UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2009 question paper

for the guidance of teachers

9702 PHYSICS

9702/04 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.

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Section A

1	(a)	force per unit mass *(ratio idea essential)*		B1	[1]
	(b)	$g = GM / R^2$		C1	
		$8.6 \times (0.6 \times 10^7)^2 = M \times 6.67 \times 10^{-11}$		C1	
		$M = 4.6 \times 10^{24}$ kg		A1	[3]
	(c)	(i)	*either* potential decreases as distance from planet decreases *or* potential zero at infinity and X is closer to zero *or* potential $\alpha -1/r$ and Y more negative	M1	
			so point Y is closer to planet.	A1	[2]
		(ii)	idea of $\Delta\phi = \frac{1}{2}v^2$	C1	
			$(6.8 - 5.3) \times 10^7 = \frac{1}{2}v^2$		
			$v = 5.5 \times 10^3$ ms^{-1}	A1	[2]

2	(a)	*either* the half-life of the source is <u>very</u> long *or* decay constant is <u>very</u> small *or* half-life >> 40 days *or* decay constant << 0.02 day^{-1}	B1	[1]
	(b)	number of helium atoms $= 3.5 \times 10^6 \times 40 \times 24 \times 3600$	C1	
		$= 1.21 \times 10^{13}$		
		either $pV = NkT$ *or* $pV = nRT$ <u>*and*</u> $n = N / N_A$	C1	
		$1.5 \times 10^5 \times V = 1.21 \times 10^{13} \times 1.38 \times 10^{-23} \times 290$		
		$V = 3.2 \times 10^{-13}$ m^3	A1	[3]
		(if uses T/°C or n = 1 or n = 4, then 1 mark max for calculation of number of atoms)		

3	(a)	increasing separation of molecules / breaking bonds between molecules *(allow atoms/molecules, overcome forces)*			B1	
		doing <u>work</u> against atmosphere (during expansion)			B1	[2]
	(b)	(i)	1	*either* bubbles produced at a <u>constant rate</u> / mass evaporates/lost at <u>constant rate</u> *or* find mass loss more than once and this rate should be constant *or* temperature of liquid remains constant	B1	[1]
			2	to allow/cancel out/eliminate/compensate for heat losses (to atmosphere) *(do not allow 'prevent'/'stop')*	B1	[1]
		(ii)		use of *power* × *time* = *mass* × *specific latent heat*	C1	
				$(70 - 50) \times 5 \times 60 = (13.6 - 6.5) \times L$	C1	
				$L = 845$ J g^{-1}	A1	[3]

4	**(a)**	**(i)**	(θ =) ωt *(allow any subject if all terms given)*	B1	[1]
		(ii)	(SQ =) $r \sin\omega t$ *(allow any subject if all terms given)*	B1	[1]
	(b)		this is the solution of the equation $a = -\omega^2 x$	M1	
			$a = -\omega^2 x$ is the (defining) equation of s.h.m.	A1	[2]
	(c)	**(i)**	$f = \omega / 2\pi$	C1	
			$= 4.7 / 2\pi$		
			$= 0.75$ Hz	A1	[2]
		(ii)	$v = r\omega$ (r must be identified)	C1	
			$= 4.7 \times 12$		
			$= 56\ \text{cm s}^{-1}$	A1	[2]
5	**(a)**	**(i)**	ratio of charge (on body) and its potential	B1	[1]
			(do not allow reference to plates of a capacitor)		
		(ii)	(potential at surface of sphere =) $V = Q / 4\pi\varepsilon_0 r$	M1	
			$C = Q / V = 4\pi\varepsilon_0 r$	A0	[1]
	(b)	**(i)**	$C = 4 \times \pi \times 8.85 \times 10^{-12} \times 0.36$		
			$= 4.0 \times 10^{-11}$ F *(allow 1 s.f.)*	A1	[1]
		(ii)	$Q = CV$		
			$= 4.0 \times 10^{-11} \times 7.0 \times 10^{5}$		
			$= 2.8 \times 10^{-5}$ C	A1	[1]
	(c)		plastic is an insulator / not a conductor / has no free electrons	B1	
			charges do not move (on an insulator)	B1	
			either so no single value for the potential		
			or charge cannot be considered to be at centre	B1	[3]
	(d)		*either* energy = $\frac{1}{2}CV^2$ *or* energy = $\frac{1}{2}QV$ and $C = Q/V$	C1	
			energy $= \frac{1}{2} \times 4 \times 10^{-11} \times \{(7.0 \times 10^5)^2 - (2.5 \times 10^5)^2\}$	C1	
			$= 8.6$ J	A1	[3]

