CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2013 series

9702 PHYSICS

9702/41 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)**		work done in moving unit mass from infinity (to the point)	M1 A1	[2]
	(b)	**(i)**	gravitational potential energy = GMm / x energy = $(6.67 \times 10^{-11} \times 7.35 \times 10^{22} \times 4.5) / (1.74 \times 10^{6})$ energy = 1.27×10^{7} J	 M1 A0	 [1]
		(ii)	change in grav. potential energy = change in kinetic energy $\frac{1}{2} \times 4.5 \times v^2 = 1.27 \times 10^7$ $v = 2.4 \times 10^3$ m s^{-1}	B1 A1	 [2]
	(c)		Earth would attract the rock / potential at Earth('s surface) not zero / <0 / at Earth, potential due to Moon not zero escape speed would be lower	 M1 A1	 [2]
2	**(a)**	**(i)**	N: (total) number of molecules	B1	[1]
		(ii)	$<c^2>$: mean square speed/velocity	B1	[1]
	(b)		$pV = \frac{1}{3}Nm<c^2> = NkT$ (mean) kinetic energy = $\frac{1}{2} m<c^2>$ algebra clear leading to $\frac{1}{2} m<c^2> = (3/2)kT$	 C1 A1	 [2]
	(c)	**(i)**	*either* energy required = $(3/2) \times 1.38 \times 10^{-23} \times 1.0 \times 6.02 \times 10^{23}$ = 12.5 J (*12J if 2 s.f.*) *or* energy = $(3/2) \times 8.31 \times 1.0$ = 12.5 J	C1 A1 (C1) (A1)	 [2]
		(ii)	energy is needed to push back atmosphere/do work against atmosphere so total energy required is greater	M1 A1	 [2]
3	**(a)**	**(i)**	any two from 0.3(0) s, 0.9(0) s, 1.50 s (*allow 2.1 s etc.*)	B1	[1]
		(ii)	*either* $v = \omega x$ and $\omega = 2\pi/T$ $v = (2\pi/1.2) \times 1.5 \times 10^{-2}$ = 0.079 m s^{-1} *or* gradient drawn clearly at a correct position working clear to give (0.08 ± 0.01) m s^{-1}	C1 M1 A0 (C1) (M1) (A0)	 [2]

(b)	**(i)**	sketch: <u>curve</u> from (±1.5, 0) passing through (0, 25) reasonable shape (*curved with both intersections between y = 12.0→13.0*)	M1 A1	[2]
	(ii)	at max. amplitude potential energy is total energy total energy = 4.0 mJ	B1 B1	[2]
4 (a)	**(i)**	force proportional to product of (two) charges and inversely proportional to square of separation reference to point charges	M1 A1	[2]
	(ii)	$F = 2 \times (1.6 \times 10^{-19})^2 / \{4\pi \times 8.85 \times 10^{-12} \times (20 \times 10^{-6})^2\}$ $= 1.15 \times 10^{-18}$ N	C1 A1	[2]
(b)	**(i)**	force per unit charge on *either* a stationary charge *or* a positive charge	M1 A1	[2]
	(ii)	**1.** electric field is a vector quantity electric fields are in opposite directions charges repel *Any two of the above, 1 each*	B2	[2]
		2. graph: line always between given lines crosses *x*-axis between 11.0 μm and 12.3 μm reasonable shape for curve	M1 A1 A1	[3]
5 (a)	**(i)**	field shown as right to left	B1	[1]
	(ii)	lines are more spaced out at ends	B1	[1]
(b)		Hall voltage depends on angle *either* between field and plane of probe *or* maximum when field normal to plane of probe *or* zero when field parallel to plane of probe	M1 A1	[2]
(c)	**(i)**	(induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage) (*allow rate of cutting of flux*)	M1 A1	[2]
	(ii)	e.g. move coil towards/away from solenoid rotate coil vary current in solenoid insert iron core into solenoid (*any three sensible suggestions, 1 each*)	B3	[3]

