CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2012 series

9702 PHYSICS

9702/43 Paper 4 (A2 Structured Questions), maximum raw mark 100

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Section A

1 (a) (i) number of molecules — B1 [1]

(ii) mean square speed — B1 [1]

(b) (i) 1. $pV = nRT$ — C1
$n = (6.1 \times 10^5 \times 2.1 \times 10^4 \times 10^{-6}) / (8.31 \times 285)$ — C1
$n = 5.4\,\text{mol}$ — A1 [3]

2. *either* $N = nN_A$
$= 5.4 \times 6.02 \times 10^{23}$ — C1
$= 3.26 \times 10^{24}$ — A1
or
$pV = NkT$
$N = (6.1 \times 10^5 \times 2.1 \times 10^4 \times 10^{-6}) / (1.38 \times 10^{-23} \times 285)$ — (C1)
$N = 3.26 \times 10^{24}$ — (A1) [2]

(ii) *either* $6.1 \times 10^5 \times 2.1 \times 10^{-2} = {}^1/_3 \times 3.25 \times 10^{24} \times 4 \times 1.66 \times 10^{-27} \times \langle c^2 \rangle$ — C1
$\langle c^2 \rangle = 1.78 \times 10^6$ — C1
$c_{RMS} = 1.33 \times 10^3\,\text{m s}^{-1}$ — A1
or
${}^1/_2 \times 4 \times 1.66 \times 10^{-27} \times \langle c^2 \rangle = {}^3/_2 \times 1.38 \times 10^{-23} \times 285$ — (C1)
$\langle c^2 \rangle = 1.78 \times 10^6$ — (C1)
$c_{RMS} = 1.33 \times 10^3\,\text{m s}^{-1}$ — (A1) [3]

2 (a) (i) 1. 0.1 s, 0.3 s, 0.5 s, etc (*any two*) — A1 [1]

2. either 0, 0.4 s, 0.8 s, 1.2 s
or
0.2 s, 0.6 s, 1.0 s (*any two*) — A1 [1]

(ii) period = 0.4 s — C1
frequency = (1/0.4 =) 2.5 Hz — A1 [2]

(iii) phase difference = 90 ° *or* ½ π rad — B1 [1]

(b) frequency = 2.4 – 2.5 Hz — B1 [1]

(c) e.g. attach sheet of card to trolley — M1
increases damping / frictional force — A1
e.g. reduce oscillator amplitude — (M1)
reduces power/energy input to system — (A1) [2]

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3 (a) (i) (tangent to line gives) direction of force on a (small test) mass B1 [1]

(ii) (tangent to line gives) direction of force on a (small test) charge M1
charge is positive A1 [2]

(b) similarity:
e.g. radial fields
lines normal to surface
greater separation of lines with increased distance from sphere
field strength $\propto$ 1 / (distance to centre of sphere)^2
(*allow any sensible answer*) B1

difference:
e.g. gravitational force (always) towards sphere B1
electric force direction depends on sign of charge on sphere / towards or away from sphere B1
e.g. gravitational field/force is attractive (B1)
electric field/force is attractive or repulsive (B1)
(*allow any sensible comparison*) [3]

(c) gravitational force = $1.67 \times 10^{-27} \times 9.81$
$= 1.6 \times 10^{-26}$ N A1
electric force = $1.6 \times 10^{-19} \times 270 / (1.8 \times 10^{-2})$ C1
$= 2.4 \times 10^{-15}$ N A1
electric force very much greater than gravitational force B1 [4]

4 (a) force on proton is normal to velocity and field M1
provides centripetal force (for circular motion) A1 [2]

(b) magnetic force = Bqv B1
centripetal force = $mr\omega^2$ *or* mv^2/r B1
$v = r\omega$ B1
$Bqv = Bqr\omega = mr\omega^2$
$\omega = Bq/m$ A1 [4]

5 (a) *either* $\phi = BA \sin\theta$ M1
where A is the area (through which flux passes)
θ is the angle between B and (plane of) A A1
or
$\phi = BA$ (M1)
where A is area normal to B (A1) [2]

(b) graph: V_H constant and non zero between the poles and zero outside M1
sharp increase/decrease at ends of magnet A1 [2]

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(c) (i) (induced) e.m.f. proportional to — M1
rate of change of (magnetic) flux (linkage) — A1 [2]

(ii) short pulse on entering and on leaving region between poles — M1
pulses approximately the same shape but opposite polarities — A1
e.m.f. zero between poles and outside — A1 [3]

