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

9702/41 Paper 4 (A2 Structured Questions), maximum raw mark 100

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UNIVERSITY of CAMBRIDGE
International Examinations

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	GCE AS/A LEVEL – May/June 2010	9702	41

Section A

1 (a) angle (subtended) <u>at centre</u> of circle B1
(by) arc equal in length to radius B1 [2]

(b) (i) point S shown below C B1 [1]

(ii) (max) force / tension = weight + centripetal force C1
centripetal force = $mr\omega^2$ C1
$15 = 3.0/9.8 \times 0.85 \times \omega^2$ C1
$\omega = 7.6$ rad s ^{1} A1 [4]

2 (a) (i) 27.2 + 273.15 or 27.2 + 273.2 C1
300.4 K A1 [2]

(ii) 11.6 K A1 [1]

(b) (i) ($<c^2>$ is the) mean / average square speed B1 [1]

(ii) $\rho = Nm/V$ with <u>N explained</u> B1
so, $pV = 1/3\ Nm<c^2>$ B1
and $pV = NkT$ with <u>k explained</u> B1
<u>so mean kinetic energy / $<E_K> = \frac{1}{2}m<c^2> = 3/2\ kT$</u> B1 [4]

(c) (i) $pV = nRT$
$2.1 \times 10^7 \times 7.8 \times 10^{-3} = n \times 8.3 \times 290$ C1
$n = 68$ mol A1 [2]

(ii) mean kinetic energy = $3/2\ kT$
$= 3/2 \times 1.38 \times 10^{-23} \times 290$ C1
$= 6.0 \times 10^{-21}$ J A1 [2]

(iii) realisation that total internal energy is the total kinetic energy C1
energy $= 6.0 \times 10^{-21} \times 68 \times 6.02 \times 10^{23}$ C1
$= 2.46 \times 10^5$ J A1 [3]

3 (a) (i) to-and-fro / backward and forward motion (between two limits) B1 [1]

(ii) no energy loss or gain / no <u>external</u> force acting / constant energy / constant amplitude B1 [1]

(iii) acceleration directed towards a fixed point B1
acceleration proportional to <u>distance from the fixed point</u> / displacement B1 [2]

(b) acceleration is constant (magnitude) M1
so cannot be s.h.m. A1 [2]

4 **(a)** ability to do work B1
as a result of the position/shape, etc. of an object B1 [2]

(b) **(i)** **1** $\Delta E_{gpe} = GMm / r$ C1
$= (6.67 \times 10^{-11} \times \{2 \times 1.66 \times 10^{-27}\}^2) / (3.8 \times 10^{-15})$ C1
$= 1.93 \times 10^{-49}$ J A1 [3]

2 $\Delta E_{epe} = Qq / 4\pi\varepsilon_0 r$ C1
$= (1.6 \times 10^{-19})^2 / (4\pi \times 8.85 \times 10^{-12} \times 3.8 \times 10^{-15})$ C1
$= 6.06 \times 10^{-14}$ J A1 [3]

(ii) idea that $2E_K = \Delta E_{epe} - \Delta E_{gpe}$ B1
$E_K = 3.03 \times 10^{-14}$ J
$= (3.03 \times 10^{-14}) / 1.6 \times 10^{-13}$ M1
$= 0.19$ MeV A0 [2]

(iii) fusion may occur / may break into sub-nuclear particles B1 [1]

5 **(a)** **(i)** V_H depends on angle between (plane of) probe and B-field B1
either V_H max when plane and B-field are normal to each other
or V_H zero when plane and B-field are parallel
or V_H depends on sine of angle between plane and B-field B1 [2]

(ii) **1** calculates $V_H r$ at least three times M1
to 1 s.f. constant so valid or approx constant so valid
or to 2 s.f., not constant so invalid A1 [2]

2 straight line passes through origin B1 [1]

(b) **(i)** e.m.f. induced is proportional / equal to M1
rate of change of (magnetic) flux (linkage) A1
constant field in coil / flux (linkage) of coil does not change B1 [3]

