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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CAMBRIDGE
International Examinations

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	
$n = 5.4$ 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	
$c_{RMS} = 1.33 \times 10^3\ \mathrm{m\,s^{-1}}$	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)	
$c_{RMS} = 1.33 \times 10^3\ \mathrm{m\,s^{-1}}$	(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 = $1.67 \times 10^{-27} \times 9.81$		
	= 1.6×10^{-26} N	A1	
	electric force = $1.6 \times 10^{-19} \times 270 / (1.8 \times 10^{-2})$	C1	
	= 2.4×10^{-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]

	(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* $E_K = ½mv^2$ *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 × 40 (= 84 dB) C1
$84 = 10\lg(\{450 \times 10^{-3}\} / P)$
$P = 1.8 \times 10^{-9}$ W A1 [3]
(*answer 1.1×10^{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]