Practice

A GCE Physics B H557/01

Paper 1 Fundamentals of Physics

MARK SCHEME

Duration: 2 hours 15 minutes

MAXIMUM MARK 110

FINAL

This document consists of 15 pages

Section A: MCQs

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

Section B

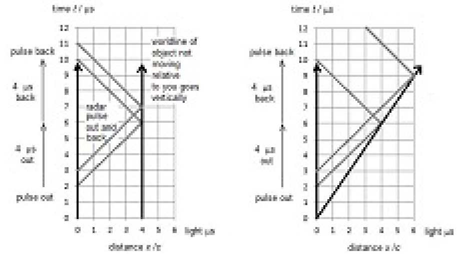
Question			Answer	Marks	Guidance
31	**(a)**		$r_{internal} = \{\varepsilon - V\} / I$ or e.g. $= \{0.8 – 0.4\} / 0.25 \times 10^{-3}$ ✓ = 1600 (Ω) ✓	**1** **1**	method read from graph intercept and another point evaluation
31	**(b)**	**(i)**	proportional graph through e.g. (0.10 mA, 1.0 V) ✓	**1**	
	(b)	**(ii)**	current = intercept = 0.07 (mA) ✓ *R* is across cell so shares same p.d. and current ✓	**1** **1**	read from graph explanation **accept** by calculation = 0.80 / 11600 = 0.069 (mA)
			Total	**5**	

Question			Answer	Marks	Guidance
32	**(a)**		<u>contrast</u> stretch / improvement / ✓ the raw image only uses a limited range of 140/1 pixel values, these are shifted and stretched to use all 255/6 levels of the greyscale ✓	**1** **1**	
32	**(b)**		(255) / (140) ✓	**1**	**accept** (255) / (175 - 35)
			Total	**3**	

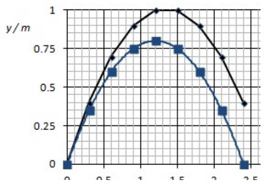
Question			Answer	Marks	Guidance
33	(a)		polarisation ✓	1	**accept** oscillations at 90° to direction of propagation if stated that aerial points at transmitter (when rotated)
33	(b)		(signal) increases / returns to original intensity ✓ receiving aerial is parallel to direction of oscillation again / aerial is back in plane of polarisation ✓	1 1	AW **accept** E or B vector
			Total	**3**	

Question			Answer	Marks	Guidance
34	(a)		energy = area under $Q \propto V$ graph is Δ area ½ $Q\ V$ ✓ or $\Delta E = Q\ \Delta V$ and $E = \Sigma\ Q\ \Delta V$ = ½ $Q\ V$	1	**accept** not all Q can be taken at the max p.d. as V falls as ΔQ is removed ½ V s average p.d. or $E = Q \times V_{mean}$ = ½ $Q\ V$
34	(b)		$V = \sqrt{(2 \times E) / C}$ or $\sqrt{(2 \times 200) / 500 \times 10^{-6}}$ ✓ = 890 (V) ✓	1 1	method in rearranged algebra or numbers evaluation **accept** 894 (V)
			Total	**3**	

Question			Answer	Marks	Guidance
35	(a)		θ = $\sin^{-1}$ (2/6) ✓ = 19 º ✓	1 1	method **accept** correctly labelled vector Δ evaluation **accept** 19.4(7) º or 19.5 º **not** 20 º **RE** (rounding error)
35	(b)		= 6 x cos(19.5 º) = 5.7 (m s^{-1}) ✓ or = √ ($6^2 - 2^2$) = 5.7 (m s^{-1})	1	evaluation **accept** by components or Pythagoras **allow** ecf on cos*θ* from (a) **accept** if scaled vector Δ answers in range 5.5 to 5.9 (m s^{-1})
			Total	**3**	

