UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2010 question paper for the guidance of teachers

9702 PHYSICS

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

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UNIVERSITY of CAMBRIDGE
International Examinations

Section A

1 (a) force per unit mass (*ratio idea essential*) B1 [1]

(b) graph: correct curvature M1
from (R,1.0 g_S) & at least one other correct point A1 [2]

(c) (i) fields of Earth and Moon are in opposite directions M1
either resultant field found by subtraction of the field strength
or any other sensible comment A1
so there is a point where it is zero A0 [2]
(*allow* $F_E = -F_M$ *for 2 marks*)

(ii) $GM_E / x^2 = GM_M / (D - x)^2$ C1
$(6.0 \times 10^{24}) / (7.4 \times 10^{22}) = x^2 / (60R_E - x)^2$ C1
$x = 54\,R_E$ A1 [3]

(iii) graph: g = 0 at least ⅔ distance to Moon B1
g_E and g_M in opposite directions M1
correct curvature (by eye) and $g_E > g_M$ at surface A1 [3]

2 (a) (i) no forces (of attraction or repulsion) between atoms / molecules / particles B1 [1]

(ii) sum of kinetic and potential energy of atoms / molecules M1
due to random motion A1 [2]

(iii) (random) kinetic energy increases with temperature M1
no potential energy
(so increase in temperature increases internal energy) A1 [2]

(b) (i) zero A1 [1]

(ii) work done = $p\Delta V$ C1
= $4.0 \times 10^5 \times 6 \times 10^{-4}$
= 240 J (*ignore any sign)* A1 [2]

(iii)

change	work done / J	heating / J	increase in internal energy / J
P → Q	**+240**	–600	**–360**
Q → R	0	+720	**+720**
R → P	**–840**	+480	**–360**

(*correct signs essential*)
(*each horizontal line correct, 1 mark – max 3*) B3 [3]

3 **(a)** **(i)** resonance B1 [1]

(ii) amplitude 16 mm and frequency 4.6 Hz A1 [1]

(b) **(i)** $a = (-)\omega^2 x$ and $\omega = 2\pi f$ C1
$a = 4\pi^2 \times 4.6^2 \times 16 \times 10^{-3}$ C1
$= 13.4\ \text{m s}^{-2}$ A1 [3]

(ii) $F = ma$ C1
$= 50 \times 10^{-3} \times 13.4$
$= 2.0\ \text{N}$ A1 [2]

(c) line always 'below' given line and never zero M1
peak is at 4.6 Hz (or slightly less) and flatter A1 [2]

4 **(a)** charge / potential (difference) (*ratio must be clear)* B1 [1]

(b) **(i)** $V = Q / 4\pi\varepsilon_0 r$ B1 [1]

(ii) $C = Q / V = 4\pi\varepsilon_0 r$ and $4\pi\varepsilon_0$ is constant M1
so $C \propto r$ A0 [1]

(c) **(i)** $r = C / 4\pi\varepsilon_0 r$ C1
$r = (6.8 \times 10^{-12}) / (4\pi \times 8.85 \times 10^{-12})$ C1
$= 6.1 \times 10^{-2}\ \text{m}$ A1 [3]

(ii) $Q = CV = 6.8 \times 10^{-12} \times 220$
$= 1.5 \times 10^{-9}\ \text{C}$ A1 [1]

(d) **(i)** $V = Q/C = (1.5 \times 10^{-9}) / (18 \times 10^{-12})$
$= 83\ \text{V}$ A1 [1]

(ii) *either* energy = $\frac{1}{2}CV^2$ C1
$\Delta E = \frac{1}{2} \times 6.8 \times 10^{-12} \times 220^2 - \frac{1}{2} \times 18 \times 10^{-12} \times 83^2$ C1
$= 1.65 \times 10^{-7} - 6.2 \times 10^{-8}$
$= 1.03 \times 10^{-7}\ \text{J}$ A1 [3]
or energy = $\frac{1}{2}QV$ (C1)
$\Delta E = \frac{1}{2} \times 1.5 \times 10^{-9} \times 220 - \frac{1}{2} \times 1.5 \times 10^{-9} \times 83$ (C1)
$= 1.03 \times 10^{-7}\ \text{J}$ (A1)

5 **(a)** field into (the plane of) the paper — B1 [1]

(b) force due to magnetic field provides the centripetal force — B1
$mv^2 / r = Bqv$ — C1
$B = (20 \times 1.66 \times 10^{-27} \times 1.40 \times 10^5) / (1.6 \times 10^{-19} \times 6.4 \times 10^{-2})$ — B1
$= 0.454\,\text{T}$ — A0 [3]

(c) **(i)** semicircle with diameter greater than 12.8 cm — B1 [1]

(ii) new flux density $= \frac{22}{20} \times 0.454$ — C1
$B = 0.499\,\text{T}$ — A1 [2]

