UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2007 question paper

9702 PHYSICS

9702/04 Paper 4 (A2 Structures Questions), maximum raw mark 100

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1 **(a)** (region of space) where a mass experiences a force — B1 [1]

(b) **(i)** potential energy = (–)GMm / x — C1
$\Delta E_P = GMm/2R - GMm/3R$ — M1
$= GMm/6R$ — A0 [2]

(ii) $E_K = ½m\,(7600^2 - 7320^2)$ — M1
$= (2.09 \times 10^6)m$ — A0 [1]

(c) **(i)** $2.09 \times 10^6 = (6.67 \times 10^{-11}\,M)/(6 \times 3.4 \times 10^6)$ — C1
$M = 6.39 \times 10^{23}$ kg — A1 [2]

(ii) e.g. no energy dissipated due to friction with atmosphere/air
rocket is outside atmosphere
not influenced by another planet etc. — B1 [1]

2 **(a)** (on melting,) bonds between molecules are broken/weakened
or molecules further apart/are able to slide over one another — B1
kinetic energy unchanged so no temperature change — B1
potential energy increased/changed so energy required — B1 [3]

(b) thermal energy/heat required to convert unit mass of solid to liquid — M1
with no change in temperature/ at its normal boiling point — A1 [2]

(c) **(i)** thermal energy lost by water = $0.16 \times 4.2 \times 100$
$= 67.2$ kJ — C1
$67.2 = 0.205 \times L$ — C1
$L = 328$ kJ kg^{-1} — A1 [3]

(ii) more energy (than calculated) melts ice — M1
so, (calculated) L is lower than the accepted value — A1 [2]

3 **(a)** field strength = potential gradient — M1
correct sign OR directions discussed — A1 [2]

(b) area is 21.2 cm^2 ± 0.4 cm^2 — C2
(*if outside ± 0.4 cm^2 but within ± 0.8 cm^2, allow 1 mark)*
1.0 cm^2 represents $(1.0 \times 10^{-2} \times 2.5 \times 10^3 =)$ 25 V — C1
potential difference = 530 V — A1 [4]

(c) $½mv^2 = qV$
$½ \times 9.1 \times 10^{-31} \times v^2 = 1.6 \times 10^{-19} \times 530$ — C1
$v = 1.37 \times 10^7$ ms^{-1} — A1 [2]

(d) **(i)** $d = 0$ — B1 [1]

(ii) acceleration decreases then increases — B1
some quantitative analysis (e.g. minimum at 4.0 cm) — B1 [2]
(*any suggestion that acceleration becomes zero or that there is a deceleration scores 0/2)*

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4 **(a)** r.m.s. output = $9/\sqrt{2}$ or peak input = $230\sqrt{2}$ C1
$N_S/N_P = V_S/V_P$ C1
$N_S = 138 \rightarrow 140$ turns A1 [3]

(b) **(i)** four diodes correctly positioned regardless of output polarity M1
giving correct output polarity (*all 'point to left'*) A1 [2]

(ii) capacitor shown in parallel with R B1 [1]

(c) **(i)** time t_1 to time t_2 B1 [1]

(ii) sketch: same peak values M1
ripple reduced and reasonable shape A1 [2]

5 **(a)** **(i)** packet/discrete quantity/quantum (of energy) of e.m. radiation B1 [1]

(ii) either $E = (6.63 \times 10^{-34} \times 3 \times 10^8)/(350 \times 10^{-9})$
or $E = (6.63 \times 10^{-34} \times 8.57 \times 10^{14})$ M1
$E = 5.68 \times 10^{-19}$ J A0 [1]

(iii) 0.5 B1 [1]

(b) **(i)** energy of photon M1
to cause emission of electron <u>from surface</u>
either with zero k.e *or* photon energy is minimum A1 [2]

(ii) correct conversion eV $\rightarrow$ J or J $\rightarrow$ eV seen once B1
photon energy must be greater than work function C1
350 nm wavelength and potassium metal A1 [3]

6 **(a)** probability of decay M1
of a nucleus per unit time A1 [2]
(*allow 1 mark for $A = \lambda N$, with symbols explained)*

(b) **(i)** $\lambda = \ln 2/(28 \times 365 \times 24 \times 3600)$ C1
$= 7.85 \times 10^{-10}$ s^{-1} A1 [2]

(ii) $A = (-)\lambda N$
$N = (6.4 \times 10^9)/(7.85 \times 10^{-10})$ C1
$= 8.15 \times 10^{18}$ C1
mass = $(8.15 \times 10^{18} \times 90)/(6.02 \times 10^{23})$ (e.c.f. for value of N) C1
$= 1.22 \times 10^{-3}$ g A1 [4]

(iii) volume = $(1.22 \times 10^{-3}/2.54 =) 4.8 \times 10^{-4}$ cm^3 A1 [1]

(c) *either* very small volume of Strontium-90 has high activity
or dust can be highly radioactive B1
breathing in dust presents health hazard B1 [2]

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7 **(a)** **(i)** oscillations are <u>damped</u>/amplitude decreases B1
as magnet moves, flux is cut by coil B1
e.m.f./current is induced in the coil B1
causing energy loss in load OR force on magnet B1
energy is derived from oscillations of magnet
OR force opposes motion of magnet B1 [5]

(ii) T = 0.60 s C1
ω_0 (= $2\pi/T$) = 10.5 rad s^{-1} A1 [2]

(b) sketch: sinusoidal wave with period unchanged or slightly smaller M1
same initial displacement, less damping A1 [2]

(c) **(i)** sketch: general shape – peaked curve M1
peak at ω_0 and amplitude never zero A1 [2]

(ii) <u>resonance</u> B1 [1]

(iii) useful: e.g. child on swing, microwave oven heating B1
avoid: e.g. vibrating panels, vibrating bridges B1 [2]
(*for credit, stated example must be put in context*)

Section B

8 **(a)** e.g. infinite (voltage) gain
infinite input impedance
zero output impedance
infinite bandwidth
infinite slew rate
(*any three, 1 each*) B3 [3]

(b) **(i)** negative (feedback) B1 [1]

(ii) **1** gain (= 5.8/0.069) = 84 B1 [1]

(ii) **2** gain = 1 + 120/X C1
84 = 1 + 120/X
X = 1.45 kΩ A1 [2]

(iii) gain increases OR bandwidth reduced OR output increases B1 [1]

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9 **(a)** X-ray beam directed through body onto detector (plate) B1
different tissues absorb/attenuate beam by different amounts B1
giving 'shadow' image of structures B1
any other detail e.g. comment re sharpness or contrast B1 [4]

(b) X-ray image is flat OR 2-dimensional (1)
CT scan takes many images of a slice at different angles (1)
these build up an image of a slice through the body (1)
series of images of slices is made (1)
so that 3D image can be built up (1)
image can then be rotated (1)
1 mark for each point, max 5 B5 [5]

10 **(a)** correct values of 2, 5, 10, 15 and 4 (*–1 each error*) B2
graph drawn as a series of steps M1
steps occurring at correct times A1 [4]

(b) sample more frequently B1
greater number of bits B1 [2]

11 **(a)** modulator and oscillator identified B1
both amplifiers identified correctly B1
ADC and parallel-to serial converter identified B1 [3]

(b) computer at cellular exchange B1
monitors signal strength B1
switches call from one base station to another B1
to maintain maximum signal strength B1 [4]

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