UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2012 question paper

for the guidance of teachers

9702 PHYSICS

9702/42 Paper 4 (A2 Structured Questions), maximum raw mark 100

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UNIVERSITY of CAMBRIDGE
International Examinations

Section A

1	**(a)**	force proportional to product of masses and inversely <u>proportional to</u> square of separation (*do not allow square of distance/radius*)	M1	
		either point masses *or* separation @ size of masses	A1	[2]
	(b) (i)	$\omega = 2\pi / (27.3 \times 24 \times 3600)$ or $2\pi / (2.36 \times 10^6)$	M1	
		$= 2.66 \times 10^{-6}\,\text{rad s}^{-1}$	A0	[1]
	(ii)	$GM = r^3\omega^2$ or $GM = v^2r$	C1	
		$M = (3.84 \times 10^5 \times 10^3)^3 \times (2.66 \times 10^{-6})^2 / (6.67 \times 10^{-11})$	M1	
		$= 6.0 \times 10^{24}\,\text{kg}$	A0	[2]
		(special case: uses $g = GM/r^2$ with $g = 9.81$, $r = 6.4 \times 10^6$ scores max 1 mark)		
	(c) (i)	grav. force $= (6.0 \times 10^{24}) \times (7.4 \times 10^{22}) \times (6.67 \times 10^{-11})/(3.84 \times 10^8)^2$	C1	
		$= 2.0 \times 10^{20}\,\text{N}$ (*allow 1 SF*)	A1	[2]
	(ii)	*either* $\Delta E_P = Fx$ because F constant as x ! radius of orbit	B1	
		$\Delta E_P = 2.0 \times 10^{20} \times 4.0 \times 10^{-2}$	C1	
		$= 8.0 \times 10^{18}\,\text{J}$ (*allow 1 SF*)	A1	[3]
		or $\Delta E_P = GMm/r_1 - GMm/r_2$	C1	
		Correct substitution	B1	
		$8.0 \times 10^{18}\,\text{J}$	A1	
		($\Delta E_P = GMm/r_1 + GMm/r_2$ is incorrect physics so 0/3)		
2	**(a)**	energy $= \frac{1}{2}m\omega^2a^2$ and $\omega = 2\pi f$	C1	
		$= \frac{1}{2} \times 37 \times 10^{-3} \times (2\pi \times 3.5)^2 \times (2.8 \times 10^{-2})^2$	M1	
		$= 7.0 \times 10^{-3}\,\text{J}$	A0	[2]
		(allow $2\pi \times 3.5$ shown as 7π)		
		Energy $= \frac{1}{2}mv^2$ and $v = r\omega$	(C1)	
		Correct substitution	(M1)	
		Energy $= 7.0 \times 10^{-3}\,\text{J}$	(A0)	
	(b)	$E_K = E_P$		
		$\frac{1}{2}m\omega^2(a^2 - x^2) = \frac{1}{2}m\omega^2x^2$ *or* E_K or $E_P = 3.5\,\text{mJ}$	C1	
		$x = a/\sqrt{2} = 2.8/\sqrt{2}$ *or* $E_K = \frac{1}{2}m\omega^2(a^2 - x^2)$ *or* $E_P = \frac{1}{2}m\omega^2x^2$	C1	
		$= 2.0\,\text{cm}$	A1	[3]
		(E_K or $E_P = 7.0\,\text{mJ}$ scores 0/3)		
		Allow: $k = 17.9$	(C1)	
		$E = \frac{1}{2}kx^2$	(C1)	
		$x = 2.0\,\text{cm}$	(A1)	

(c) **(i)** graph:	horizontal line, y-intercept = 7.0 mJ with end-points of line at +2.8 cm and –2.8 cm	B1	[1]
(ii) graph:	reasonable curve	B1	
	with maximum at (0,7.0) end-points of line at (–2.8, 0) and (+2.8, 0)	B1	[2]
(iii) graph:	inverted version of **(ii)**	M1	
	with intersections at (–2.0, 3.5) and (+2.0, 3.5)	A1	[2]
	(Allow marks in **(iii)**, but not in **(ii)**, if graphs K & P are not labelled)		
(d)	gravitational potential energy	B1	[1]
3 **(a)**	sum of potential energy and kinetic energy of atoms/molecules/particles	M1	
	reference to random (distribution)	A1	[2]
(b) **(i)**	as lattice structure is 'broken'/bonds broken/forces between molecules reduced (not molecules separate)	B1	
	no change in kinetic energy, potential energy increases	M1	
	internal energy increases	A1	[3]
(ii)	*either* molecules/atoms/particles move faster/ <c^2> is increasing		
	or kinetic energy increases with temperature (increases)	B1	
	no change in potential energy, kinetic energy increases	M1	
	internal energy increases	A1	[3]
4 **(a)** **(i)**	as r decreases, energy decreases/work got out (due to)	M1	
	attraction so point mass is negatively charged	A1	[2]
(ii)	electric potential energy = charge × electric potential	B1	
	electric field strength is potential gradient	B1	
	field strength = gradient of potential energy graph/charge	A0	[2]
(b)	tangent drawn at (4.0, 14.5)	B1	
	gradient = 3.6×10^{-24}	A2	
	(*for ‹ ±0.3 allow 2 marks, for ‹ ±0.6 allow 1 mark*)		
	field strength= $(3.6 \times 10^{-24}) / (1.6 \times 10^{-19})$		
	= 2.3×10^{-5} V m^{-1} *(allow ecf from gradient value)*	A1	[4]
	(*one point solution for gradient leading to 2.3×10^{-5} Vm^{-1} scores 1 mark only*)		