6 (a) (i) connection to 'top' of resistor labelled as positive — B1 [1]

(ii) diode B and diode D — B1 [1]

(b) (i) $V_P = 4.0\,V$ — C1
mean power = $V_P^2/2R$ — C1
$= 4^2 / (2 \times 2700)$
$= 2.96 \times 10^{-3}\,W$ — A1 [3]

(ii) capacitor, correct symbol, connected in parallel with R — B1 [1]

(c) graph: half-wave rectification — M1
same period and same peak value — A1 [2]

7 (a) wavelength associated with a particle — M1
that is moving — A1 [2]

(b) (i) kinetic energy $= 1.6 \times 10^{-19} \times 4700$ — C1
$= 7.52 \times 10^{-16}\,J$
either energy = $p^2/2m$ *or* $E_K = \frac{1}{2}mv^2$ *and* $p = mv$ — C1
$p = \sqrt{(7.52 \times 10^{-16} \times 2 \times 9.1 \times 10^{-31})}$ — C1
$= 3.7 \times 10^{-23}\,N\,s$
$\lambda = h/p$ — C1
$= (6.63 \times 10^{-34}) / (3.7 \times 10^{-23})$
$= 1.8 \times 10^{-11}\,m$ — A1 [5]

(ii) wavelength is about separation of atoms — B1
can be used in (electron) diffraction — B1 [2]

8 (a) (i) $x = 2$ — A1 [1]

(ii) *either* beta particle *or* electron — B1 [1]

(b) (i) mass of separate nucleons = {(92 × 1.007) + (143 × 1.009)} u — C1
= 236.931 u — C1
binding energy = 236.931 u – 235.123 u
= 1.808 u — A1 [3]

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(ii) $E = mc^2$ C1
energy = $1.808 \times 1.66 \times 10^{-27} \times (3.0 \times 10^8)^2$
$= 2.7 \times 10^{-10}$ J C1
binding energy per nucleon = $(2.7 \times 10^{-10}) / (235 \times 1.6 \times 10^{-13})$ M1
= 7.18 MeV A0 [3]

(c) energy released = (95 × 8.09) + (139 × 7.92) – (235 × 7.18) C1
= 1869.43 – 1687.3
= 182 MeV A1 [2]
(*allow calculation using mass difference between products and reactants*)

Section B

9 **(a)** light-emitting diode (*allow LED*) B1 [1]

(b) gives a high or a low output / +5 V or –5 V output M1
dependent on which of the inputs is at a higher potential A1 [2]

(c) **(i)** provides a reference/constant potential B1 [1]

(ii) determines temperature of 'switch-over' B1 [1]

(d) **(i)** relay A1 [1]

(ii) relay connected correctly for op-amp output and high-voltage circuit B1
diode with correct polarity in output from op-amp B1 [2]

10 **(a)** background reading = 19 B1 [1]

(b) A = 2 A1
B = 5 A1
C = 9 A1
D = 3 A1 [4]
(*Allow 1 mark if only subtracts background reading*)

(c) **(i)** *either* 5, 14 *or* 14, 5 (A+D, B+C or *v.v.*) B1 [1]

(ii) Three numbers and 'inside' number is 8 (B+D) B1
Three numbers and 'outside' numbers are *either* 2,9 *or* 9,2 (A,C or *v.v.*) B1 [2]

11 **(a)** high frequency wave B1
the amplitude or the frequency is varied M1
the variation represents the information signal /
in synchrony with (the displacement of) the information signal. A1 [3]

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(b) e.g. shorter aerial required
longer transmission range / lower transmitter power / less attenuation
allows more than one station in a region
less distortion
(*allow any three sensible suggestions, 1 mark each*) B3 [3]

12 (a) (i) e.g. linking a (land) telephone to the (local) exchange B1 [1]

(ii) e.g. connecting an aerial to a television B1 [1]

(iii) e.g. linking a ground station to a satellite B1 [1]

(b) (i) attenuation = $10 \lg (P_2 / P_1)$ C1
total attenuation = 2.1×40 (= 84 dB) C1
$84 = 10 \lg (\{450 \times 10^{-3}\} / P)$
$P = 1.8 \times 10^{-9}$ W A1 [3]
(*answer 1.1 $\times 10^{8}$ W scores 1 mark only*)

(ii) maximum attenuation = $10 \lg (\{450 \times 10^{-3}\} / \{7.2 \times 10^{-11}\})$
= 98 dB C1
maximum length = 98/2.1
= 47 km A1 [2]

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