OCR
RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced GCE **H559**

Advanced Subsidiary GCE **H159**

Mark Scheme for the Units

January 2010

HX59/MS/R/10J

Oxford Cambridge and RSA Examinations

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MARK SCHEMES FOR THE UNITS

G491 – Physics in Action

Section A

Question			Expected Answers	Marks	Additional Guidance
1	(a)		Ω m / V A^{-1} m / etc.	1	**accept** any correct equivalent base units e.g. S^{-1} m / Ω m^2 m^{-1} **accept** in words e.g. Ohm metres / capital M for m
	(b)		S m^{-1} / $(\Omega$ m$)^{-1}$ / etc.	1	**accept** any correct equivalent base units e.g. A V^{-1} m^{-1} **accept** in words e.g. Siemens per metre / capital M for m
2			increase ; brightness / increase / stretch / improve ; contrast / **OR** Any two from: (pixel value) subtract (smallest pixel value) / multiply / by greater than 1	2	AW sense of change for first mark ; named modification **accept** brighter for 2 marks **accept** increase pixel values for 1 mark **accept** stretch **/** increase range of pixel values for 2 marks e.g. times pixel value by 4 gets 2 mark **ignore** edge detection, noise reduction etc
3	(a)		crystal features / sharp or straight edges / flat planes or straight lines / regular angles / cleavage	1	**accept** AW for idea of regularity in any form **accept** straight breaks / sharp cracks **Ignore** references to crack propagation **accept** ORA: states feature of plastic flow and notes they are missing **NOT** edges are rough / jagged / harsh
	(b)		structure might fail / fracture / is not tough in low temperatures (of space)	1	AW ora but need to make link to low temperatures **allow** weaker / not as strong in cold
4	(a)		peak to peak signal in the range 4.1 to 4.5 mV	1	n.b. analogue signal without noise variation – judge by value
	(b)		peak to peak noise in the range 0.2 to 0.5 mV	1	
	(c)		(2^8) = 256 (levels)	1	**NOT** 255
	(d)		**First** easy **mark,** any **one** relevant point: 4 bits / 2^4 gives 16 levels / coding for noise detail is pointless / (4) bits are redundant / resolution for (8 bits) is too good / small / smaller than noise (level) **Second mark** (must be quantitative) $(V_{total} / V_{noise}) \approx 16$ / own value correctly calculated / resolution $\approx$ 5 mV / 255 = 0.02 mV	2	AW throughout **accept** $\log_2 (V_{total} / V_{noise}) \approx 4$ for 1 mark / with own value correctly calculated 2 marks **NOT** Any credit for sampling eliminating noise / converting noise to signal, but do not penalise with **con**. **accept** for first mark resolution of 4 bits $\approx$ noise level **allow** ecf on their values from **a** and **b** e.g. 2.3/0.2 =11.5

Question			Expected Answers	Marks	Additional Guidance
5			$R = V^2 / P$ / = 240^2 / 2200 26.(2) (Ω)	1 1	method / **allow** 1st mark for ($I = P / V$) = 9.1(7) A evaluation no s.f. penalty
6	(a)		components e.g. glass & plastic / steel & concrete / stone/aggregate & cement / steel & glass / lignin & cellulose make composite e.g. GRP / reinforced concrete / concrete / safety glass / natural wood	1 1	must mention two sensible components of a known / feasible composite for first mark **accept** natural composite materials e.g. wood / bone name the composite material for second mark (must be plausible) **NOT** e.g. steel reinforced carbon / carbon fibre reinforced steel / alloys (0 marks for alloy answers in part (**a**)) 1 mark only if the materials do not correspond to composite
	(b)		any one benefit of **each** component made clear e.g. strength / stiffness of glass ; toughness of plastic OR toughness / tensile strength of steel ; cheapness / aesthetics / moldability of concrete	2	**accept** aesthetic / economic / other non-physical properties for **one** component only **only** credit same property repeated once only **accept** tensile and compressive strength as different properties **allow** correct properties even if no credit for composite in (a) credit alloys answers from **(a)** e.g. steel – iron confers strength to alloy / carbon confers toughness **accept** properties developed in composite or properties of individual component materials to all answers (even if not the most significant property conferred)
7			wavefronts concave focusing where ray meets CCD wavelengths consistent with plane waves (judged by eye)	1 1	**NOT** any credit for only **rays** focussing Expect 3 or 4 wavefronts drawn to fill gap, **but** 2 correctly placed waves can score also 2 marks
			Total section A	**19**	