Question			Answer	Marks	Guidance
36	(a)		4 light-μs = $4 \times 10^{-6} \times 3 \times 10^{8}$ = 1200 (m) ✓	1	
36	(b)	(i)	e-m radiation pulses travel 1 light-μs in 1 μs (so 45º ∆) ✓	1	
36	(b)	(ii)	e.g. tan θ = 4 light-μs / 6 μs ✓ = 4 c/ 6 = $^{2}/_{3}$ c = 2.0×10^{8} (m s^{-1}) ✓	1 1	 **accept** $^{2}/_{3}$ c for the mark
36	(c)		all pulses out and return at 45º angles on each figure ✓ ✓	2	**accept** judged by eye 
			Total **Total section B**	**6** **23**	

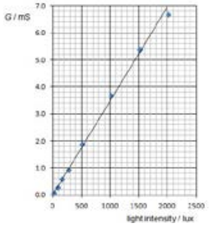
Section C

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>37</td><td>(a)</td><td>(i)</td><td>$\Delta v = g\,\Delta t$ this only recognises gravitational acceleration there is no term involving the force of drag and the acceleration it would produce ✓</td><td>1</td><td>accept the only acceleration is due to gravity</td></tr>
<tr><td>37</td><td>(a)</td><td>(ii)</td><td>iterative model assumes v_y remains constant during Δt instead of continuously changing, so y values are always bigger than reality ✓</td><td>1</td><td>not just v_y or y overshoots</td></tr>
<tr><td>37</td><td>(a)</td><td>(iii)</td><td>by making Δt smaller and doing more iterations per time interval we can make the process as ✓</td><td>1</td><td></td></tr>
<tr><td>37</td><td>(a)</td><td>(iv)</td><td>v_x really is constant (ignoring air resistance) so no ≈ or approximation is involved ✓</td><td>1</td><td>accept there is no horizontal acceleration / force acting</td></tr>
<tr><td>37</td><td>(b)</td><td></td><td><table><tr><th>y / m</th><th>analytic</th></tr><tr><td>1</td><td>0.8</td></tr><tr><td>1</td><td>0.75</td></tr></table> ✓✓</td><td>2</td><td>one mark for each correct column</td></tr>
<tr><td>37</td><td>(c)</td><td>(i)</td><td> ✓ ✓</td><td>2</td><td>one mark for each correct graph with points
allow small plotting errors or small calculation errors ecf (b)</td></tr>
</table>

Question			Answer	Marks	Guidance
37	(c)	(ii)	general shape is parabolic / both have same *x* values at same times ✓ iteration reaches higher *y* -value / peaks later in time / analytical reaches larger downward velocity ✓	1 1	similarity **accept** any sensible answer **not** start at same angle of projection difference **accept** any sensible answer **not** iteration reaches further
37	(d)		not every problem has an analytical solution / but many can be modelled by iteration and predictions can be made / approximations or models can be improved in the light of more real world data ✓✓	1 1	**accept** any two sensible points
			Total	**12**	

Question			Answer	Marks	Guidance
38	(a)	(i)	(wave) superposition ✓ (when waves from two or more sources overlap), the resultant displacement (at a given instant and position) is equal to the sum of the individual displacements ✓	1 1	**accept** (wave) interference **accept** when a wave crest/trough meets another wave crest/trough a large crest/trough forms called constructive interference **and** If a wave crest meets a wave trough, the waves cancel each other out momentarily called destructive interference. **accept** labelled diagrams
38	(a)	(ii)	diffraction by single slit with ripple tank / light / μ-waves can show circular / sideways spreading of wave energy ✓	1	**accept** spreading of waves through a slit occurs at any point along an interrupted wavefront as if circular spreading was occurring from all points on the wavefront
38	(a)	(iii)	wavelets spread on circular arcs of fixed radius = c Δt ✓	1	
38	(b)	(i)	wavefronts of wavelets line up along **BB'** with waves from successive slits being delayed by one cycle / one λ ✓	1	**not** just wavelets line up
38	(b)	(ii)	**Level 3 (5–6 marks)** Marshals argument in a clear manner and includes clear explanation of three strands: • using grating equation for spectral orders • explain grating using wave ideas • explain grating using phasor ideas *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*	6	**Indicative scientific points may include:** **Grating equation for spectral orders** • recognising that n = 1 is first order at θ_1 or that n = 2 is second order at θ_2 • use of $\sin\theta = n\lambda / d$ with n = 1 ⇨ θ_1 = 23.6° or use of $\sin\theta = n\lambda / d$ with n = 2 ⇨ θ_2 = 53.1° **ORA** **Explain grating using wave ideas** • path difference between consecutive slits = $d \sin\theta$ • if path difference is an integer number of λs then waves at angle θ are in phase and will constructively interfere to give a high intensity at that angle or • if path difference is an odd number of ½ λs then waves at angle θ are in antiphase and will destructively interfere to give a zero intensity at that

