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

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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## Section A

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

**(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

**(ii)** amplitude 16 mm <u>and</u> frequency 4.6 Hz — A1

**(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 <u>$4\pi\varepsilon_0$ is constant</u> — 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

**(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
$= (6.63 \times 10^{-34} \times 3.0 \times 10^8) / (4.57 \times 10^{-19})$
$= 4.4 \times 10^{-7}\,\text{m}$ — 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 | |
| | (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)**<br>($1 + R_1 / R_2$) scores 0 in **(a)(ii)**, no mark in **(b)(i)**, possible 1 mark in **(b)(ii)**<br>($1 - R_2 / R_1$) or $R_1 / R_2$ scores 0 in **(a)(ii), (b)(i)** and **(b)(ii)**) | | | |
| 10 | (a) (i) | density × <u>speed of wave</u> (in the medium) | | B1 | [1] |
| | (ii) | $\rho = (7.0 \times 10^6) / 4100$<br>$= 1700\,\text{kg m}^{-3}$ | | 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, $24 = 10\,\lg(P / \{3.4 \times 10^{-9}\})$ | | | |
| | | $P = 8.54 \times 10^{-7}\,\text{W}$ | (A1) | | |
| | | power loss in cables $= 10\,\lg(\{2.9 \times 10^{-6}\} / \{8.54 \times 10^{-7}\})$ | (C1) | | |
| | | $= 5.3\,\text{dB}$ | | | |
| | | length $= 5.3 / 12\,\text{km}$ | | | |
| | | $= 440\,\text{m}$ | (A1) | | |

**(ii)** use an amplifier
coupled to the microphone A
(*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 <u>back to Earth</u> 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]