Section B

Question			Expected Answers	Marks	Additional Guidance
8	(a)	(i)	(stress / strain graph) is proportional / constant stiffness / obeys Hooke's Law / shows elastic behaviour / is linear and through origin	1	AW **accept** any one answer **accept** Young Modulus is constant **not** just linear (need both points if this answer)
		(ii)	*E* is initial gradient / numerical attempt up to strain 0.11% e.g. gradient = 200 MPa / 0.0009 = 2.2(2) x 10^{11} ($\pm$ 0.1 x 10^{11}) (Pa)	1 1 1	method **accept** triangle drawn on graph for this mark **accept** other correct values from graph including linear extrapolations **evaluation**: penalise incorrect use of % as -1 mark i.e. max 2/3 for 2.2 x 10^{7} Pa / 2.2 x 10^{9} Pa also penalise missing M prefix -1 mark i.e. 2200 Pa scores 1 out of 3 **NOT** any credit for graph points outside elastic region e.g. 300 MPa / 0.005 (scores 0)
	(b)	(i)	($L_0 \varepsilon$ = 0.2 x 0.005) = 0.001 (m) / 1.0 mm	1	evaluation only, method not expected
		(ii)	($A = \pi D^2 / 4$) = 5.0(3) x 10^{-5} (m^2) $F = \sigma A$ / = 300 x 10^{6} x 5.0(3) x 10^{-5} = 1.5(1) x 10^{4} (N)	1 1 1	part evaluation method **accept** full credit for correct answer **accept** ecf on incorrect areas for last two marks **accept** max stress of 220 MPa gives 1.1(1) x 10^{4} (N) for max 2/3
	(c)		3 points from: not all of the planes slip at once ; dislocation described / annotated diagrams ; produce stress / strain concentration ; which moves (through grain) by a few planes / rows slipping at a time ; if all of planes slip the resulting strain >> 0.1% plausible diagrams illustrating the above points (without mention of dislocations) can gain full credit	3	3rd mark is for **QWC** clarity that slip / stress / strain is localised to a few planes / rows of atoms at a time not all at once AW throughout **QWC** answer must clearly explain that slip is localised to a few planes / rows of atoms at a time, otherwise max 2
			Total question 8	**11**	

Question			Expected Answers	Marks	Additional Guidance
9	(a)		for functioning circuit diagram including: battery / cell, (m)A and sample in series voltmeter in parallel with sample	 1 1	 **accept** Ωmeter and sample in one loop for full credit **NOT** voltmeter in series (scores 0 for part (**a**)) **accept** voltmeter in parallel with sample **and** ammeter **ignore** series / safety resistors (unless voltmeter across them)
	(b)		Any 3 points from measure *R* directly / measure *V* and *I* ; *G* = 1 / *R* / *G* = *I* / *V* ; measure length *L* (of semiconductor) ; measure width and height (of semiconductor)	3	**NOT** any credit for lengths only mentioned in an equation
	(c)		(cross-sectional) area = width x height (use of) $\sigma = G L / A$ in symbols / σ = 0.01 x 0.01 / (0.01 x 0.001)	1 1	**Look at (b) / (c) together, credit here if seen in (b)** **must** be clear area is width x height in (b) / (c) for this mark **must** have transposed equation from formulae sheet for this mark
	(d)		**identify** source of uncertainty (any measurement) / systematic error (zero error / calibration of any instrument) **changes** e.g. use micrometer to measure thickness / Vernier calliper to measure width & height / more sensitive meters repeat readings / swap / calibrate meters **and** average to find mean / spread / monitor temperature / reduce p.d. **improvements / explanation** measurements more precise to ± 0.01 mm / plot *I* vs *V* graph & line of best fit, use gradient for *G* to reduce absolute / % uncertainty swap / calibrate meters to eliminate systematic error	1 1 1 1	1st mark quite easy e.g. uncertainty in thickness measurement / systematic error in resistance measurement / temperature effects / meter resistance / meter resolution **NOT** human error / internal resistance of supply **NOT just** repeat readings / take more accurate measurements **QWC** max 2 if ideas are not clearly described and explained
			Total question 9	**10**	

Question			Expected Answers	Marks	Additional Guidance
10	(a)	(i)	720 x 1280 x 24 x 50 = 1.1(1) x 10^9 (bits s^{-1})	1	**accept** bare answer to 2 or more s.f.
		(ii)	1.1 x 10^9 x 3600 (s/hr) / 8 (bits/byte) = 498 Gbytes	1 1	method / **allow** 1st mark for getting as far as 3.98 x 10^{12} bits or for recognising 8 bits per byte evaluation **accept** 450 Gbytes using 10^9 bits s^{-1} / 495 Gbytes using rounded bit rate
		(iii)	200 (Gbyte) / 80 (hr) = 2.5 (Gbyte / hr)	1	**accept** bare answer to 2 s.f. **accept** ORA 3Gbytes x 80 = 240 > 200
	(b)	(i)	max information per hour > memory capacity per hour / 498 Gbyte > 2.5 Gbyte (so data must be compressed)	1	**accept** ecf on (a)(ii) > (a)(iii) **accept** total information for 80hrs (312 Tb > 1.6 Tb) **ignore** factors of 2 or 0.5 expect compression ratio 200:1 if worked out
		(ii)	one point from: 10 MHz < 1.1 Gbit s^{-1} / (a)(i) signal bandwidth is too small to support the max bit rate / bandwidth needs to be ≈ bit rate / cannot transmit several bits per carrier cycle (so data must be compressed)	1	**accept** ecf on 10 MHz < (a)(i) AW
	(c)		transverse wave by word / diagram oscillations (of E / B field) only in vertical direction / plane	1 1	**accept** any transverse wave diagram AW but must be described / diagram labelled clearly **NOT** travels / moves in one plane / direction
			Total question 10	**8**	

