

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the May/June 2015 series**9702 PHYSICS****9702/41**

Paper 4 (A2 Structured Questions), maximum raw mark 100

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Section A

- 1 (a) (gravitational) force proportional to product of masses and inversely proportional to square of separation
reference to *either* point masses *or* particles *or* 'size' much less than separation M1
A1 [2]
- (b) gravitational force provides/is the centripetal force B1
 $GM_N m / r^2 = m r \omega^2$ (or $m v^2 / r$) M1
 $2\pi / T$ (or $v = 2\pi r / T$) leading to $GM_N = 4\pi^2 r^3 / T^2$ A1 [3]
- (c) $M_N / M_U = (3.55 / 5.83)^3 \times (13.5 / 5.9)^2$
 x^3 factor correct C1
 T^2 factor correct C1
ratio = 1.18 (allow 1.2) A1
- alternative method:* mass of Neptune = 1.019×10^{26} kg (C1)
mass of Uranus = 8.621×10^{25} kg (C1)
ratio = 1.18 (A1) [3]
- 2 (a) (sum of) potential energy and kinetic energy of molecules/atoms/particles M1
mention of random motion/distribution A1 [2]
- (b) (i) $pV = nRT$
either at A, $1.2 \times 10^5 \times 4.0 \times 10^{-3} = n \times 8.31 \times 290$
or at B, $3.6 \times 10^5 \times 4.0 \times 10^{-3} = n \times 8.31 \times 870$ C1
 $n = 0.20$ mol A1 [2]
- (ii) $1.2 \times 10^5 \times 7.75 \times 10^{-3} = 0.20 \times 8.31 \times T$ *or* $T = (7.75 / 4.0) \times 290$ C1
 $T = 560$ K A1 [2]
(Allow tolerance from graph: $7.7-7.8 \times 10^{-3} \text{ m}^3$)
- (c) temperature changes/decreases so internal energy changes/decreases B1
volume changes (at constant pressure) so work is done B1 [2]
- 3 (a) (numerically equal to) quantity of (thermal) energy/heat to change state/phase of unit mass M1
at constant temperature A1 [2]
(allow 1/2 for definition restricted to fusion or vaporisation)
- (b) (i) at 70 W, $\text{mass s}^{-1} = 0.26 \text{ g s}^{-1}$ A1
at 110 W, $\text{mass s}^{-1} = 0.38 \text{ g s}^{-1}$ A1 [2]

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	(ii) 1. $P + h = mL$ or substitution of one set of values (110 – 70) = (0.38 – 0.26)L $L = 330 \text{ Jg}^{-1}$		C1 C1 A1 [3]
	2. either $70 + h = 0.26 \times 330$ or $110 + h = 0.38 \times 330$ $h = 17/16/15 \text{ W}$		C1 A1 [2]
4	(a) (i) frequency at which object is made to vibrate/oscillate		B1 [1]
	(ii) frequency at which object vibrates when free to do so		B1 [1]
	(iii) maximum amplitude of vibration of oscillating body when forced frequency equals natural frequency (of vibration)		B1 B1 [2]
	(b) e.g. vibration of quartz/piezoelectric crystal (<i>what is vibrating</i>) either for accurate timing or maximise amplitude of ultrasound waves (<i>why it is useful</i>)		M1 A1 [2]
	(c) e.g. vibrating metal panels (<i>what is vibrating</i>) either place strengthening struts across the panel or change shape/area of panel (<i>how it is reduced</i>)		M1 A1 [2]
5	(a) (magnitude of electric field strength is the potential gradient use of gradient at $x = 4.0 \text{ cm}$ gradient = $4.5 \times 10^4 \text{ NC}^{-1}$ (allow $\pm 0.3 \times 10^4$) or $V = \frac{Q}{4\pi\epsilon_0 x}$ and $E = \frac{Q}{4\pi\epsilon_0 x^2}$ leading to $E = \frac{V}{x}$ $E = 1.8 \times 10^3 / 0.04$ $= 4.5 \times 10^4 \text{ NC}^{-1}$		B1 M1 A1 (B1) (M1) (A1) [3]
	(b) (i) $3.6 \times 10^3 \text{ V}$		A1 [1]
	(ii) capacitance = Q/V $= (8.0 \times 10^{-9}) / (3.6 \times 10^3)$ $= 2.2 \times 10^{-12} \text{ F}$		C1 A1 [2]
6	(a) (i) gravitational		B1 [1]
	(ii) gravitational and electric		B1 [1]
	(iii) magnetic and one other field given magnetic, gravitational and electric		B1 B1 [2]

