**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

**9702/43** 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) (i)** rate of change of angle / angular displacement — M1
swept out by radius — A1

**(ii)** $\omega \times T = 2\pi$ — B1 [1]

**(b)** centripetal force is provided by the gravitational force — B1
*either* $mr(2\pi/T)^2 = GMm/r^2$ *or* $mr\omega^2 = GMm/r^2$ — M1
$r^3 \times 4\pi^2 = GM \times T^2$ — A1
$GM/4\pi^2$ is a constant ($c$) — A1
$T^2 = cr^3$ — A0 [4]

**(c) (i)** *either* $T^2 = (45/1.08)^3 \times 0.615^2$ *or* $T^2 = 0.30 \times 45^3$ — C1
$T$ = 165 years — A1 [2]

**(ii)** speed = $(2\pi \times 1.08 \times 10^8) / (0.615 \times 365 \times 24 \times 3600)$ — C1
= 35 km s$^{-1}$ — A1 [2]

**2 (a)** atoms / molecules / particles behave as elastic (identical) spheres — (1)
volume of atoms / molecules negligible compared to volume of containing vessel — (1)
time of collision negligible to time between collisions — (1)
no forces of attraction or repulsion between atoms / molecules — (1)
atoms / molecules / particles are in (continuous) random motion — (1)
(*any four, 1 each*) — B4 [4]

**(b)** $pV = \frac{1}{3}Nm\langle c^2\rangle$ and $pV = nRT$ *or* $pV = NkT$ — B1
$\frac{1}{3}Nm\langle c^2\rangle = nRT$ or $= NkT$ and $\langle E_K\rangle = \frac{1}{2}m\langle c^2\rangle$ — B1
$n = N/N_A$ *or* $k = R/N_A$ — B1
$\langle E_K\rangle = \frac{3}{2} \times R/N_A \times T$ — A0 [3]

**(c) (i)** reaction represents *either* build-up of nucleus from light nuclei
*or* build-up of heavy nucleus from nuclei — M1
so fusion reaction — A1 [2]

**(ii)** proton and deuterium nucleus will have equal kinetic energies — B1
$1.2 \times 10^{-14} = \frac{3}{2} \times 8.31 / (6.02 \times 10^{23}) \times T$ — C1
$T = 5.8 \times 10^8$ K — A1 [3]
(*use of $E = 2.4 \times 10^{-14}$ giving $1.16 \times 10^9$ K scores 1 mark*)

**(iii)** *either* inter-molecular / atomic / nuclear forces exist
*or* proton and deuterium nucleus are positively charged / repel — B1 [1]

**3** **(a)** **(i)** 8.0 cm

**(ii)** $2\pi f = 220$ C1
$f = 35$ (*condone unit*) A1 [2]

**(iii)** line drawn mid-way between AB and CD (*allow ±2 mm*) B1 [1]

**(iv)** $v = \omega a$ C1
$= 220 \times 4.0$
$= 880 \text{ cm s}^{-1}$ A1 [2]

**(b)** **(i)** **1.** line drawn 3 cm above AB (*allow ±2 mm*) B1 [1]
**2.** arrow pointing upwards B1 [1]

**(ii)** **1.** line drawn 3 cm above AB (*allow ±2 mm*) B1 [1]
**2.** arrow pointing downwards B1 [1]

**(iii)** $v = \omega\sqrt{(a^2 - x^2)}$
$= 220 \times \sqrt{(4.0^2 - 2.0^2)}$ C1
$= 760 \text{ cm s}^{-1}$ A1 [2]
(*incorrect value for x, 0/2 marks*)

**4** **(a)** **(i)** work done moving unit positive charge M1
from infinity <u>to the point</u> A1 [2]

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

**(b)** **(i)** capacitance $= (2.7 \times 10^{-6}) / (150 \times 10^{3})$ C1
(*allow any appropriate values*)
capacitance $= 1.8 \times 10^{-11}$ (*allow 1.8 ±0.05)* A1 [2]

**(ii)** *either* energy $= \frac{1}{2}CV^2$ *or* energy $= \frac{1}{2}QV$ <u>*and*</u> $Q = CV$ C1
energy $= \frac{1}{2} \times 1.8 \times 10^{-11} \times (150 \times 10^{3})^2$ *or* $\frac{1}{2} \times 2.7 \times 10^{-6} \times 150 \times 10^{3}$
$= 0.20$ J A1 [2]

**(c)** *either* since energy $\propto V^2$, capacitor has $(\frac{1}{2})^2$ of its energy left
*or* full formula treatment C1
energy lost = 0.15 J A1 [2]