Question			Expected Answers	Marks	Additional Guidance
11	(a)	(i)	($I = V / R$ = 6.0 / 240) = 0.025 (A)	1	**accept** 0.03 (A)
		(ii)	**Constant current, any 2 from** **B** increases resistance / **F** decreases in resistance / changes of resistance are equal (and opposite) / total resistance remains constant **p.d. across B increases** Constant current and larger R hence larger V OR ratio $R_B / R_F > 1$ / correct discussion of potential divider $R_B / R_{total} > ½$	2 1	AW **allow** $V = I R$ argument
	(b)	(i)	$\Delta y / \Delta x$ / e.g. = (3.010 – 2.998) / (0.6 – 0) = 0.020 (V MPa^{-1})	1 1	method **must** clearly be attempt at a gradient for 1st mark evaluation two marks if value is correct
		(ii)	from graph when Δy = 1 mV / pressure resolution = voltage resolution / sensitivity Δx = 0.05 M(Pa) / 5.0 x 10^4 (Pa)	1 1	method must be clear for 1st mark evaluation **allow** 0.05 (Pa) for 1 mark (prefix omission)
		(iii)	change of temperature will change resistance / (if a resistor changes temp.) p.d. will shift off 3.0 V / produces a constant difference / error offset / zero error	1 1	**accept** wrong sense for metals **accept** shift up / down in p.d / sense of shift **not** expected
	(c)	(i)	both potential dividers produce 3.0 V so p.d. is zero / the voltage at both **M** and **N** is the same so p.d. is zero	1	AW
		(ii)	(pressure resolution) = 500 (Pa)	1	**accept** ecf on (b)(ii) / 100
			Total question 11	**12**	
			Total section B	**41**	
			Paper total	**60**	

G492 – Understanding Processes, Experimentation and Data Handling

Qn	Expected Answers	Marks	Additional guidance
1	(a) hf and $\frac{1}{2}mv^2$ (1) (b) $d \sin\theta$ and $\frac{1}{2}at^2$ (1)	1 1	Both needed (either order) in each part.
2	$\frac{1}{4}\lambda$ (1)	1	Allow ringing, underlining, etc. of $\frac{1}{4}\lambda$ in list
3	$v = \sqrt{(200^2 - 50^2)} = 190$ m s^{-1} (1); θ = arcsin(50/200) (1); = arcsin (0.25) = 14.47° = 14° (1)	3	Ignore any vector triangle with θ to the east instead of west. Allow resultant = 200 km h^{-1} or assuming v = hypotenuse = 206 km h^{-1} Allow θ = arctan(50/200)= 14.0° in either case Alternatives: 193.6 km h^{-1} & 14.5°, 200 km h^{-1} & 14.0°, 206 km h^{-1} & 14.0° For scale drawing allow greater tolerance.
4	**X** = $\frac{1}{2}at^2$ (3rd box) **Y** = ut (4th box)	2	One for each correct tick. If more than one choice for X or for Y, ignore that area.
5	$\lambda/d = \sin\theta \approx x/L$ (1) $d = \lambda L/x$ = 590 × 10^{-9} m × 1.2 m/3.5 × 10^{-3} m (1) = 2.0 × 10^{-4} m (1)	3	Or quote $\lambda = xd/L$, etc. Rearrange/substitute. Must be correct from first stage (no ecf). θ =0.17°. Eval.; allow 0.20 mm
6	(a) $f = E/h$ = 3.5 × 10^{-19} J/6.6 × 10^{-34} J s (1) = 5.3 × 10^{14} Hz (1) (b) P = NE/t = 1.2 × 10^{17} × 3.5 × 10^{-19} J / 1 s = 0.042 W (1)m (1)e	2 2	Method/substitution Evaluation
7	(a) $E = mgh$ = 6.0 × 10^{-3} kg × 9.8 m s^{-2} × 0.50 m (1) = 0.029 J (1) (b) displacement x = (30 - 9) × 10^{-3} m = 0.021 m (1) $W = Fx$ = 3 N × 0.021 m (1) = 0.063 J (1)	2 3	Method/substitution Evaluation Can be incorporated into calc. of W Method/substitution Evaluation. Penalise 1 mark for use of mm instead of m.
	Section A total:	**20**	