6	**(a)**		unit of magnetic flux density / magnetic field strength	B1	
			(uniform) field normal to wire carrying current of 1 A	M1	
			giving force (per unit length) of 1 N m^{-1}	A1	[3]
	(b)	**(i)**	force on magnet / balance is downwards (so by Newton's third law)	B1	
			force on wire is upwards	M1	
			pole P is a north pole	A1	[3]
		(ii)	$F = BIL$ and $F = mg$ *(g missing, then 0/3 in **(ii)**)*	C1	
			$2.3 \times 10^{-3} \times 9.8 = B \times 2.6 \times 4.4 \times 10^{-2}$ *(g = 10, loses this mark)*	C1	
			$B = 0.20$ T	A1	[3]
	(c)		reading for maximum current = $2.3 \times \sqrt{2}$	C1	
			total variation = $2 \times 2.3 \times \sqrt{2}$		
			= 6.5 g	A1	[2]
7			coil in series with meter *(do not allow inclusion of a cell)*	B1	
			push known pole into coil	B1	
			observe current direction *(not reading)*	B1	
			(induced) field / field from coil repels magnet	B1	
			either states rule to determine direction of magnetic field in coil		
			or reversing magnet direction gives opposite deflection on meter	B1	
			direction of induced current such as to oppose the change producing it	B1	[6]
8	**(a)**		wave theory predicts any frequency would give rise to emission of electron	M1	
			if exposure time is sufficiently long	A1	
			photon has (specific value of) energy dependent on frequency	M1	
			emission if energy greater than threshold / work function / energy to remove electron from surface	A1	[4]
	(b)		photon is packet/quantum of energy	M1	
			of electromagnetic radiation	A1	
			(photon) energy = $h \times$ frequency	B1	[3]
			every particle has an (associated) wavelength	B1	
			wavelength = h / p	M1	
			where p is the momentum (of the particle)	A1	[3]
9	**(a)**	**(i)**	$\Delta N / \Delta t$ (ignore any sign)	B1	[1]
		(ii)	$\Delta N / N$ (ignore any sign)	B1	[1]
	(b)		source must decay by 8%	C1	
			$A = A_0 \exp(-\ln 2\ t / T_{½})$ *or* $A/A_0 = 1 / (2^{t/T})$	C1	
			$0.92 = \exp(-\ln 2 \times t / 5.27)$ *or* $0.92 = 1 / (2^{t/5.27})$	C1	
			t = 0.634 years		
			= 230 days	A1	[4]
			(allow 2 marks for A/A_0 = 0.08, answer 7010 days		
			allow 1 mark for A/A_0 = 0.12, answer 5880 days)		

Section B

10 (a)	(part of) the output is added to /returned to / mixed with the input	B1	
	and is out of phase with the input / fed to inverting input	B1	[2]
(b)	$25 = 1 + (120 / R)$	C1	
	$R = 5\,\text{k}\Omega$	A1	[2]
(c) (i)	–2 V	A1	[1]
(ii)	9 V	A1	[1]
11 (a)	<u>pulse</u> of ultrasound (1) reflected at boundaries / boundary (1) received / detected (at surface) by transducer (1) signal processed and displayed (1) time between transmission and receipt of pulse gives (information about) depth of boundary (1) reflected intensity gives information as to nature of boundary (1) *(any four points, 1 each, max 4)*	B4	[4]
(b) (i)	coefficient $= (Z_2 - Z_1)^2 / (Z_2 + Z_1)^2$		
	$= (6.3 - 1.7)^2 / (6.3 + 1.7)^2$	C1	
	= 0.33 *(unit quoted, then –1)*	A1	[2]
(ii)	fraction $= \exp(-\mu x)$	C1	
	$= \exp(-23 \times 4.1 \times 10^{-2})$		
	= 0.39	A1	[2]
(iii)	intensity $= 0.33 \times 0.39^2 \times I$	C1	
	$= 0.050\,I$	A1	[2]
	*(do not allow e.c.f. from **(i)** and **(ii)** if these answers are greater than 1)*		
12 (a)	loss / reduction in power / energy / voltage/ amplitude (of the signal)	B1	[1]
(b) (i)	attenuation = 125 × 7 = 875 dB	A1	[1]
(ii)	20 amplifiers		
	gain = 20 × 43 = 860 dB	A1	[1]
(c)	gain $= 10\,\lg(P_1/P_2)$	C1	
	overall gain = –15 dB / attenuation is 15 dB	C1	
	$-15 = 10\,\lg(P / 450)$		
	P = 14 mW	A1	[3]

13	**(a)**	switch; tuning cct; (r.f.) amplifier; demodulator; serial-to-parallel converter; DAC; (a.f.) amplifier *mark as 2 sets of 2 marks each*		
		5 blocks identified correctly *(each error or omission, deduct 1 mark)*	B2	
		5 blocks in correct order *(4 or 3 blocks in correct order, allow 1 mark)*	B2	[4]

(b)	phone transmits signal (to identify itself)	(1)		
	signal received by (several) base station<u>s</u>	(1)		
	transferred to cellular exchange	(1)		
	computer selects base station with strongest signal	(1)		
	assigns a (carrier) frequency	(1)		
	(any four, 1 each, max 4)		B4	[4]