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	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	
		$GM_N m / r^2 = mr\omega^2$ (or mv^2 / r)	M1	
		$2\pi / T$ (*or* $v = 2\pi r / T$) leading to $GM_N = 4\pi^2 r^3 / T^2$	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 $\times 10^{-3}$ 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) × 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 <u>anode</u> 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 × 0.21)	C1	
			= 38 dB	A1	[2]
		(ii)	ratio / dB = 10 lg (P_2 / P_1) 38 = 10 lg (P / {9.2 × 10^{-6}})	C1	
			P = 58 mW or 5.8 × 10^{-2} W (*allow 1/2 for missing 10 in equation*)	A1	[2]

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]