Qn	Expected Answers	Marks	Additional guidance
8 (a)	(i) between 0.1 and 0.3 s (1) (ii) demonstrating that either area under graph or (average speed × time) (1); is considerably less than 200m / ≈ 100 m (1)	1 2	Must use data from **both** axes. method mark for getting a typical/average speed & time and multiplying, or indicating that total area = distance and indicating area (1); evaluation mark for comparison with 100 m (1) (final speed × time) gets only (1) unless qualified e.g. final speed is about the average.
(b)	(i) a = 4 m s^{-1}/(0.7 s – 0.2 s) = 8 m s^{-2} (1)m; (1)e; $F = ma$ = 88 × 8 = 704 N ≈ 700 N (1) (ii) assumes no resistive forces/reference to lack of precision in data from graph (1)	3 1	Method is gradient of straight line: must have Δv > 1 m s^{-1} and allow for reaction time (1); Evaluation ± 2 m s^{-2} (1) ecf for *a;* may see answers (with correct *a*) from 530-880 N
(c)	Drop in speed noticeable in last 1.2 – 1.7 s / after 8s (1); Mean speed over this time is 11.5 – 11.8 m s^{-1} (1); Combining above & comparing with 20 m.(1)	3	First two points and combination can be done by area: needs comparison with 20 m for 3rd mark. Third mark is the QWC 'organise information clearly' mark.
	Total:	**10**	
9 (a)	(i) F (1) (ii) A and B (1)	1 1	 Both needed
(b)	First out from the centre (on each side) = A (1); Outermost (on each side) = F (1)	2	
(c)	(i) $f = c/\lambda$ = c = 3.0 × 10^{8} m s^{-1}/360 × 10^{-9} m = 8.3 × 10^{14} Hz (1)m; (1)e $E = hf$ = 6.6 × 10^{-34} J s × 8.3 × 10^{14} Hz = 5.5 × 10^{-19} J (1) (ii) Comparing electron energy from table (0.82 × 10^{-19} J) with photon energy (5.5 × 10^{-19} J) (1); Difference ≈ 4.7 × 10^{-19} J (1)	3 2	Allow ecf. "Show that" so needs 2 sf. Give all 3 marks for $E=h\,c/\lambda$ & eval. photon energy e.c.f. from (i) Can calculate photon energy for 435 nm for both marks.
	Total:	**9**	

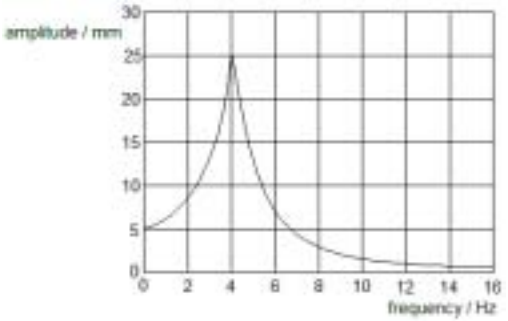
Qn	Expected Answers	Marks	Additional guidance
10 (a)	(i) wave reflects (at open end) (1); resonance idea e.g. sets up right frequency (1); there is superposition / interference between waves (in opposite directions) (1); nodes = destructive interference/out of phase (1); antinodes = constructive interference/in phase (1) QWC is 'spelling, punctuation and grammar' of reflection and interference or superposition	3	Allow pressure N & A if clear. Any three points. Incorrect spelling of underlined terms means max 2. Allow paraphrases for the marking point.
	(ii) length of didgeridoo = ¼ λ so λ = 6.4 m (1); $f = c/\lambda$ = 340 m s^{-1}/6.4 m = 53 Hz (2)	3	m & e; ecf for λ
	(iii) A at open end and N at 'mouth' end (1); A and N alternate and equally spaced (1); pattern A N A N (1)	3	
(b)	Test: constant $f:T$ /straight line graph through origin (1) $f:T$ = 4.93, 3.01, 2.19 (1) conclusion: not proportional. (1)	3	If test for linearity proposed and done correctly (equal differences, so looks linear) give 1 mark. {for ref: $T:f$ = 0.203, 0.332, 0.457}
	Total:	**12**	
11(a)	5 m s^{-1} × 0.2 s = 1.0 m (1); Horizontal motion not affected by gravity/$F_{resultant}$ =0 (1)	2	Allow 'no horizontal acceleration'
(b)	(i) Straight line segments (1); $x \propto t$ so velocity = gradient = constant / acceleration would produce curve (1)	2	Second mark requires recognition that $x \propto t$ so straight line is constant velocity as y-x graph is same shape as y-t graph.
	(ii) $x \approx$ 3.5 m (at $y \approx 0$) (1); $t = x/v_x \approx$ 3.5 m/5 m s^{-1}=0.7 s (1)/ there are 4 line segments (1); each segment is 0.2 s (so total is 0.8 s) (1)	2	
	(iii) $s = ½at^2 \Rightarrow t = \sqrt{(2s/g)} = \sqrt{(2\times1.6\text{ m}/ 9.8\text{ m s}^{-2})}$ = 0.57 s (< 0.7 s) (1)m; (1)e	2	
	(iv) Velocity at start of each interval used / velocity changes constantly/ time interval too big (1);	1	
(c)	Use smaller time intervals / more steps per second (1) so v updated more often / true v modelled better (1)	2	Or include acceleration during time intervals in the model (1) so true v modelled better (1)
	Total:	**11**	
	Section B total:	**42**	

