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

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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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
$= 2.66 \times 10^{-6}$ 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
$= 6.0 \times 10^{24}$ 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
$= 2.0 \times 10^{20}$ 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
$= 8.0 \times 10^{18}$ J (*allow 1 SF*) A1 [3]

or $\Delta E_P = GMm/r_1 - GMm/r_2$ C1
Correct substitution B1
8.0×10^{18} 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
$= 7.0 \times 10^{-3}$ 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 $= 7.0 \times 10^{-3}$ 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 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 cm A1 [3]
(E_K or E_P = 7.0 mJ scores 0/3)

Allow: $k = 17.9$ (C1)
$E = \frac{1}{2} kx^2$ (C1)
$x = 2.0$ 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

(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) <u>gravitational potential</u> 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
<u>attraction</u> 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= $(3.6 \times 10^{-24}) / (1.6 \times 10^{-19})$
= $2.3 \times 10^{-5}\ \mathrm{V\,m^{-1}}$ *(allow ecf from gradient value)* — A1 — [4]
(*one point solution for gradient leading to $2.3 \times 10^{-5}\ \mathrm{Vm^{-1}}$ 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 N m^{-1}		A1	
	(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 metal plates		B1	
		plates are horizontal	(1)		
		adjustable potential difference/field between plates		B1	
		until oil drop is stationary		B1	
		mg = *q* × *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} eV s		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
(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
$\lambda = \ln 2 / t_{½}$
$= 0.693 / (52 \times 24 \times 3600)$ — 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 $= (9.8 \times 10^6 \times 89) / (1.54 \times 10^{-7} \times 6.02 \times 10^{23})$
$= 9.4 \times 10^{-9}\,g$ — 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

(ii) serial-to-parallel converter (*accept series-to-parallel converter*) B1

(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]