UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 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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UNIVERSITY of CAMBRIDGE
International Examinations

Section A

1 (a) work done moving unit mass — M1
from infinity to the point — A1 [2]

(b) (i) at R, $\phi = 6.3 \times 10^7$ J kg^{-1} (allow $\pm 0.1 \times 10^7$) — B1
$\phi = GM / R$
$6.3 \times 10^7 = (6.67 \times 10^{-11} \times M) / (6.4 \times 10^6)$ — C1
$M = 6.0 \times 10^{24}$ kg (allow $5.95 \rightarrow 6.14$) — A1 [3]
Maximum of 2/3 for any value chosen for ϕ not at R

(ii) change in potential $= 2.1 \times 10^7$ J kg^{-1} (allow $\pm 0.1 \times 10^7$) — C1
loss in potential energy = gain in kinetic energy — B1
$½ mv^2 = \phi m$ or $½ mv^2 = GM / 3R$ — C1
$½ v^2 = 2.1 \times 10^7$
$v = 6.5 \times 10^3$ m s^{-1} ……(allow $6.3 \rightarrow 6.6$) — A1 [4]
(answer 7.9×10^3 m s^{-1}, based on $x = 2R$, allow max 3 marks)

(iii) e.g. speed / velocity / acceleration would be greater — B1
deviates / bends from straight path — B1 [2]
(any sensible ideas, 1 each, max 2)

2 (a) (i) reduction in energy (of the oscillations) — (B1)
reduction in amplitude / energy of oscillations — (B1)
due to force (always) opposing motion / resistive forces — (B1) [2]
any two of the above, max 2

(ii) amplitude is decreasing (very) gradually / oscillations would continue (for a long time) /many oscillations — M1
light damping — A1 [2]

(b) (i) frequency = 1 / 0.3
= 3.3 Hz — A1 [1]
allow points taken from time axis giving $f = 3.45$ Hz

(ii) energy = $½ mv^2$ and $v = \omega a$ — C1
$= ½ \times 0.065 \times (2\pi/0.3)^2 \times (1.5 \times 10^{-2})^2$ — M1
= 3.2 mJ — A0 [2]

(c) amplitude reduces exponentially / does not decrease linearly — M1
so will be not be 0.7 cm — A1 [2]

3 **(a)** **(i)** 1 deg C corresponds to (3840 – 190) / 100 Ω — C1
for resistance 2300 Ω, temperature is 100 × (2300 – 3840) / (190 – 3840)
temperature is 42 °C — A1 [2]

(ii) *either* 286 K ≡ 13 °C *or* 42 °C ≡ 315 K — B1
thermodynamic scale does not depend on the property of a substance — M1
so change in resistance (of thermistor) with temperature is non-linear — A1 [3]

(b) heat gained by ice in melting = $0.012 \times 3.3 \times 10^5$ J — C1
= 3960 J
heat lost by water = $0.095 \times 4.2 \times 10^3 \times (28 - \theta)$ — C1
$3960 + (0.012 \times 4.2 \times 10^3 \times \theta) = 0.095 \times 4.2 \times 10^3 \times (28 - \theta)$ — C1
θ = 16°C — A1 [4]
(answer 18°C – melted ice omitted – allow max 2 marks)
(use of (θ – T) then allow max 1 mark)

4 **(a)** force = $q_1q_2 / 4\pi\varepsilon_0x^2$ — C1
$= (6.4 \times 10^{-19})^2 / (4\pi \times 8.85 \times 10^{-12} \times \{12 \times 10^{-6}\}^2)$ — C1
$= 2.56 \times 10^{-17}$ N — A1 [3]

(b) potential at P is same as potential at Q — B1
work done = $q\Delta V$ — M1
$\Delta V = 0$ so zero work done — A0 [2]

(c) at midpoint, potential is $2 \times (6.4 \times 10^{-19}) / (4\pi\varepsilon_0 \times 6 \times 10^{-6})$ — C1
at P, potential is $(6.4 \times 10^{-19}) / (4\pi\varepsilon_0 \times 3 \times 10^{-6}) + (6.4 \times 10^{-19}) / (4\pi\varepsilon_0 \times 9 \times 10^{-6})$ — C1
change in potential = $(6.4 \times 10^{-19}) / (4\pi\varepsilon_0 \times 9 \times 10^{-6})$
energy = $1.6 \times 10^{-19} \times (6.4 \times 10^{-19}) / (4\pi\varepsilon_0 \times 9 \times 10^{-6})$ — C1
= 1.0×10^{-22} J — A1 [4]