Qn	Expected Answers	Marks	Additional guidance
12 (a)	(i) 5000 Ω (1) (ii) 5000 Ω (1) (iii) 50 000 Ω (1)	1 1 1	
(b)	ΔV = (4.0 – 2.6) V = 1.4 V (1); Sensitivity = $\Delta V/\Delta T$ = 1.4 V / 20 °C = 0.070 (1)m; (1)e With units V °C $^{-1}$ (1)	4	Values 20°C, 4 V and 2.6 V imply use of graph. 0.01 V ÷ gradient of line is valid: ΔV mark from triangle. If 'insensitivity' in °C V^{-1} calculated, maximum 3/4 if completely correct.
(c)	Identifies voltage range is 2.4 – 2.6 V to 3.0 V i.e. 0.4 – 0.6 V (1) Dividing this by 0.01 V gives 40 – 60 steps in range (1) Temp. resolution = 10°C /(40 to 60) = 0.25 to 0.17°C (1)	3	Look for gradient 0.4 to 0.6 V °C^{-1}. Can use values at 50°C and 60°C. Compares with ± 0.01V. Ecf from first step for factor. Translates to °C. Ecf of factor from second step.
	Total:	**10**	
13 (a)	(i) P = 1/0.21 m – 1/0.11 m = 4.76 D – 9.09 D = -4.3(3) D (ii) measured to nearest 0.01 m (so ± 0.005 m) (1) (iii) P_1 = 1/0.215 m – 1/0.105 m = -4.87 D (1) P_2 = 1/0.205 m – 1/0.115 m = -3.82 D (1) Range = 1.05 D so uncertainty = 0.525 D (1); =0.5 D (1)	1 1 4	Accept any clear recognition of 2 s.f./2 d.p. implying ± ½ of last digit. If v_{max} and $\underline{u}_{max}$ (& mins) used in same calc, get P_1 = -4.65 D and P_2 = -4.04 D; in this case give 1/2 for both calculations together. Ecf from P_1 & P_2 for 3rd mark (above gives 0.61/2 = 0.3 D) 1 s.f. for 4th mark (even if answer wrong); 0.525 D or 0.53 D gets 3/4 total If one extreme and mean used, completely correct answer would get 3 /4.
(b)	(i) 9.1 | 4.8 8.3 | 4.2 7.7 | 3.4 Annotation: put ✕ on any wrong numbers (ii) All correct (2); one wrongly plotted (1) (iii) best-fit line (1); P = – 1/u when v = 0 = - 4.4 to - 4.5 D (1)	2 2 2	One mark for each correct column Allow 3 s.f. but not 4 or more; 3 s.f. → 9.09 | 4.76 8.33 | 4.17 7.69 | 3.45 Overlay to be used. Ecf from (i) if needed. By eye: must have points both sides of line. Ecf: allow any method using line on graph, e.g. subst. values of 1/u,1/v from line
	Total:	**12**	

Qn	Expected Answers	Marks	Additional guidance
14 (a)	(i) 13 900 km/ 902 km h^{-1} = 15.4 h (≈ 15 h) (1)	1	ora
	(ii) fuel used = 15.4 h × 9800 L h^{-1} = 151 000 L (1) 80% of 195 600 = 156 000 L (1) > 151 000 L (1)	2	15.4 h = 77%; 15h = 75%
	(iii) Plausible suggestion (1); Explains effect of suggestion on fuel needed – must have correct physics reasoning (1)	2	e.g. head winds / diversion from route / delays in landing (1); so plane must stay longer in the air (1) or more fuel needed at take-off (1); work done in accelerating/overcoming turbulence/denser air at ground level (1)
(b)	(i) F = 3 × 270 000 = 810 000 N (1) $a = F/m$ = 810 000 N/273 900 kg = 2.96 m s^{-2} (1)	2	Calc. of a from wrong F can gain 1 mark.
	(ii) $s = v^2/2a$ = (81 m s^{-1})^2/2×2.96 m s^{-2} = 1100 m (1)m; (1)e	2	Calc. of s from wrong v can gain 1 mark.
	(iii) Plausible suggestion (1); Explains effect of suggestion on take-off distance – must have correct physics reasoning (1)	2	e.g. May not reach required v due to wind / other traffic on runway / turbulence (1) If v not reached, plane would crash /need space to slow down to a halt(1)
(c)	Lift must equal weight (1); weight = mg so Lift $\propto m$ (1)	2	
(d)	Best-fit line excluding Boeing 777 point (1); Larger mass planes have larger wing area (1); Identifying Boeing 777 as different from the others (1); suggestion for odd position of Boeing 777 (1)	3	Line should obviously exclude Boeing 777 and should be reasonable best fit of other points by eye, i.e. have points on each side Any **two** of these explanations/descriptions. Can credit use of other data related to Boeing 777 e.g. fuel capacity.
	Total:	**16**	
	Section C total:	**40**	