6 **(a)** **(i)** e.g. prevent flux losses / improve flux linkage — B1 [1]

(ii) flux in core is changing — B1
e.m.f. / current (induced) in core — B1
induced current in core causes heating — B1 [3]

(b) **(i)** that value of the direct current producing same (mean) power / heating in a resistor — M1 A1 [2]

(ii) power in primary = power in secondary — M1
$V_P I_P = V_S I_S$ — A1 [2]

7 **(a)** **(i)** e.g. electron / particle diffraction — B1 [1]

(ii) e.g. photoelectric effect — B1 [1]

(b) **(i)** 6 — A1 [1]

(ii) change in energy $= 4.57 \times 10^{-19}$ J
$\lambda = hc / E$ — C1
$= (6.63 \times 10^{-34} \times 3.0 \times 10^8) / (4.57 \times 10^{-19})$
$= 4.4 \times 10^{-7}\,\text{m}$ — A1 [2]

8 **(a)** splitting of a heavy nucleus (*not atom/nuclide*) — M1
into two (lighter) nuclei of approximately same mass — A1 [2]

(b) ${}^1_0\text{n}$
${}^4_2\text{He}$ (*allow* ${}^4_2\alpha$) — M2
${}^7_3\text{Li}$ — A1 [3]

(c) emitted particles have kinetic energy — B1
range of particles in the control rods is short / particles stopped in rods / lose kinetic energy in rods — B1
kinetic energy of particles converted to thermal energy — B1 [3]

Section B

9 (a) (i) non-inverting (amplifier) B1 [1]

(ii) (G =) $1 + R_2 / R_1$ B1 [1]

(b) (i) gain = 1 + 100 / 820 C1
output = 17 mV A1 [2]

(ii) 9 V A1 [1]
(R_2 / R_1 scores 0 in **(a)(ii)** but possible 1 mark in each of **(b)(i)** and **(b)(ii)**
($1 + R_1 / R_2$) scores 0 in **(a)(ii)**, no mark in **(b)(i)**, possible 1 mark in **(b)(ii)**
($1 – R_2 / R_1$) or R_1 / R_2 scores 0 in **(a)(ii), (b)(i)** and **(b)(ii)**)

10 (a) (i) density × speed of wave (in the medium) B1 [1]

(ii) $\rho = (7.0 \times 10^6) / 4100$
$= 1700\,\text{kg m}^{-3}$ A1 [1]

(b) (i) $I = I_T + I_R$ B1 [1]

(ii) 1. $\alpha = (0.1 \times 10^6)^2 / (3.1 \times 10^6)^2$ C1
$= 0.001$ A1 [2]

2. $\alpha \approx 1$ A1 [1]

(c) *either* very little transmission at an air-skin boundary M1
(almost) complete transmission at a gel-skin boundary M1
when wave travels in or out of the body A1 [3]
or no gel, majority reflection (M1)
with gel, little reflection (M1)
when wave travels in or out of the body (A1)

11 (a) (i) unwanted random power / signal / energy B1 [1]

(ii) loss of (signal) power / energy B1 [1]

(b) (i) *either* signal-to-noise ratio at mic. $= 10 \lg (P_2 / P_1)$ C1
$= 10 \lg (\{2.9 \times 10^{-6}\} / \{3.4 \times 10^{-9}\})$
$= 29\,\text{dB}$ A1
maximum length $= (29 – 24) / 12$ C1
$= 0.42\,\text{km} = 420\,\text{m}$ A1 [4]

or signal-to-noise ratio at receiver = $10 \lg (P_2 / P_1)$ (C1)
at receiver, $24 = 10 \lg (P / \{3.4 \times 10^{-9}\})$
$P = 8.54 \times 10^{-7}$ W (A1)
power loss in cables $= 10 \lg (\{2.9 \times 10^{-6}\} / \{8.54 \times 10^{-7}\})$ (C1)
$= 5.3\,\text{dB}$
length = 5.3 / 12 km
= 440 m (A1)

(ii) use an amplifier M1
coupled to the microphone A1 [2]
(*repeater amplifiers scores no mark*)

12 (a) (carrier wave) transmitted from Earth to satellite (1)
satellite receives greatly attenuated signal (1)
signal amplified and transmitted back to Earth B1
at a different (carrier) frequency B1
different frequencies prevent swamping of uplink signal (1)
e.g. of frequencies used (6/4 GHz, 14/11 GHz, 30/20 GHz) (1)
(*two B1 marks plus any two other for additional physics*) B2 [4]

(b) advantage: e.g. much shorter time delay M1
because orbits are much lower A1
e.g. whole Earth may be covered (M1)
in several orbits / with network (A1)
disadvantage: e.g. *either* must be tracked
or limited use in any one orbit M1
more satellites required for continuous operation A1 [4]