5	(a)	(long) straight conductor carrying current of 1 A		M1	
		current/wire normal to magnetic field		M1	
		(for flux density 1 T,) force per unit length is $1\,\text{N m}^{-1}$		A1	[3]
	(b) (i)	(originally) downward force on magnet (due to current)		B1	
		by Newton's third law (allow "N3")		M1	
		upward force on wire		A1	[3]
	(ii)	$F = BIL$			
		$2.4 \times 10^{-3} \times 9.8 = B \times 5.6 \times 6.4 \times 10^{-2}$		C1	
		B = 0.066 T *(need 2 SF)*		A1	[2]
		(*g missing scores 0/2, but g = 10 leading to 0.067T scores 1/2*)			
	(c)	new reading is 2.4√2 g		C1	
		either changes between +3.4 g and –3.4 g			
		or total change is 6.8 g		A1	[2]
6	(a)	oil drop charged by friction/beta source		B1	
		between parallel <u>metal</u> plates		B1	
		plates are horizontal	(1)		
		adjustable potential difference/field between plates		B1	
		until oil drop is stationary		B1	
		$mg = q \times V/d$		B1	
		symbols explained	(1)		
		oil drop viewed through microscope	(1)		
		m determined from terminal speed of drop (when p.d. is zero)	(1)		
		(*any two extras, 1 each*)		B2	[7]
	(b)	3.2×10^{-19} C		A1	[1]
7	(a)	minimum energy to remove an electron from the metal/surface		B1	[1]
	(b)	gradient = 4.17×10^{-15} *(allow 4.1 → 4.3)*		C1	
		$h = 4.15 \times 10^{-15} \times 1.6 \times 10^{-19}$ *or* h = 4.1 to 4.3 × 10^{-15} <u>eV s</u>		A1	
		$= 6.6 \times 10^{-34}$ J s		A0	[2]
	(c)	graph: straight line parallel to given line			
		with intercept at any higher frequency		B1	
		intercept at between 6.9×10^{14} Hz and 7.1×10^{14} Hz		B1	[3]

8	**(a)**	nuclei having same number of protons/proton (atomic) number	B1	
		different numbers of neutrons/neutron number	B1	[2]
		(allow second mark for nucleons/nucleon number/mass number/atomic mass if made clear that same number of protons/proton number)		
	(b)	probability of decay per unit time is the decay constant	C1	
		λ = ln 2 / $t_{½}$		
		= 0.693 / (52 × 24 × 3600)	C1	
		= $1.54 \times 10^{-7}\,s^{-1}$	A1	[3]
	(c) (i)	$A = A_0 \exp(-\lambda t)$		
		$7.4 \times 10^6 = A_0 \exp(-1.54 \times 10^{-7} \times 21 \times 24 \times 3600)$	C1	
		$A_0 = 9.8 \times 10^6$ Bq	A1	[2]
		(*alternative method uses 21 days as 0.404 half-lives*)		
	(ii)	$A = \lambda N$ and mass = $N \times 89 / N_A$	C1	
		mass = $(9.8 \times 10^6 \times 89) / (1.54 \times 10^{-7} \times 6.02 \times 10^{23})$		
		= 9.4×10^{-9} g	A1	[2]

Section B

9 **(a)**	e.g. infinite input impedance/resistance zero output impedance/resistance infinite (open loop) gain infinite bandwidth infinite slew rate (*any four, one mark each*)	B4	[4]
(b)	graph: square wave	M1	
	180° phase change	A1	
	amplitude 5.0 V	A1	[3]
(c)	correct symbol for LED	M1	
	diodes connected correctly between V_{OUT} and earth	A1	
	diodes identified correctly	A1	[3]
	(*special case: if diode symbol, not LED symbol, allow 2nd and 3rd marks to be scored*)		
10 **(a)**	e.g. beam is divergent/obeys inverse square law absorption (in block) scattering (of beam in block) reflection (at boundaries) (*any two sensible suggestions, 1 each*)	B2	[2]
(b) **(i)**	$I = I_0 \exp(-\mu x)$	C1	
	$I_0/I = \exp(0.27 \times 2.4)$		
	$= 1.9$	A1	[2]
(ii)	$I_0/I = \exp(0.27 \times 1.3) \times \exp(3.0 \times 1.1)$	C1	
	$= 1.42 \times 27.1$		
	$= 38.5$	A1	[2]
(c)	*either* much greater absorption in bone than in soft tissue		
	or I_o / I much greater for bone than soft tissue	B1	[1]
11 **(a)** **(i)**	loss of (signal) power	B1	[1]
(ii)	unwanted power (on signal)	M1	
	that is random	A1	[2]
(b)	for digital, only the 'high' and the 'low' / 1 and 0 are necessary	M1	
	variation between 'highs' and 'lows' caused by noise not required	A1	[2]
(c)	attenuation = $10 \lg(P_2 / P_1)$	C1	
	either $195 = 10 \lg(\{2.4 \times 10^3\} / P)$		
	or $-195 = 10 \lg(P / 2.4 \times 10^3)$	C1	
	$P = 7.6 \times 10^{-17}$ W	A1	[3]

12	**(a)**	**(i)**	modulator	B1	[1]
		(ii)	serial-to-parallel converter (*accept series-to-parallel converter*)	B1	[1]
	(b)	**(i)**	enables one aerial to be used for transmission and receipt of signals	A1	[1]
		(ii)	all bits for one number arrive at one time	B1	
			bits are sent out one after another	B1	[2]