CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2013 series

9702 PHYSICS

9702/42 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)** equatorial orbit / above equator — B1
satellite moves from west to east / same direction as Earth spins — B1
period is 24 hours / same period as spinning of Earth — B1 [3]
(allow 1 mark for 'appears to be stationary/overhead' if none of above marks scored)

(b) gravitational force provides/is the centripetal force — B1
$GMm/R^2 = mR\omega^2$ or $GMm/R^2 = mv^2/R$ — M1
$\omega = 2\pi / T$ or $v = 2\pi R / T$ or clear substitution — M1
clear working to give $R^3 = (GMT^2 / 4\pi^2)$ — A1 [4]

(c) $R^3 = 6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times (24 \times 3600)^2 / 4\pi^2$ — C1
$= 7.57 \times 10^{22}$ — C1
$R = 4.2 \times 10^7$ m — A1 [3]
(missing out 3600 gives 1.8×10^5 m and scores 2/3 marks)

2 **(a)** **(i)** **1.** $pV = nRT$
$1.80 \times 10^{-3} \times 2.60 \times 105 = n \times 8.31 \times 297$ — C1
$n = 0.19$ mol — A1 [2]

2. $\Delta q = mc\Delta T$
$95.0 = 0.190 \times 12.5 \times \Delta T$ — B1
$\Delta T = 40$ K — A1 [2]
(allow 2 marks for correct answer with clear logic shown)

(ii) p/T = constant
$(2.6 \times 10^5) / 297 = p / (297 + 40)$ — M1
$p = 2.95 \times 10^5$ Pa — A0 [1]

(b) change in internal energy is 120 J / 25 J — B1
internal energy decreases / ΔU is negative / kinetic energy of molecules decreases — M1
so temperature lower — A1 [3]

3	(a) (i)	$\omega = 2\pi / T$		
		$= 2\pi / 0.69$	C1	
		$= 9.1$ rad s^{-1}	A1	[2]
		(allow use of $f = 1.5$ Hz to give $\omega = 9.4$ rad s^{-1})		
	(ii) 1.	$x = 2.1 \cos 9.1t$		
		2.1 and 9.1 numerical values	B1	
		use of cos	B1	[2]
	2.	$v_0 = 2.1 \times 10^{-2} \times 9.1$ (allow ecf of value of x_0 from **(ii)1.**)		
		$= 0.19$ m s^{-1}	B1	
		$v = v_0 \sin 9.1t$ (allow cos $9.1t$ if sin used in **(ii)1.**)	B1	[2]
	(b)	energy = either $\frac{1}{2} m v_0^2$ or $\frac{1}{2} m\omega^2 x_0^2$		
		= either $\frac{1}{2} \times 0.078 \times 0.19^2$ or $\frac{1}{2} \times 0.078 \times 9.1^2 \times (2.1 \times 10^{-2})^2$	C1	
		$= 1.4 \times 10^{-3}$ J	A1	[2]
4	(a) (i)	$V = q / 4\pi\varepsilon_0 R$	B1	[1]
	(ii)	(capacitance is) ratio of charge and potential or q/V	M1	
		$C = q/V = 4\pi\varepsilon_0 R$	A0	[1]
	(b) (i)	$C = 4\pi \times 8.85 \times 10^{-12} \times 0.45$	C1	
		$= 50$ pF	A1	[2]
	(ii)	either energy $= \frac{1}{2} CV^2$ or energy $= \frac{1}{2} QV$ and $Q = CV$	C1	
		energy of spark $= \frac{1}{2} \times 50 \times 10^{-12} \{(9.0 \times 10^5)^2 - (3.6 \times 10^5)^2\}$	C1	
		$= 17$ J	A1	[3]
5	(a)	(uniform magnetic) flux normal to long (straight) wire carrying a current of 1 A	M1	
		(creates) force per unit length of 1 N m^{-1}	A1	[2]
	(b) (i)	sketch: concentric circles	M1	
		increasing separation *(must show more than 3 circles)*	A1	
		correct direction (anticlockwise, looking down)	B1	[3]
	(ii)	$B = (4\pi \times 10^{-7} \times 6.3) / (2\pi \times 4.5 \times 10^{-2})$	C1	
		$= 2.8 \times 10^{-5}$ T	A1	[2]
	(iii)	$F = BIL$ ($\sin\theta$)	C1	
		$= 2.8 \times 10^{-5} \times 9.3 \times 1$		
		$F/L = 2.6 \times 10^{-4}$ N m^{-1}	A1	[2]
	(c)	force per unit length depends on product $I_X I_Y$ / by Newton's third law / action and reaction are equal and opposite	M1	
		so same for both	A1	[2]