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 that are relevant to the argument but does not link them together and shows only superficial engagement with the argument. *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		angle **Explain grating using phasor ideas** • photons are emitted and detected discretely • description of phasor arrow rotating at *f* to describe every possible path and find phasor angle for each • add phasor arrows tip to tail to get phasor resultant for all possible paths between emission and detection • phasors near straight line paths “line up” and contribute most to resultant amplitude and probability • away from the straight line path phasors “curl up” and contribute little to resultant amplitude and probability • probability of photon arrival at this detection point $\propto$ (resultant phasor amplitude)^2 • repeat for all possible detection points • sum probabilities and normalise so that total probability is 1 i.e. photon arrives somewhere • **accept** well labelled diagrams throughout for credit if integrated into the explanation
			Total	**11**	

Question			Answer	Marks	Guidance
39	(a)	(i)	✓✓ ✓ ✓ 1.89 or 1.9 3.70 or 3.7 5.38 or 5.4 6.67 or 6.7 	1 1 1 1	*G* / mS values in table **allow** 2 or 3 S.F. *G* values plotted correctly **allow** ecf on wrong values best fit line **must** show proportionality for mark
39	(a)	(ii)	*R* vs Intensity both variables change over about 2 orders of magnitude / by about x 100 / graph is highly curved ✓ both graphs give linear best fit graph / test a functional relationship ✓ straight log / log graph shows a power law $R \propto I^n$ (gradient = n ≈ -1) ✓	1 1 1	**accept** log / log graphs compress large ranges of data **accept** straight line graphs are only function that can be judged by eye **accept** $R \propto 1/I^n$ (n ≈ 1) or $G \propto I$
39	(a)	(iii)	photons give energy to electrons and free them into the conduction band ✓ $G \propto$ carrier density and $G \propto I$ so expect $I \propto$ carrier density (provided electrons drop back into bonds / recombine with holes) ✓	1 1	reason evaluation
39	(b)	(i)	threshold λ above which process of freeing electrons does not occur ✓ or threshold *f* or *E* below which electrons are not freed from bonds	1	
39	(b)	(ii)	$E = hc / \lambda = 6.6 \times 10^{-34} \times 3 \times 10^{8} / 770 \times 10^{-9}$ ✓ $= 2.6 \times 10^{-19}$ (J) ✓	1 1	**must** have threshold λ not peak λ

Question			Answer	Marks	Guidance
39	(c)		$V = 6 \times R / (R + R_{LDR})$ or $6 \times 470 / (470 + 270)$ ✓	1	method
			= 3.8 (V) ✓	1	evaluation
			Total	**14**	

