**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

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## Section A

**1 (a) (i)** rate of change of angle / angular displacement — M1
swept out by radius — A1 [2]

**(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]

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**3** **(a)** **(i)** 8.0 cm A1 [1]

**(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]

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**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 [2]

**(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]

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## Section B

**9 (a) (i)** edges can be (clearly) distinguished — B1 [1]

**(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]

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**12 (a) (i) 1.** signal has same variation (with time) as the data B1

**2.** consists of (a series of) 'highs' and 'lows' B1

*either* analogue is continuously variable (between limits)

*or* digital has no intermediate values B1 [3]

**(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]

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