5 **(a)** e.g. 'storage of charge' / storage of energy
blocking of direct current
producing of electrical oscillations
smoothing
(any two, 1 mark each) — B2 [2]

(b) **(i)** capacitance of parallel combination = 60 μF — C1
total capacitance = 20 μF — A1 [2]

(ii) p.d. across parallel combination = ½ × p.d. across single capacitor — C1
maximum is 9V — A1 [2]

(c) *either* energy = $\frac{1}{2}CV^2$ *or* energy = $\frac{1}{2}QV$ and $Q = CV$ — C1
energy = $\frac{1}{2} \times 4700 \times 10^{-6} \times (18^2 - 12^2)$ — C1
= 0.42 J — A1 [3]

6 **(a)** **(i)** straight line with positive gradient M1
through origin A1 [2]

(ii) maximum force shown at $\theta = 90°$ M1
zero force shown at $\theta = 0°$ M1
reasonable curve with F about ½ max at 30° A1 [3]

(b) **(i)** force on electron due to magnetic field B1
force on electron normal to magnetic field and direction of electron B1 [2]

(ii) quote / mention of (Fleming's) left hand rule M1
electron moves towards QR A1 [2]

7 **(a)** *either* the value of steady / constant voltage M1
that produces same power (in a resistor) as the alternating voltage A1 [2]
or if alternating voltage is squared and averaged (M1)
the r.m.s. value is the square root of this averaged value (A1)

(b) **(i)** 220 V A1 [1]

(ii) 156 V A1 [1]

(iii) 60 Hz A1 [1]

(c) power = V_{rms}^2 / R C1
$R = 156^2 / 1500$
$= 16\ \Omega$ A1 [2]

8 **(a)** **(i)** number = $(5.1 \times 10^{-6} \times 6.02 \times 10^{23}) / 241$ C1
$= 1.27 \times 10^{16}$ A1 [2]

(ii) $A = \lambda N$ C1
$5.9 \times 10^5 = \lambda \times 1.27 \times 10^{16}$
$\lambda = 4.65 \times 10^{-11}\ s^{-1}$ A1 [2]

(iii) $4.65 \times 10^{-11} \times t_{½} = \ln 2$ C1
$t_{½} = 1.49 \times 10^{10}$ s
= 470 years A1 [2]

(b) sample / activity would decay appreciably whilst measurements are being made B1 [1]

Section B

9 (a) (i) fraction of the output (signal) is added to the input (signal) M1
out of phase by 180° / π rad / to inverting input A1 [2]

(ii) e.g. reduces gain
increases bandwidth
greater stability
reduces distortion
(any two, 1 mark each) B2 [2]

(b) (i) gain = 4.4 / 0.062
= 71 A1 [1]

(ii) $71 = 1 + 120/R$ C1
$R = 1.7 \times 10^3\ \Omega$ A1 [2]

(c) for the amplifier not to saturate B1
maximum output is ($71 \times 95 \times 10^{-3}$ =) approximately 6.7 V M1
supply should be +/– 9 V A1 [3]

10 (a) (i) strain gauge B1 [1]

(ii) piezo-electric / quartz crystal / transducer B1 [1]

(b) circuit: coil of relay connected between sensing circuit output and earth B1
switch across terminals of external circuit B1
diode in series with coil with correct polarity for diode B1
second diode with correct polarity B1 [4]

11 *either* quartz *or* piezo-electric crystal B1
opposite faces /two sides coated (with silver) to act as electrodes B1
either molecular structure indicated
or centres of (+) and (–) charge not coincident B1
potential difference across crystal causes crystal to change shape B1
alternating voltage (in US frequency range) applied across crystal B1
causes crystal to oscillate / vibrate B1
(crystal cut) so that it vibrates at resonant frequency B1 [6]
(max 6)

12 (a) signal becomes distorted / noisy B1
signal loses power / energy / intensity / is attenuated B1 [2]

(b) (i) *either* numbers involved are smaller / more manageable / cover wider range
or calculations involve addition & subtraction rather than multiplication and division
B1 [1]

(ii) $25 = 10 \lg(P_{min} / (6.1 \times 10^{-19}))$ C1
minimum signal power $= 1.93 \times 10^{-16}$ W C1
signal loss $= 10 \lg(6.5 \times 10^{-3})/(1.93 \times 10^{-16})$
$= 135$ dB C1
maximum cable length $= 135 / 1.6$ C1
$= 85$ km so no repeaters necessary A1 [5]