Question			Answer	Marks	Guidance
40	(a)	(i)	gravitational force is always attractive so potential energy per kg increases as body is lifted above the Earth's surface, towards zero at ∞ by convention ✓	1	**accept** arbitrary zero of potential is at ∞ separation, so as bodies approach, potential energy decreases below zero hence negative
40	(a)	(ii)	to launch $\frac{1}{2} v^2 = 62 \times 10^6$ J kg^{-1} or $v = \sqrt{(124 \times 10^6)}$ ✓ $v = 1.1(1) \times 10^4$ (m s^{-1}) ✓	1 1	method **accept** energy per kg or for mass *m* which cancels in words / algebra / numbers evaluation
40	(b)	(i)	(k.e. lost = p.e. gained) ⇨ ✓ $\frac{1}{2} \cancel{m} v^2 = GM\cancel{m} / r$ ⇨ $v = \sqrt{(2GM / r)}$ ✓ where *M* is mass of spherical body of radius *r* that you are trying to escape and *G* is the gravitational constant ✓	1 1 1	
40	(b)	(ii)	$v = \sqrt{(2G\{^4/_3 \pi R^3 \rho\} / R}$ ⇨ $v = \sqrt{(^8/_3 G\pi\rho)}\, R$ ✓	1	algebraic reasoning **accept** $M = {^4/_3} \pi R^3 \rho$
40	(b)	(iii)	$R = \sqrt{(3 / 8G\pi\rho)}\, c$ or $= \sqrt{(3 / (8 \times 6.7 \times 10^{-11} \times \pi \times 10^{17})} \times 3 \times 10^8$ ✓ $= 4.0 \times 10^4$ (m) ✓	1 1	method change subject of equation and sub for *c* in algebra / numbers evaluation
			Total	**9**	

Question			Answer	Marks	Guidance
41	(a)		**Level 3 (5–6 marks)** Marshals argument in a clear manner and includes clear explanation of three strands: • change in mass • binding energy equivalent • forces and momentum *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.* **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. *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.*	6	**Indicative scientific points may include:** **Change in mass** • protons and neutrons in a nucleus are bound by the strong nuclear force, which is a short-range attractive force sufficient to overcome the electrostatic repulsion between the protons in a nucleus. • For a nucleus with Z protons and N neutrons Δm = mass of nucleus - ($Z\ m_p + N\ m_n$) OR • change in mass = 221.9703 – (217.9628 + 4.0015) = 0.0060 (u) **Binding energy equivalent** • to pull nuclei apart requires energy called the binding energy of the nucleus • binding energy of a nucleus can be calculated from the difference in mass between the nucleus and its separate neutrons and protons binding energy = $\Delta m\ c^2$ • rest energy of the nucleus is less than that of its constituent particles. Since the rest energy $E_{rest} = m\ c^2$, the mass of the nucleus is also less than that of its constituent particles. • $\Delta E = \Delta m\ c^2 = 0.0060 \times 1.661 \times 10^{-27} \times (3.00 \times 10^8)^2$ $= 8.969 \times 10^{-13}$ (J) $= 8.969 \times 10^{-13} / (1.6 \times 10^{-19} \times 10^6) = 5.61$ (MeV) • OR accept knowledge of 1 u = 931 MeV **Forces and momenta**

Question			Answer	Marks	Guidance
			0 marks No response or no response worthy of credit		• during emission α and remnant nucleus repel with equal and opposite electrostatic forces (for equal times) or $F = k\,Q_1\,Q_2\,/\,r^2$ • by Newton's 3rd Law nucleus recoils • so impulses are equal and opposite on α and nucleus • so gaining equal and opposite momenta • nucleus carries away some k.e. from binding energy released • **accept** well labelled diagrams throughout for credit if integrated into the explanation
41	(b)	(i)	conservation of momentum	1	**accept** momentum before = momentum after = zero or equal magnitude opposite direction for two particles momenta
41	(b)	(ii)	$= m_{Po}\,v_{Po}^2\,/\,m_\alpha\,v_\alpha^2 = m_{Po}\,m_\alpha^2\,/\,m_\alpha\,m_{Po}^2 = m_\alpha\,/\,m_{Po}$	1	mid step must be clear for mark
41	(b)	(iii)	= 0.98(2) ✓ 5.61 MeV x 0.982 = 5.5(1) MeV ✓ value of α k.e. 5.5 MeV agrees at 2 S.F. level ✓	1 1 1	**accept** evaluation of energy or fractional energy **allow** nuclear fraction of total k.e. = 0.018 or nuclear recoil k.e. = 0.10(1) MeV comparison of energy to actual value
			Total **Total section C** **Total sections B & C**	**11** **57** **80**	