(ii) e.g. vary current (in wire) / switch current on or off / use a.c. current
rotate coil
move coil towards / away from wire (1 mark each, max 3) B3 [3]

6 **(a)** all four diodes correct to give output, regardless of polarity M1
connected for correct polarity A1 [2]

(b) $N_S / N_P = V_S / V_P$ C1
$V_0 = \sqrt{2} \times V_{rms}$ C1
ratio $= 9.0 / (\sqrt{2} \times 240)$
$= 1/38$ or $1/37$ or 0.027 A1 [3]

7 **(a)** arrow pointing up the page — B1 [1]

(b) **(i)** $Eq = Bqv$ — C1
$v = (12 \times 10^3) / (930 \times 10^{-6})$ — C1
$= 1.3 \times 10^7$ m s^{-1} — A1 [3]

(ii) $Bqv = mv^2 / r$ — C1
$q/m = (1.3 \times 10^7) / (7.9 \times 10^{-2} \times 930 \times 10^{-6})$ — C1
$= 1.8 \times 10^{11}$ C kg^{-1} — A1 [3]

8 **(a)** momentum conservation hence momenta of photons are equal (but opposite) — M1
same momentum so same energy — A1 [2]

(b) **(i)** $(\Delta)E = (\Delta)mc^2$ — C1
$= 1.2 \times 10^{-28} \times (3.0 \times 10^8)^2$
$= 1.08 \times 10^{-11}$ J — A1 [2]

(ii) $E = hc / \lambda$
$\lambda = (6.63 \times 10^{-34} \times 3.0 \times 10^8) / (1.08 \times 10^{-11})$ — C1
$= 1.84 \times 10^{-14}$ m — A1 [2]

(iii) $\lambda = h / p$
$p = (6.63 \times 10^{-34}) / (1.84 \times 10^{-14})$ — C1
$= 3.6 \times 10^{-20}$ N s — A1 [2]

Section B

9 **(a)** **(i)** point X shown correctly — B1 [1]

(ii) op-amp has very large / infinite gain — M1
non-inverting input is at earth (potential) / earthed / at 0 V — M1
if amplifier is not to saturate, inverting input must be (almost)
at earth potential / 0 (V) same potential as inverting input — A1 [3]

(b) **(i)** total input resistance = 1.2 kΩ — C1
(amplifier) gain (= –4.2 / 1.2) = –3.5 — C1
(voltmeter) reading = –3.5 × –1.5
= 5.25 V — A1 [3]
(total disregard of signs or incorrect sign in answer, max 2 marks)

(ii) (less bright so) resistance of LDR increases — M1
(amplifier) gain decreases — M1
(voltmeter) reading decreases — A1 [3]

10 (a) X-ray taken of slice / plane / section B1
repeated at different angles B1
images / data is processed B1
combined / added to give (2-D) image of slice B1
repeated for successive slices B1
to build up a 3-D image B1
image can be viewed from different angles / rotated B1
max 6 [6]

(b) (i) 16 A1 [1]

(ii) evidence of deducting 16 then dividing by 3 C1
to give A1 [2]

3	2
6	5

11 (a) frequency of carrier wave varies (in synchrony) with signal M1
(in synchrony) with displacement of signal A1 [2]

(b) advantages e.g. less noise / less interference
greater bandwidth / better quality
(1 each, max 2)
disadvantages e.g. short range / more transmitters / line of sight
more complex circuitry
greater expense
(1 each, max 2) B4 [4]

12 (a) gain / loss/dB = 10 lg(P_1/P_2) C1
190 = 10 lg($18 \times 10^3 / P_2$)
or –190 = 10 lg $P_2 / 18 \times 10^3$) C1
power = 1.8×10^{15} W A1 [3]

(b) (i) 11 GHz / 12 GHz B1 [1]

(ii) e.g. so that input signal to satellite will not be 'swamped'
to avoid interference of uplink with / by downlink B1 [1]