

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
 $GM_N m / r^2 = m r \omega^2$ (or $m v^2 / r$)
 $2\pi / T$ (or $v = 2\pi r / T$) leading to $GM_N = 4\pi^2 r^3 / T^2$
- B1
M1
A1 [3]
- (c) $M_N / M_U = (3.55 / 5.83)^3 \times (13.5 / 5.9)^2$
 x^3 factor correct
 T^2 factor correct
ratio = 1.18 (*allow 1.2*)
- C1
C1
A1
- alternative method:* mass of Neptune = 1.019×10^{26} kg
mass of Uranus = 8.621×10^{25} kg
ratio = 1.18
- (C1)
(C1)
(A1) [3]
- 2 (a) (sum of) potential energy and kinetic energy of molecules/atoms/particles
mention of random motion/distribution
- M1
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, $3.6 \times 10^5 \times 4.0 \times 10^{-3} = n \times 8.31 \times 870$
 $n = 0.20$ mol
- C1
A1 [2]
- (ii) $1.2 \times 10^5 \times 7.75 \times 10^{-3} = 0.20 \times 8.31 \times T$ *or* $T = (7.75 / 4.0) \times 290$
 $T = 560$ K
(*Allow tolerance from graph: $7.7-7.8 \times 10^{-3} \text{ m}^3$*)
- C1
A1 [2]
- (c) temperature changes/decreases so internal energy changes/decreases
volume changes (at constant pressure) so work is done
- B1
B1 [2]
- 3 (a) (numerically equal to) quantity of (thermal) energy/heat to change state/phase of unit mass
at constant temperature
(*allow 1/2 for definition restricted to fusion or vaporisation*)
- M1
A1 [2]
- (b) (i) at 70 W, $\text{mass s}^{-1} = 0.26 \text{ g s}^{-1}$
at 110 W, $\text{mass s}^{-1} = 0.38 \text{ g s}^{-1}$
- A1
A1 [2]

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(ii)	<p>1. $P + h = mL$ or substitution of one set of values $(110 - 70) = (0.38 - 0.26)L$ $L = 330 \text{ Jg}^{-1}$</p> <p>2. <i>either</i> $70 + h = 0.26 \times 330$ <i>or</i> $110 + h = 0.38 \times 330$ $h = 17/16/15 \text{ W}$</p>	C1 C1 A1	[3]
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>) <i>either</i> for accurate timing <i>or</i> 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>) <i>either</i> place strengthening struts across the panel <i>or</i> 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 = $4.5 \times 10^4 \text{ NC}^{-1}$ (<i>allow</i> $\pm 0.3 \times 10^4$)	B1 M1 A1
		<i>or</i>	
		$V = \frac{Q}{4\pi\epsilon_0 x} \text{ and } E = \frac{Q}{4\pi\epsilon_0 x^2} \text{ leading to } E = \frac{V}{x}$	(B1)
		$E = 1.8 \times 10^3 / 0.04$ $= 4.5 \times 10^4 \text{ NC}^{-1}$	(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 (*not* “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 cm B1 [1]
- 7 (a) can change (output) voltage efficiently *or* to suit different consumers/appliances by using transformers B1
B1 [2]
- (b) for same power, current is smaller B1
- less heating in cables/wires
or thinner cables possible
or less voltage loss in cables B1 [2]
- 8 (a) (i) $p = h/\lambda$
 $= (6.63 \times 10^{-34})/(6.50 \times 10^{-12})$ C1
 $= 1.02 \times 10^{-22} \text{ N s}$ A1 [2]
- (ii) $E = hc/\lambda$ *or* $E = pc$
 $= (6.63 \times 10^{-34} \times 3.00 \times 10^8)/(6.50 \times 10^{-12})$ C1
 $= 3.06 \times 10^{-14} \text{ J}$ A1 [2]
- (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 M1
this energy is derived from the incident photon A1
deflected photon has less energy, longer wavelength (so $\Delta\lambda$ always positive) B1 [3]
- 9 (a) nucleus/nuclei emits M1
spontaneously/randomly A1
 α -particles, β -particles, γ -ray photons 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) M1
 n at $2t_{1/2}$ is 1.5 times that at $t_{1/2}$ ($\pm 2 \text{ mm}$) 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]