6	**(a)**	(induced) e.m.f. <u>proportional to rate</u> of change of (magnetic) flux (linkage)	M1 A1	 [2]
	(b) (i)	positive terminal identified (upper connection to load)	B1	[1]
	(ii)	$V_P = \sqrt{2} \times V_{RMS}$ ratio = $240\sqrt{2} / 9$ = 38 ($V_P = V_{RMS} / \sqrt{2}$ *gives ratio* = 18.9 *and scores* 1/3) (*ratio* = 240 / 9 = 26.7 *scores* 1/3) (*ratio* = $9 / (240 / \sqrt{2})$ = 0.0265 *is inverted ratio and scores* 1/3)	C1 C1 A1	 [3]
	(c) (i)	e.g. (output) p.d. / voltage / current does not fall to zero e.g. range of (output) p.d. / voltage / current is reduced *(any sensible answer)*	 B1	 [1]
	(ii)	sketch: same peak value at start of discharge correct shape between one peak and the next	M1 A1	 [2]
7	**(a)**	each wavelength is associated with a discrete <u>change</u> in energy discrete energy <u>change</u> / difference implies discrete levels	M1 A1	 [2]
	(b) (i)	**1.** arrow from –0.54 eV to –0.85 eV, labelled L	B1	[1]
		2. arrow from –0.54 eV to –3.4 eV , labelled S *(two correct arrows, but only one label – allow 2 marks)* *(two correct arrows, but no labels – allow 1 mark)*	B1	[1]
	(ii)	$E = hc / \lambda$ $(3.4 - 0.54) \times 1.6 \times 10^{-19} = (6.63 \times 10^{-34} \times 3.0 \times 10^{8}) / \lambda$ $\lambda = 4.35 \times 10^{-7}$ m	C1 C1 A1	 [3]
	(c)	–1.50 → –3.4 = 1.9 eV –0.85 → –3.4 = 2.55 eV (allow 2.6 eV) –0.54 → –3.4 = 2.86 eV (allow 2.9 eV) *3 correct, 2 marks with –1 mark for each additional energy* *2 correct, 1 mark but no marks if any additional energy differences*	 B2	 [2]

8 **(a)**	energy is given out / released on formation of the α-particle (or reverse argument)	M1	
	either $E = mc^2$ so mass is less		
	or reference to mass-energy equivalence	A1	[2]
(b) **(i)**	mass change = 18.00567 u – 18.00641 u	C1	
	= 7.4×10^{-4} u *(sign not required)*	A1	[2]
(ii)	energy = $c^2\Delta m$		
	= $(3.0 \times 10^8)^2 \times 7.4 \times 10^{-4} \times 1.66 \times 10^{-27}$	C1	
	= 1.1×10^{-13} J	A1	[2]
	(*allow use of* u = 1.67×10^{-27} kg)		
	(*allow method based on* 1u *equivalent to* 930 MeV *to* 933 MeV)		
(iii)	*either* mass of products greater than mass of reactants	M1	
	this mass/energy provided as kinetic energy of the helium-4 nucleus	A1	
	or both nuclei positively charged	(M1)	
	energy required to overcome electrostatic repulsion	(A1)	[2]

Section B

9 **(a)** 30 litres → 54 litres *(allow ± 4 litres on both limits)* A1 [1]

(b) **(i)** only 0.1 V change in reading for 10 litre consumption *(or similar numbers)* B1
above about 60 litres gradient is small compared to the gradient at about 40 litres B1 [2]

(ii) voltmeter reading (nearly) zero when fuel is left C1
voltmeter reads only about 0.1 V when 10 litres of fuel left in tank A1 [2]
("voltmeter reads zero when about 4 litres of fuel left in tank" scores 2 marks)

10 **(a)** product of density and speed of sound / wave M1
(density of medium and) speed of sound / wave in medium A1 [2]

(b) if $(Z_1 – Z_2)$ is small, mostly transmission M1
if $(Z_1 – Z_2)$ is large, mostly reflection M1
(if 'mostly' not stated allow 1/2 marks for these first two marks)
either reflection / transmission also depends on $(Z_1 + Z_2)$
or intensity reflection coefficient = $(Z_1 – Z_2)^2 / (Z_1 + Z_2)^2$ A1 [3]

(c) e.g. smaller structures can be distinguished B1
because better resolution at shorter wavelength / higher frequency B1 [2]

11 **(a)** changing voltage changes energy / speed of <u>electrons</u> M1
changing electron energy changes maximum X-ray photon energy A1 [2]

(b) **(i)** **1.** loss of power / energy / intensity B1 [1]

2. intensity changes when beam not parallel C1
decreases when beam is divergent A1 [2]

(ii) ratio = (exp {–2.9 × 2.5}) / (exp {–0.95 × 6.0}) C1
= 0.21 *(min. 2 sig. fig.)* A1 [2]
(values of both lengths incorrect by factor of 10^{-2} to give ratio of 0.985 scores 1 mark)

12 **(a)** takes all the simultaneous digits for one number B1
and 'sends' them one after another (along the transmission line) B1 [2]

(b) **(i)** 0111 A1 [1]

(ii) 0110 A1 [1]

(c) levels shown

t	0	0.2	0.4	0.6	0.8	1.0	1.2
	0	8	7	15	6	5	8

(–1 for each error or omission) A2
correct basic shape of graph i.e. series of steps M1
with levels staying constant during correct time intervals A1 [4]
(vertical lines in steps do not need to be shown)

(d) increasing number of bits reduces step height M1
increasing sampling frequency reduces step depth / width M1
reproduction of signal is more exact A1 [3]