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

9702/41 Paper 4 (A2 Structured Questions), maximum raw mark 100

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Section A

1 **(a)** work done in bringing unit mass from infinity (to the point) B1 [1]

(b) gravitational force is (always) attractive B1
either as r decreases, object/mass/body does work
or work is done by masses as they come together B1 [2]

(c) *either* force on mass = mg (where g is the acceleration of free fall /gravitational field strength) B1
$g = GM/r^2$ B1
if r @ h, g is constant B1
ΔE_P = force × distance moved M1
$= mgh$ A0
or $\Delta E_P = m\Delta\phi$ (C1)
$= GMm(1/r_1 - 1/r_2) = GMm(r_2 - r_1)/r_1r_2$ (B1)
if $r_2 \approx r_1$, then $(r_2 - r_1) = h$ and $r_1r_2 = r^2$ (B1)
$g = GM/r^2$ (B1)
$\Delta E_P = mgh$ (A0) [4]

(d) $\frac{1}{2}mv^2 = m\Delta\phi$
$v^2 = 2 \times GM/r$ C1
$= (2 \times 4.3 \times 10^{13}) / (3.4 \times 10^6)$ C1
$v = 5.0 \times 10^3\,\text{m s}^{-1}$ A1 [3]
(Use of diameter instead of radius to give $v = 3.6 \times 10^3\,\text{m s}^{-1}$ scores 2 marks)

2 **(a)** **(i)** *either* random motion
or constant velocity until hits wall/other molecule B1 [1]

(ii) (total) volume of molecules is negligible M1
compared to volume of containing vessel A1
or
radius/diameter of a molecule is negligible (M1)
compared to the average intermolecular distance (A1) [2]

(b) *either* molecule has component of velocity in three directions
or $c^2 = c_X^2 + c_Y^2 + c_Z^2$ M1
random motion and averaging, so $\langle c_X^2\rangle = \langle c_Y^2\rangle = \langle c_Z^2\rangle$ M1
$\langle c^2\rangle = 3\langle c_X^2\rangle$ A1
so, $pV = \frac{1}{3}Nm\langle c^2\rangle$ A0 [3]

(c) $\langle c^2\rangle \propto T$ or $c_{rms} \propto \sqrt{T}$ C1
temperatures are 300 K and 373 K C1
$c_{rms} = 580\,\text{m s}^{-1}$ A1 [3]
(Do not allow any marks for use of temperature in units of ºC instead of K)

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3 **(a)** (numerically equal to) quantity of (thermal) energy required to change the state of unit mass of a substance M1
without any change of temperature A1 [2]
(Allow 1 mark for definition of specific latent heat of fusion/vaporisation)

(b) *either* energy supplied = 2400 × 2 × 60 = 288000 J C1
energy required for evaporation = 106 × 2260 = 240000 J C1
difference = 48000 J
rate of loss = 48000 / 120 = 400 W A1
or energy required for evaporation = 106 × 2260 = 240000 J (C1)
power required for evaporation = 240000 / (2 × 60) = 2000 W (C1)
rate of loss = 2400 – 2000 = 400 W (A1) [3]

4 **(a)** $a = (-)\omega^2 x$ and $\omega = 2\pi/T$ C1
$T = 0.60\,\text{s}$ C1
$a = (4\pi^2 \times 2.0 \times 10^{-2}) / (0.6)^2$
$= 2.2\,\text{m s}^{-2}$ A1 [3]

(b) sinusoidal wave with all values positive B1
all values positive, all peaks at E_K and energy = 0 at $t = 0$ B1
period = 0.30 s B1 [3]

5 **(a)** force per unit positive charge acting on a stationary charge B1 [1]

(b) **(i)** $E = Q / 4\pi\varepsilon_0 r^2$ C1
$Q = 1.8 \times 10^4 \times 10^2 \times 4\pi \times 8.85 \times 10^{-12} \times (25 \times 10^{-2})^2$ M1
$Q = 1.25 \times 10^{-5}\,\text{C} = 12.5\,\mu\text{C}$ A0 [2]

(ii) $V = Q / 4\pi\varepsilon_0 r$
$= (1.25 \times 10^{-5}) / (4\pi \times 8.85 \times 10^{-12} \times 25 \times 10^{-2})$ C1
$= 4.5 \times 10^5\,\text{V}$ A1 [2]
(Do not allow use of V = Er unless explained)

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6 **(a)** **(i)** peak voltage = 4.0 V — A1 [1]

(ii) r.m.s. voltage (= 4.0/√2) = 2.8 V — A1 [1]

(iii) period T = 20 ms — M1
frequency = 1 / (20 × 10^{-3}) — M1
frequency = 50 Hz — A0 [2]

(b) **(i)** change = 4.0 – 2.4 = 1.6 V — A1 [1]