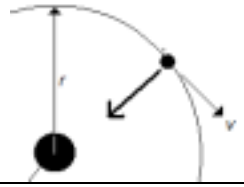
G494 Rise and Fall of the Clockwork Universe

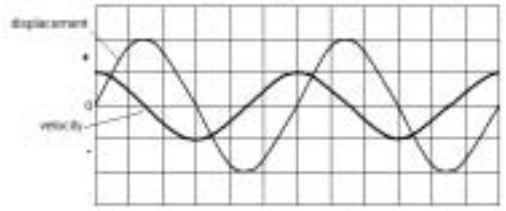
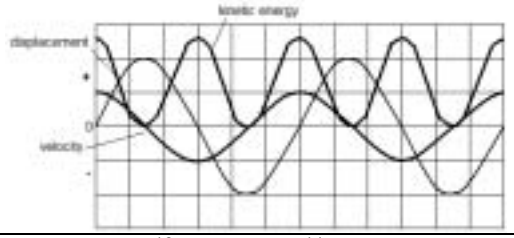
Question			Expected Answers	Marks	Additional Guidance
1	(a)		J kg^{-1}	1	
	(b)		N s	1	look for capital n, not lower case
2	(a)		$\lambda = 1.3\times10^{-5}$	1	accept 1.28×10^{-5} but not 1.2×10^{-5} (incorrect rounding)
	(b)		the probability per second; of a decay / change of a (single) nucleus/atom	1 1	accept chance per second / unit time look for mention of nucleus or atom, but not particle / sodium-24 ... accept alternative answer: fraction of nucleii / atoms for [1] decaying per second for [1]
3	(a)		$\Delta p = (0.15 \times 5) \times 700 = 525$ kg m s^{-1}	1	accept correct reverse calculation: e.g. 500 kg m s^{-1} gives 4.8 s for [1]
	(b)		$p_{initial}$ = 120 x 60 = +720 Ns p_{final} = +720 - 525 = 195 Ns v_{final} = +195 / 120 = 1.6(3) m s^{-1}	2	evidence of correct calculation of initial momentum (±) for [1] ecf: 500 kg m s^{-1} gives 1.8(3) m s^{-1} for [2] ignore sign of final answer alternative method for [2]: change of velocity = 525/120 = 4.38 m s^{-1} final velocity = 6.0 – 4.38 = 1.6(3) m s^{-1} allow [1] for correct change of velocity allow final mass of astronaut = 119.25 kg to give 1.6(4) m s^{-1}
4	(a)		$\gamma = 1.3\underline{4}$	1	look for more than just 1.3
	(b)		1.1×10^{-6} s	1	
5	(a)		minus (-); 4.9×10^{9} J	1 1	look for minus sign with their final answer (from whatever formula)
	(b)		A	1	
6	(a)		A	1	
	(b)		C	1	remember **A**ll **A**ble **C**andidates

Question			Expected Answers	Marks	Additional Guidance
7			25 mm peak at 4 Hz; tends towards zero above 4 Hz; 5 mm at 0 Hz;  	1 1 1	look for maximum at 4 Hz, sharpness of peak is not important must be at or below 2.5 mm at 16 Hz (by eye) must be at 5 mm at 0 Hz (by eye)
8			Microwave radiation from the universe can be detected in all directions. The red-shift of lines in a galaxy's spectrum is proportional to its distance from our galaxy. ☐ ☑ ☐ ☐ ☑	1 1	correct pattern of ticks for [2] one mistake for [1] a mistake is: • a tick in the wrong place • a missing tick • an extra tick accept any unambiguous correct response
			Total Section A	**20**	

