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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CAMBRIDGE International Examinations

Section A

1 (a) (gravitational) force proportional to product of masses and inversely proportional to square of separation — M1
reference to *either* point masses *or* particles *or* 'size' much less than separation — A1 [2]

(b) gravitational force provides/is the centripetal force — B1
$GM_Nm/r^2 = mr\omega^2$ (or mv^2/r) — M1
$2\pi/T$ (*or* $v = 2\pi r/T$) leading to $GM_N = 4\pi^2r^3/T^2$ — 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*: $7.7–7.8 \times 10^{-3}$ 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, mass $s^{-1} = 0.26$ g s^{-1} — A1
at 110 W, mass $s^{-1} = 0.38$ g s^{-1} — A1 [2]

(ii) **1.** $P + h = mL$ or substitution of one set of values — C1
$(110 - 70) = (0.38 - 0.26)L$ — C1
$L = 330\,\text{J g}^{-1}$ — A1 [3]

2. *either* $70 + h = 0.26 \times 330$
or $110 + h = 0.38 \times 330$ — C1
$h = 17 / 16 / 15\,\text{W}$ — 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 — B1
when forced frequency equals natural frequency (of vibration) — B1 [2]

(b) e.g. vibration of quartz/piezoelectric crystal (*what is vibrating*) — M1
either for accurate timing
or maximise amplitude of ultrasound waves (*why it is useful*) — A1 [2]

(c) e.g. vibrating metal panels (*what is vibrating*) — M1
either place strengthening struts across the panel
or change shape/area of panel (*how it is reduced*) — A1 [2]

5 **(a)** (magnitude of electric field strength is the potential gradient — B1
use of gradient at $x = 4.0\,\text{cm}$ — M1
gradient $= 4.5 \times 10^4\,\text{N C}^{-1}$ (*allow* $\pm 0.3 \times 10^4$) — A1

or

$V = \dfrac{Q}{4\pi\varepsilon_0 x}$ and $E = \dfrac{Q}{4\pi\varepsilon_0 x^2}$ leading to $E = \dfrac{V}{x}$ — (B1)

$E = 1.8 \times 10^3 / 0.04$ — (M1)
$= 4.5 \times 10^4\,\text{N C}^{-1}$ — (A1) [3]

(b) **(i)** $3.6 \times 10^3\,\text{V}$ — A1 [1]

(ii) capacitance $= Q / V$ — C1
$= (8.0 \times 10^{-9}) / (3.6 \times 10^3)$
$= 2.2 \times 10^{-12}\,\text{F}$ — A1 [2]

6 **(a)** **(i)** gravitational — B1 [1]

(ii) gravitational and electric — B1 [1]

(iii) magnetic and one other field given — B1
magnetic, graviational and electric — B1 [2]

(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		B1	
		by using transformers		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	
		$\theta = 30.7°$		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 $2t_{½}$ is 1.5 times that at $t_{½}$ (± 2 mm)		A1	[2]

Section B

10 (a) (i) (potential =) $1.2/(1.2 + 4.2) \times 4.5 = +1.0\,V$ — A1 [1]

(ii) (for $V_{IN} > 1.0\,V$) $V^+ > V^-$ — 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 $V_{IN} < 1.0\,V$) output of op-amp –5 V / negative so diode does not conduct, giving V_{out} = 0 or 0 V 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
$38 = 10 \lg (P / \{9.2 \times 10^{-6}\})$

$P = 58$ mW or 5.8×10^{-2} W — A1 [2]
(*allow 1/2 for missing 10 in equation*)

13 (a) (i) to align nuclei/protons — B1
to cause Larmor/precessional frequency to be in r.f. region — B1 [2]

(ii) Larmor/precessional frequency depends on (applied magnetic) field strength — B1
knowing field strength enables (region of precessing) nuclei to be located — M1
by knowing the frequency — 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]