**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

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.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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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]

**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)
$\theta$ 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]

**(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]

**(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]

**(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 = $2.1 \times 40$ (= 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]