(ii) $\Delta Q = C\Delta V$ or $Q = CV$ — C1
= 5.0 × 10^{-6} × 1.6 = 8.0 × 10^{-6} C — A1 [2]

(iii) discharge time = 7 ms — C1
current = (8.0 × 10^{-6}) / (7.0 × 10^{-3}) — M1
= 1.1(4) × 10^{-3} A — A0 [2]

(c) average p.d. = 3.2 V — C1
resistance = 3.2 / (1.1 × 10^{-3})
= 2900 Ω *(allow 2800 Ω)* — A1 [2]

7 **(a)** sketch: concentric circles *(minimum of 3 circles)* — M1
separation increasing with distance from wire — A1
correct direction — B1 [3]

(b) **(i)** arrow direction from wire B towards wire A — B1 [1]

(ii) *either* reference to Newton's third law
or force on each wire proportional to product of the two currents — M1
so forces are equal — A1 [2]

(c) force <u>always</u> towards wire A/<u>always</u> in same direction — B1
varies from zero (to a maximum value) (1)
variation is sinusoidal / $\sin^2$ (1)
(at) twice frequency of current (1)
(any two, one each) — B2 [3]

8 **(a)** packet/quantum/discrete amount of energy — M1
of electromagnetic radiation — A1
(allow 1 mark for 'packet of electromagnetic radiation')
energy = Planck constant × frequency *(seen here or in **b**)* — B1 [3]

(b) each (coloured) line corresponds to one wavelength/frequency — B1
energy = Planck constant × frequency
implies specific energy change between energy levels — B1
so discrete levels — A0 [2]

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9 (a) (i) *either* probability of decay (of a nucleus) M1
per unit time A1 [2]
or $\lambda = (-)(dN/dt) / N$ (M1)
$(-)dN/dt$ and N explained (A1)

(ii) in time $t_{½}$, number of nuclei changes from N_0 to $½N_0$ B1
$½ = \exp(-\lambda t_{½})$ *or* $2 = \exp(\lambda t_{½})$ B1
$\ln(½) = -\lambda t_{½}$ and $\ln(½) = -0.693$ *or* $\ln 2 = \lambda t_{½}$ and $\ln 2 = 0.693$ B1
$0.693 = \lambda t_{½}$ A0 [3]

(b) $228 = 538\exp(-8\lambda)$ C1
$\lambda = 0.107$ (hours^{-1}) C1
$t_{½} = 6.5$ hours *(do not allow 3 or more SF)* A1 [3]

(c) e.g. random nature of decay
background radiation
daughter product is radioactive
(any two sensible suggestions, 1 each) B2 [2]

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Section B

10 (a) light-dependent resistor (allow LDR) B1 [1]

(b) (i) two resistors in series between +5 V line and earth M1
midpoint connected to inverting input of op-amp A1 [2]

(ii) relay coil between diode and earth M1
switch between lamp and earth A1 [2]

(c) (i) switch on/off mains supply using a low voltage/current output B1 [1]
(allow 'isolates circuit from mains supply')

(ii) relay will switch on for one polarity of output (voltage) C1
switches on when output (voltage) is negative A1 [2]

11 (a) (i) e.m. radiation produced whenever charged particle is accelerated M1
electrons hitting target have distribution of accelerations A1 [2]

(ii) *either* wavelength shorter/shortest for greater/greatest acceleration
or $\lambda_{min} = hc/E_{max}$
or minimum wavelength for maximum energy B1
all electron energy given up in one collision/converted to single photon B1 [2]

(b) (i) hardness measures the penetration of the beam C1
greater hardness, greater penetration A1 [2]

(ii) controlled by changing the anode voltage C1
higher anode voltage, greater penetration/hardness A1 [2]

(c) (i) long-wavelength radiation more likely to be absorbed in the body/less likely to penetrate through body B1 [1]

(ii) (aluminium) filter/metal foil placed in the X-ray beam B1 [1]

12 (a) strong uniform (magnetic) field M1
either aligns nuclei
or gives rise to Larmor/resonant frequency in r.f. region A1
non-uniform (magnetic) field M1
either enables nuclei to be located
or changes the Larmor/resonant frequency A1 [4]

(b) (i) difference in flux density = $2.0 \times 10^{-2} \times 3.0 \times 10^{-3} = 6.0 \times 10^{-5}$ T A1 [1]

(ii) $\Delta f = 2 \times c \times \Delta B$ C1
$= 2 \times 1.34 \times 10^{8} \times 6.0 \times 10^{-5}$
$= 1.6 \times 10^{4}$ Hz A1 [2]

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13 (a) (i) no interference (between signals) near boundaries (of cells) B1 [1]

(ii) for large area, signal strength would have to be greater and this could be hazardous to health B1 [1]

(b) mobile phone is sending out an (identifying) signal M1
computer/cellular exchange continuously selects cell/base station with strongest signal A1
computer/cellular exchange allocates (carrier) frequency (and slot) A1 [3]

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