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	(b) (i) out of (plane of) paper/page (<i>not</i> “upwards”)	B1	[1]
	(ii) $B = mv/qr$	C1	
	$= (3.32 \times 10^{-26} \times 7.6 \times 10^4)/(1.6 \times 10^{-19} \times 6.1 \times 10^{-2})$	C1	
	$= 0.26 \text{ T}$	A1	[3]
	(c) sketch: semicircle with diameter $< 12.2 \text{ cm}$	B1	[1]
7	(a) can change (output) voltage efficiently <i>or</i> to suit different consumers/appliances by using transformers	B1 B1	[2]
	(b) for same power, current is smaller	B1	
	less heating in cables/wires <i>or</i> thinner cables possible <i>or</i> less voltage loss in cables	B1	[2]
8	(a) (i) $p = h/\lambda$	C1	
	$= (6.63 \times 10^{-34})/(6.50 \times 10^{-12})$	A1	[2]
	$= 1.02 \times 10^{-22} \text{ N s}$		
	(ii) $E = hc/\lambda$ <i>or</i> $E = pc$	C1	
	$= (6.63 \times 10^{-34} \times 3.00 \times 10^8)/(6.50 \times 10^{-12})$	A1	[2]
	$= 3.06 \times 10^{-14} \text{ J}$		
	(b) (i) $0.34 \times 10^{-12} = (6.63 \times 10^{-34})/(9.11 \times 10^{-31} \times 3.0 \times 10^8) \times (1 - \cos \theta)$	C1	
	$\theta = 30.7^\circ$	A1	[2]
	(ii) deflected electron has energy this energy is derived from the incident photon deflected photon has less energy, longer wavelength (so $\Delta\lambda$ always positive)	M1 A1 B1	[3]
9	(a) nucleus/nuclei emits spontaneously/randomly α -particles, β -particles, γ -ray photons	M1 A1 A1	[3]
	(b) (i) $N - \Delta N$	A1	[1]
	(ii) $\Delta N/\Delta t$	A1	[1]
	(iii) $\Delta N/N$	A1	[1]
	(iv) $\Delta N/N\Delta t$	A1	[1]
	(c) graph: smooth curve in correct direction starting at (0,0) n at $2t_{1/2}$ is 1.5 times that at $t_{1/2}$ ($\pm 2 \text{ mm}$)	M1 A1	[2]

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Section B

- 10 (a) (i)** (potential =) $1.2 / (1.2 + 4.2) \times 4.5 = +1.0\text{V}$ A1 [1]
- (ii)** (for $V_{\text{IN}} > 1.0\text{V}$) $V^+ > V^-$ B1
 output (of op-amp) is +5 V or positive M1
 diode conducts giving +5 V across R or V_{out} is +5 V A1
- (for $V_{\text{IN}} < 1.0\text{V}$) output of op-amp -5V /negative so diode does not conduct,
 giving $V_{\text{out}} = 0$ or 0V across R A1 [4]
- (b) (i)** square wave with maximum value +5 V and minimum value 0 M1
 vertical sides in correct positions and correct phase A1 [2]
- (ii)** re-shaping (digital) signals/regenerator (amplifier) B1 [1]
- 11 (a)** change/increase/decrease anode/tube voltage B1
 electrons striking anode have changed (kinetic) energy/speed B1
 X-ray/photons/beam have different wavelength/frequency B1 [3]
- (b) (i)** $I = I_0 e^{-\mu x}$ B1 [1]
- (ii)** contrast is difference in degree of blackening (of regions of the image) B1
 μ (very) similar so similar absorption of radiation (for same thickness) so little contrast A1 [2]
- 12 (a) (i)** loudspeaker/doorbell/telephone etc. B1 [1]
- (ii)** television set/audio amplifier etc. B1 [1]
- (iii)** satellite/satellite dish/mobile phone etc. B1 [1]
- (b)** e.g. lower attenuation/fewer repeaters
 more secure
 less prone to noise/interference
 physically smaller/less weight
 lower cost
 greater bandwidth
 (any two sensible suggestions, 1 each) B2 [2]
- (c) (i)** ratio = $25 + (62 \times 0.21)$ C1
 = 38 dB A1 [2]
- (ii)** ratio/dB = $10 \lg(P_2/P_1)$ C1
 $38 = 10 \lg(P/\{9.2 \times 10^{-6}\})$
- $P = 58 \text{ mW}$ or $5.8 \times 10^{-2} \text{ W}$ A1 [2]
 (allow 1/2 for missing 10 in equation)

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- 13 (a) (i) to align nuclei/protons
to cause Larmor/precessional frequency to be in r.f. region
- B1
B1 [2]
- (ii) Larmor/precessional frequency depends on (applied magnetic) field strength
knowing field strength enables (region of precessing) nuclei to be located
by knowing the frequency
- B1
M1
A1 [3]
- (b) $E = 2.82 \times 10^{-26} \times B$
 $6.63 \times 10^{-34} \times 42 \times 10^6 = 2.82 \times 10^{-26} \times B$
- C1
- $B = 0.99 \text{ T}$
- A1 [2]