Question			Expected Answers	Marks	Additional Guidance
9	(a)	(i)	$N = PV/kT$;	1	evidence of this rule (as algebra or subsitution of numbers) [1] accept $PV = NkT$ or nkT or nRT or NRT as the rule
			$T_A = 27 + 273 = 300$ K; $N = 1.1(4)\times10^{22}$	1 1	correct conversion of °C to K for [1] ecf incorrect conversion of °C to K e.g. T_A = 27 K gives 1.3×10^{23} for [2] correct reverse calculation for [3]: $N = 1\times10^{22}$ gives T = 343 K for [2] and therefore 70°C for [1] $N = 1\times10^{22}$ and T = 300 K gives $V = 4.2\times10^{-4}$ m^3 for [3] $N = 1\times10^{22}$ and T = 300 K gives $P = 8.8\times10^{4}$ Pa for [3] use of $k = 1.38\times10^{-23}$ gives $N = 1.16\times10^{22}$ for [3]
		(ii)	$P_B = 20\times10^5$ Pa; full value N from (i) gives T_B = 750 - 273 = 477 °C; accept answers rounded to 2 sig fig	1 1	evidence of correct reading off graph for [1] allow P_B = 17 to 21×10^5 Pa for [1] and subsequent calculation for [1] no ecf for P_B = 20 $N = 1\times10^{22}$ gives T_B = 857 K and 584°C for [2] $N = 1.1\times10^{22}$ gives T_B = 779 K and 506°C for [2] $N = 1.14\times10^{22}$ gives T_B = 752 K and 479°C for [2] accept correct reverse calculation for [2] e.g. T = 273 + 500 = 773 K and $N = 1\times10^{22}$ gives $V = 5.4\times10^{-5}$ m^3 [1] comparable to 6×10^{-5} m^3 [1] e.g. T = 273 + 500 = 773 K and $N = 1\times10^{22}$ gives $P = 1.8\times10^{6}$ Pa [1] comparable to 20×10^5 Pa [1]

Question			Expected Answers	Marks	Additional Guidance
	(b)	(i)	increased their speed/velocity; greater momentum change per collision (with the walls); increases rate of collisions (with walls)	1 1 1	not just increase of kinetic energy look for complete statement for [1] not just more collisions QWC should include the full story for the third mark
		(ii)	number of molecules / particles doesn't change; $T = \frac{PV}{Nk} = \frac{35\times10^{5}\times0.5\times10^{-4}}{1.14\times10^{22}\times1.4\times10^{-23}} = 1096$ K	1 1	NOT just ideal gas N: 1×10^{22} gives 1250 K for [1] $V = 0.6\times10^{-4}$ m^3 gives 1316 K or 1500 K for [1] look for correct method with sensible values and answer between 1522 K and 1090 K
	(c)		work done by gas; equals decrease in internal energy	1 1	for example: gas does work on the piston for [1] work done by gas equals decrease in internal energy for [2]
			Total Q9	**12**	

Question			Expected Answers	Marks	Additional Guidance
10	(a)	(i)	pulses of light/microwaves from Earth reflect from the Moon; speed of light × half the pulse-echo time = distance (owtte); assumes: speed of light same all the way through the journey / same time for both halves of journey	1 1 1	accept EM waves instead of light / microwaves (not IR, UV ...) look for pulses of radiation from Earth to Moon and back to Earth look for how to calculate the distance for [1] accept a formula e.g. $d = ct/2$ accept effect of atmosphere is negligible (on speed of EM wave) QWC candidates who cannot spell correctly cannot earn more than [2]
		(ii)	$t = 27 \times 24 \times 3600 = 2.3\times10^6$ s $v = \frac{2\pi r}{t} = \frac{2\pi \times 3.8\times10^8}{2.3\times10^6} = 1.02\times10^3$ m s^{-1}	1 1	look for correct method of conversion to seconds for [1] accept ecf from incorrect t for [1] e.g. 27 s gives 8.8×10^7 m s^{-1} for [1] 27×24 s gives 3.7×10^6 m s^{-1} for [1] $27\times 24 \times 60$ s gives 6.1×10^4 m s^{-1} [1] accept correct reverse calculation for [2] e.g. $v = 1000$ m s^{-1} gives 2.4×10^6 s [1] which is 27.6 days [1]
	(b)	(i)		1	arrow from centre of Moon towards centre of Earth for [1] accept arrow pushing Moon towards centre of Earth look for extrapolated arrow passing through Earth.
		(ii)	acceleration / force is at right angles to displacement / velocity so no work is done	1	look for complete argument to award [1]
		(iii)	$F = \frac{mv^2}{r} = \frac{GMm}{r^2}$ $v = 1000$ m s^{-1} gives 5.7×10^{24} kg $v = 1023$ m s^{-1} gives 5.9×10^{24} kg	1 1	use of this rule for [1]
			Total Q10	**9**	