**5** **(a)** magnetic flux = $BA$
= $89 \times 10^{-3} \times 5.0 \times 10^{-2} \times 2.4 \times 10^{-2}$ C1
= $1.07 \times 10^{-4}$ Wb A1

**(b)** **(i)** e.m.f. = $\Delta\phi / \Delta t$ C1
(for $\Delta\phi$ = $1.07 \times 10^{-4}$ Wb), $\Delta t = 2.4 \times 10^{-2} / 1.8 = 1.33 \times 10^{-2}$ s C1
e.m.f. = $(1.07 \times 10^{-4}) / (1.33 \times 10^{-2})$
= $8.0 \times 10^{-3}$ V A1 [3]

**(ii)** current = $8.0 \times 10^{-3} / 0.12$ M1
≈ 70 mA A0 [1]

**(c)** force on wire = $BIL$
= $89 \times 10^{-3} \times 70 \times 10^{-3} \times 5.0 \times 10^{-2}$ C1
≈ $3 \times 10^{-4}$ (N) M1
suitable comment e.g. this force is too / very small (to be felt) A1 [3]

**6** **(a)** power / heating depends on $I^2$ M1
so independent of current direction A1 [2]

**(b)** *either* maximum power = $I_0^2 R$ *or* average power = $I_{RMS}^2 R$ M1
$I_0 = \sqrt{2} \times I_{RMS}$ M1
maximum power = 2 × average power
ratio = 0.5 A1 [3]

**7** **(a)** force due to $E$-field is <u>equal and opposite</u> to force due to $B$-field B1
$Eq = Bqv$ B1
$v = E/B$ B1 [3]

**(b)** *either* charge and mass are not involved in the equation in **(a)**
*or* $F_E$ and $F_B$ are both doubled
*or* $E$, $B$ and $v$ do not change M1
so no deviation A1 [2]

**8** **(a)** minimum frequency for electron to be emitted (from surface) M1
of electromagnetic radiation / light / photons A1 [2]

**(b)** $E = hc / \lambda$ *or* $E = hf$ <u>and</u> $c = f\lambda$ C1
*either* threshold wavelength = $(6.63 \times 10^{-34} \times 3.0 \times 10^8) / (5.8 \times 10^{-19})$
= 340 nm
*or* energy of 340 nm photon = $4.4 \times 10^{-19}$ J
*or* threshold frequency = $8.7 \times 10^{14}$ Hz
*or* 450 nm → $6.7 \times 10^{14}$ Hz A1
appropriate comment comparing wavelengths / energies / frequencies B1
so no effect on photo-electric current B1 [4]

## Section B

**9 (a) (i)** edges can be (clearly) distinguished — B1

**(ii)** e.g. size of X-ray source / anode / target / aperture
scattering of X-ray beam
pixel size
(*any two, 1 each*) — B2
further detail e.g. use of lead grid — B1 [3]

**(b)** X-ray image involves a single exposure — B1
CT scan: exposure of a slice from many different angles — M1
repeated for different slices — A1
CT scan involves a (much) greater exposure — B1 [4]

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

**(b) (i)** with switch open, $V^-$ is less (positive) than $V^+$ — M1
output is positive — A1
with switch closed, $V^-$ is more (positive) than $V^+$ so output is negative — A1 [3]
(*allow similar scheme if $V^-$ more positive than $V^+$ treated first*)

**(ii) 1.** diodes connected correctly between output and earth — M1
**2.** green identified correctly — A1 [2]
(*do not allow this mark if not argued in **(i)***)

**11 (a) (i)** $I / I_0$ = exp(–1.5 × 2.9) — C1
= 0.013 — A1 [2]

**(ii)** $I / I_0$ = exp(–4.6 × 0.95)
= 0.013 — A1 [1]

**(b)** attenuation (coefficients) in muscle and in fat are similar — B1
attenuation (coefficients) in bone and muscle / fat are different — B1
contrast depends on difference in attenuation — B1 [3]

**12 (a) (i) 1.** signal has same variation (with time) as the data

**2.** consists of (a series of) 'highs' and 'lows' B

*either* analogue is continuously variable (between limits)

*or* digital has no intermediate values B1 [

**(ii)** e.g. can be regenerated / noise can be eliminated

extra data can be added to check / correct transmitted signal

(*any two reasonable suggestions, 1 each*) B2 [2]

**(b) (i)** analogue signal is sampled at (regular time) intervals B1

sampled signal is converted into a binary number B1 [2]

**(ii)** one channel is required for each bit (of the digital number) B1 [1]