6	**(a)**	force due to magnetic field is constant force is (always) normal to direction of motion this force provides the centripetal force	B1 A1	 [3]
	(b)	$mv^2 / r = Bqv$ hence $q / m = v / Br$	M1 A0	 [1]
	(c) (i)	$q / m = (2.0 \times 10^7) / (2.5 \times 10^{-3} \times 4.5 \times 10^{-2})$ $= 1.8 \times 10^{11}$ C kg^{-1}	C1 A1	 [2]
	(ii)	sketch: curved path, constant radius, in direction towards bottom of page tangent to curved path on entering and on leaving the field	M1 A1	 [2]
7	**(a)**	*either* if light passes through suitable film / cork dust etc. diffraction occurs and similar pattern observed *or* concentric circles are evidence of diffraction diffraction is a wave property	M1 A1 (M1) (A1)	 [2]
	(b)	(speed increases so) momentum increases $\lambda = h/p$ so λ decreases hence radii decrease (*special case: wavelength decreases so radii decreases – scores 1/3*) *or* (speed increases so) energy increases $\lambda = h / \sqrt{(2Em)}$ so λ decreases hence radii decrease	M1 M1 A1 (B1) (M1) (A1)	 [3]
	(c)	electron and proton have same (kinetic) energy *either* $E = p^2 / 2m$ *or* $p = \sqrt{(2Em)}$ ratio $= p_e / p_p = \sqrt{(m_e / m_p)}$ $= \sqrt{\{(9.1 \times 10^{-31}) / (1.67 \times 10^{-27})\}}$ $= 2.3 \times 10^{-2}$	C1 C1 C1 A1	 [4]
8	**(a)**	energy to separate nucleons (in a nucleus) separate to infinity	M1 A1	 [2]
	(b) (i)	fission	B1	[1]
	(ii)	**1.** U: near right-hand end of line	B1	[1]
		2. Mo: to right of peak, less than 1/3 distance from peak to U	B1	[1]
		3. La: 0.4 → 0.6 of distance from peak to U	B1	[1]

(iii) 1.	right-hand side, mass = 235.922 u	C1	
	mass change = 0.210 u	A1	[2]
2.	energy = mc^2	C1	
	$= 0.210 \times 1.66 \times 10^{-27} \times (3.0 \times 10^8)^2$		
	$= 3.1374 \times 10^{-11}$ J	C1	
	= 196 MeV (<u>*need 3 s.f.*</u>)	A1	[3]
	(*use of 1 u = 934 MeV, allow 3/3; use of 1 u = 930 MeV or 932 MeV, allow 2/3*)		
	(*use of* 1.67×10^{-27} *not* 1.66×10^{-27} *scores max. 2/3*)		

Section B

9 (a)	operates on / takes signal from sensing device		B1	
	(so that) it gives an voltage output		B1	[2]
(b)	thermistor and resistor in series between +4 V line and earth		M1	
	V_{OUT} shown clearly across *either* thermistor *or* resistor		A1	
	V_{OUT} shown clearly across thermistor		A1	[3]
(c)	e.g. remote switching			
	switching large current by means of a small current			
	isolating circuit from high voltage			
	switching high voltage by means of a small voltage/current			
	(*any two sensible suggestions, 1 each to max. 2*)		B2	[2]
10 (a)	pulse (of ultrasound)		B1	
	produced by quartz / piezo-electric crystal	(1)		
	reflected from boundaries (between media)		B1	
	reflected pulse detected		B1	
	by the ultrasound transmitter	(1)		
	signal processed and displayed		B1	
	intensity of reflected pulse gives information about the boundary	(1)		
	time delay gives information about depth	(1)		
	(*four B marks plus any two from the four, max. 6*)		B2	[6]
(b)	shorter wavelength		B1	
	smaller structures resolved / detected (*not more sharpness)*		B1	[2]
(c) (i)	$I = I_0 \mathrm{e}^{-\mu x}$		C1	
	ratio = $\exp(-23 \times 6.4 \times 10^{-2})$		C1	
	= 0.23		A1	[3]
(ii)	later signal has passed through greater thickness of medium		M1	
	so has greater attenuation / greater absorption / smaller intensity		A1	[2]

11 **(a)**	left-hand bit underlined	B1	[1]
(b)	1010, 1110, 1111, 1010, 1001 (*5 correct scores 2, 4 correct scores 1*)	A2	[2]
(c)	significant changes in detail of *V* between samplings	M1	
	so frequency too low	A1	[2]
12 **(a)**	e.g. logarithm provides a smaller number gain of amplifiers is series found by addition, (not multiplication) (*any sensible suggestion*)	B1	[1]
(b) **(i)**	optic fibre	B1	[1]
(ii)	attenuation/dB = 10 lg(P_2/P_1)	C1	
	= 10 lg($\{6.5 \times 10^{-3}\}/\{1.5 \times 10^{-15}\}$)	C1	
	= 126		
	length = 126 / 1.8		
	= 70 km	A1	[3]