Question			Expected Answers	Marks	Additional Guidance
11	(a)	(i)	(model has each atom at centre of a cube of side d, so) volume occupied by a single atom is d^3	1	accept volume of an atom/particle is d^3
		(ii)	$d = \sqrt[3]{\frac{m}{\rho}}$ $d = 2.3\times10^{-10}$ m	1 1	correct rearrangement for density with symbols or numbers for [1] award [1] for correct calculation of $d^3 = 1.2\times10^{-29}$ m^3
	(b)	(i)	full value d from (ii) gives $2.312\times10^{-10} \times 1.3\times10^{11} = 30.1$ N m^{-1}	1	$d = 2.31\times10^{-10}$ m gives 30.0 N m^{-1} for [1] $d = 2.3\times10^{-10}$ m gives 29.9 N m^{-1} for [1] $d = 2\times10^{-10}$ m gives 26 N m^{-1} for [1] accept correct reverse calculation for [1] e.g. $k = 30$ N m^{-1}, $d = 2.3\times10^{-10}$ m gives $E = 1.30\times10^{11}$ Pa
		(ii)	k/d is (N m^{-1}) (m^{-1}) = N m^{-2}	1	look for correct units for k and d combined correctly to give N m^{-2}
	(c)	(i)		1	accept any constant amplitude, look for correct peaks and zero-crossing points across whole timespan, cosine curve. at least one of the curves for (i) or (ii) must be clearly labelled for marks to be awarded.
		(ii)		1	any constant amplitude, must be positive, and correct pattern across timespan ecf incorrect phase of velocity-time graph - peak energy to coincide with peak speed accept full-wave rectified cosine wave
	(d)		$A = 0.15 \times 2.3\times10^{-10} = 3.5\times10^{-11}$ m; $E = kA^2 / 2 = 1.8\times10^{-20}$ J; $T_m = E/k = 1.8\times10^{-20} / 1.4\times10^{-23} = 1280$ K	1 1 1	2×10^{-10} m gives 3×10^{-11} m for [1] 2×10^{-10} m gives 1.4×10^{-20} J for [1] 2×10^{-10} m gives 960 K for [1] look for calculation of amplitude for [1], energy for [1] and T_m for [1] with ecf from one step to the next.
			Total Q11	**10**	

Question			Expected Answers	Marks	Additional Guidance
12	(a)	(i)	$E_T = 1.3\times10^{-20}$ J; $f = E/h = 2.0\times10^{13}$ Hz; $\lambda = c/f = 1.47\times10^{-5}$ m	1 1 1	correct answer for [3] allow ecf from incorrect E $E = kT$ gives 2.36×10^{-5} m for [2] allow ecf from incorrect f accept 1.5×10^{-5} m
		(ii)	infrared	1	accept any correct and unambiguous response allow ecf from incorrect (i) X-rays below 1×10^{-9} m ultraviolet from 1×10^{-9} m to 4×10^{-7} m visible from 4×10^{-7} m to 8×10^{-7} m infrared from 8×10^{-7} m to 1×10^{-3} m microwaves above 1×10^{-3} m
	(b)		current is determined by rate at which electrons leave the surface owtte; probability that an electron will (have energy ε to) be able to leave the surface (at temperature T) is proportional to BF ($e^{-\varepsilon/kT}$);	1 1	accept current is electrons per second owtte for [1] accept proportion of electrons able to leave the surface
	(c)	(i)	$\ln I = \ln C - \varepsilon/kT$	1	look for this formula in the response accept $\log_e$ but not log
		(ii)	gradient = $5.0\times10^{4} \pm 0.5\times10^{4}$ $\varepsilon = 7.0\times10^{-19} \pm 0.7\times10^{-19}$ J	1 1	allow ecf only from incorrect gradient calculation for [1] e.g. $\varepsilon = 7.0\times10^{-22}$ J for [1] watch out for one point from graph instead of gradient for [0]
			Total Q12	**9**	

Grade Thresholds

Advanced GCE Physics B (H159/H559)
January 2010 Examination Series

Unit Threshold Marks

Unit		Maximum Mark	A	B	C	D	E	U
G491	Raw	60	34	29	24	20	16	0
	UMS	90	72	63	54	45	36	0
G492	Raw	100	71	64	57	50	43	0
	UMS	150	120	105	90	75	60	0
G494	Raw	60	39	35	31	27	23	0
	UMS	90	72	63	54	45	36	0

Specification Aggregation Results

Overall threshold marks in UMS (i.e. after conversion of raw marks to uniform marks)

	Maximum Mark	A	B	C	D	E	U
H159	300	240	210	180	150	120	0

The cumulative percentage of candidates awarded each grade was as follows:

	A	B	C	D	E	U	Total Number of Candidates
H159	10.1	32.1	57.4	79.4	95.8	100	530

530 candidates aggregated this series

For a description of how UMS marks are calculated see:
http://www.ocr.org.uk/learners/ums_results.html

Statistics are correct at the time of publication.

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