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

Page 2	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	42

Section A

1 **(a)** force proportional to product of masses and inversely proportional to 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 [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= $(3.6 \times 10^{-24}) / (1.6 \times 10^{-19})$
$= 2.3 \times 10^{-5}\ \text{V m}^{-1}$ *(allow ecf from gradient value)* — A1 [4]
(*one point solution for gradient leading to* $2.3 \times 10^{-5}\ Vm^{-1}$ *scores 1 mark only*)

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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 [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 $2.4\sqrt{2}$ 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
$\lambda = \ln 2 / t_{½}$
$= 0.693 / (52 \times 24 \times 3600)$ 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	[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 bits are sent out one after another	B1 B1	[2]