**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

**9702/42** Paper 4 (A2 Structured Questions), maximum raw mark 100

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## 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
$= 150 \times 10^{-3} \times 13.4$
$= 2.0\,\text{N}$ 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 <u>provides</u> 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)** <u>semicircle</u> 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) <u>in core</u> — B1
induced current in core causes heating — B1 [3]

**(b)** **(i)** that value of the direct current producing same (mean) power / heating — M1
in a resistor — 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
$= (6.63 \times 10^{-34} \times 3.0 \times 10^8) / (4.57 \times 10^{-19})$
$= 4.4 \times 10^{-7}$ m — A1 [2]

**8** **(a)** splitting of a heavy nucleus (*not atom/nuclide*) — M1
into two (lighter) nuclei of <u>approximately same mass</u> — 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 dB A1
maximum length = (29 – 24) / 12 C1
= 0.42 km = 420 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 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]