat) **OR** higher range only is a reasonable fit	4	any 4 points from the list but must include a comment on graph **AND** a suggestion about radiation for full marks i.e. a **max 3** from each section complete log analysis worth **2 marks accept** if *k* taken as 1 conclusion **ecf** on their gradient value if outside range then not a good fit **accept** need to know ± uncertainties to estimate the significance of the small difference i.e. recognising the significance of knee in graph

Question			Answer	Marks	Guidance
			Suggestions about radiation: α attenuated by a few cms in air inverse square law applies to point sources, close to source will not be a good approximation / it will be more constant γ should follow 1 / R^2 dilution γ travel in straight lines from (point) source with little interaction / absorption by the air		accept β with explanation that these follow 1 / R^2 reasonably well up to this range
			Total	**9**	

Question			Answer	Marks	Guidance
40	(a)		(50 MPa / 7 x 10^{-4}) = 7.1(4) x 10^{10} (Pa) ✓	1	evaluation **accept** in range 7.0 to 7.3 x 10^{10} (Pa)
40	(b)		**alloy** absorbs more energy (per volume) ✓ **alloy** is stronger / has higher breaking stress ✓	1 1	choice explained **accept** alloy because it is tougher **not** stiffer **not** any credit for pure metal takes greater strain and prolongs time of collision
40	(c)	(i)	method: any {scaled distance ÷ appropriate number of atoms} ✓ evaluation: e.g. 4 atoms per nm gives 0.25 nm / 2.5 x 10^{-10} (m) ✓ OR 5 atoms per nm gives 0.20 nm = 2.0 x 10^{-10} (m)	 1 1	 **allow** atom counting angled to atomic rows **not** unreal estimates like 10 atoms per 1 nm estimation **accept** in range { 1.8 to 2.7 } x 10^{-10} (m) credit 2 marks for answer in range with no working
40	(c)	(ii)	a dislocation / edge dislocation ✓	1	**accept** extra half-plane of atoms
40	(d)		**Level 3 (5–6 marks)** Marshals argument in a clear manner and includes clear **explanation of three strands**: • metallic bonding • structure of metal and alloy • elastic and plastic deformation *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*	6	**Look for number of strands attempted to help decide the Level, then look at quality.** **Indicative scientific points may include:** **Metallic bonding** • +ve ion lattice in sea / gas of free mobile electrons • non-directional strong electrostatic bond electron glue • similar for pure metal and alloy **Structure of metal and alloy** • ordered regular stacking of atoms in planes in metal • alloy has a few impurity metal atoms of different size • most metals are polycrystalline with grains and grain boundaries between crystals of different orientation • ions can slip and atomic planes move

Question			Answer	Marks	Guidance
			Level 2 (3–4 marks) Shows clear understanding of at least **two of the three strands** above to the argument **or** covers all three at a superficial manner and does not include enough indicative points for level 3. *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 at least **two independent points** (possibly from one strand) that are relevant to the argument but does not link them together and shows only superficial engagement with the argument. *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 worthy of credit remember* *No response at all record NR*		• dislocations are stacking imperfections e.g. extra half plane reduce stress at which planes slip by localising stress **Elastic and plastic deformation** • elastic behaviour atoms return to original position when stress removed stretched stiff bonds spring back • metals and alloys are stiff and elastic for small strains • dislocation movement in pure metals allows slip and plastic deformation at relatively low stress this is permanent and ions do not return when stress removed • dislocations are pinned by impurity atoms in alloy which restricts slip giving a smaller plastic region at higher yield stress • reference to Fig. 40.2 • **accept** well labelled diagrams throughout for credit if integrated into the explanation
			Total	**12**	

Question			Answer	Marks	Guidance
41	(a)		**. N** on Fig. 41.1 ✓ ; **. V** on Fig. 41.2 ✓	2	**both** at mid-points of charges judged by eye and field lines (may need magnification to see amongst field lines)
41	(b)	(i)		1 1	both sketches **any** 3 equipotentials of roughly correct shape judged by eye **accept** ΔV not equal (as diagram) **expect** attempt at orthogonality **accept** on Fig. 41.1 three equipotential loops surrounding both charges
41	(c)		$E = 2kQ/R^2$ or $= 2 \times 9 \times 10^9 \times 1 / 500^2$ ✓ $= 7.2 \times 10^4$ (V m^{-1}) ✓	1 1	method **must** have 2 factor for method mark evaluation **allow** 1 mark for 3.6×10^4 (½ correct value)
41	(d)		**Level 3 (5–6 marks)** Marshals argument in a clear manner and includes clear explanation of **three strands**: • work done • area under $E(R)$ field graph • gradient of $V(R)$ potential graph *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)** Shows clear understanding of at least **two of the three strands** above to the argument **or** covers all three at a superficial manner and does not include enough indicative points for level 3. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.*	6	**Look for number of strands attempted to help decide the Level, then look at quality.** **Do not penalise incorrect signs in this answer.** **Indicative scientific points may include:** **work done** • work W is done against electrical attraction of + and – charges which increases the electrical potential energy of the system • + charge is worked on in raising it up the potential well of the – charge • $W_{\text{total}} = \Sigma \Delta W = \Sigma F\Delta s = \Sigma F \Delta R$ **area under $E(R)$ graph:** **accept algebraic or numerical reasoning** • $W_{\text{total}} = \Sigma \Delta W = \Sigma F\Delta s = \Sigma F \Delta R$ **only credit once** • $E_{\text{field}} = F/q$ but test charge is unit charge $q = 1$ C • in this example $E_{\text{field}} = F$

Question			Answer	Marks	Guidance
			Level 1 (1–2 marks) Makes at least two independent points that are relevant to the argument but does not link them together and shows only superficial engagement with the argument. *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 worthy of credit scores zero No response record NR		• $\therefore W$ = Area under the field graph • 15 squares x 4 x 10^6 J per square = 60 MJ C^{-1} or MV • agrees with increase in potential from (-90 to -30) MV • recognising that $E = k\,Q / R^2$ **gradient of *V*(*R*) graph** • E_{field} = - gradient of $V(R)$ = - dV / dR = - $\Delta V / \Delta R$ • tangent to graph drawn and shown = field • e.g. at R = 200 m grad = (120 MV) / 600 m = 2 x 10^5 V m^{-1} • agrees with the field at R = 200 m of 20 x 10^4 V m^{-1} • recognising that $V = k\,Q / R$ **check** graphs for annotation credit
			Total	**12**	
			Total section C **Total sections B & C**	**56** **80**	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

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