9701CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2013 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

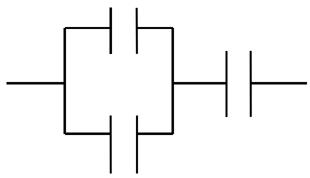
1	**(a)**	force proportional to product of the two masses and inversely proportional to the square of their separation	M1	
		either reference to point masses *or* separation >> 'size' of masses	A1	[2]
	(b)	gravitational force provides the centripetal force	B1	
		$GMm/R^2 = mR\omega^2$	M1	
		where *m is* the mass of the planet	A1	
		$GM = R^3\omega^2$	A0	[3]
	(c)	$\omega = 2\pi / T$	C1	
		either $M_{star} / M_{Sun} = (R_{star} / R_{Sun})^3 \times (T_{Sun} / T_{star})^2$		
		$M_{star} = 4^3 \times (½)^2 \times 2.0 \times 10^{30}$	C1	
		$= 3.2 \times 10^{31}$ kg	A1	[3]
		or $M_{star} = (2\pi)^2 R_{star}{}^3 / GT^2$	(C1)	
		$= \{(2\pi)^2 \times (6.0 \times 10^{11})^3\} / \{6.67 \times 10^{-11} \times (2 \times 365 \times 24 \times 3600)^2\}$	(C1)	
		$= 3.2 \times 10^{31}$ kg	(A1)	
2	**(a) (i)**	sum of kinetic and potential energies of the molecules	M1	
		reference to random distribution	A1	[2]
	(ii)	for ideal gas, no intermolecular forces	M1	
		so no potential energy (only kinetic)	A1	[2]
	(b) (i)	*either* change in kinetic energy $= 3/2 \times 1.38 \times 10^{-23} \times 1.0 \times 6.02 \times 10^{23} \times 180$	C1	
		$= 2240$ J	A1	[2]
		or $R = kN_A$		
		energy $= 3/2 \times 1.0 \times 8.31 \times 180$	(C1)	
		$= 2240$ J	(A1)	
	(ii)	increase in internal energy = heat supplied + work done on system	B1	
		2240 = energy supplied – 1500	C1	
		energy supplied = 3740 J	A1	[3]
3	**(a)**	work done bringing unit positive charge	M1	
		from infinity (to the point)	A1	[2]
	(b) (i)	*either* both potentials are positive / same sign	M1	
		so same sign	A1	[2]
		or gradients are positive & negative (so fields in opposite directions)	(M1)	
		so same sign	(A1)	
	(ii)	the individual potentials are summed	B1	[1]
	(iii)	allow value of *x* between 10 nm and 13 nm	A1	[1]
	(iv)	$V = 0.43$ V (*allow 0.42 V → 0.44 V*)	M1	
		energy $= 2 \times 1.6 \times 10^{-19} \times 0.43$	A1	
		$= 1.4 \times 10^{-19}$ J	A1	[3]

4 **(a)** e.g. store energy (do not allow 'store charge')
in smoothing circuits
blocking d.c.
in oscillators
any sensible suggestions, one each, max. 2 B2 [2]

(b) **(i)** potential across each capacitor is the same <u>and</u> $Q = CV$ B1 [1]

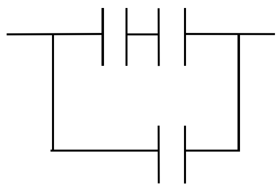
(ii) total charge $Q = Q_1 + Q_2 + Q_3$ M1
$CV = C_1V + C_2V + C_3V$ M1
(*allow Q = CV here* or in **(i)**)
so $C = C_1 + C_2 + C_3$ A0 [2]

(c) **(i)**



A1 [1]

(ii)



A1 [1]

5 **(a)** **(i)** region (of space)
either where a moving charge (may) experience a force
or around a magnet where another magnet experiences a force B1 [1]

(ii) (Φ =) $BA \sin\theta$ A1 [1]

(b) **(i)** plane of frame is always parallel to B_V / flux linkage always zero B1 [1]

(ii) $\Delta\Phi = 1.8 \times 10^{-5} \times 52 \times 10^{-2} \times 95 \times 10^{-2}$ C1
$= 8.9 \times 10^{-6}$ Wb A1 [2]

(c) **(i)** (induced) e.m.f. proportional to rate of M1
change of (magnetic) flux (linkage) A1 [2]
(*allow rate of cutting of flux*)

(ii) e.m.f. $= (8.9 \times 10^{-6}) / 0.30$
$= 3.0 \times 10^{-5}$ V A1 [1]

(iii) This question part was removed from the assessment. All candidates were awarded 1 mark. B1 [1]

6	**(a)**	*either* constant speed parallel to plate *or* accelerated motion / force normal to plate / in direction field so not circular	B1 A0	[1]
	(b) (i)	direction of force due to magnetic field opposite to that due to electric field magnetic field into plane of page	B1 B1	[2]
	(ii)	force due to magnetic field = force due to electric field $Bqv = qE$ $B = E / v$ $= (2.8 \times 10^4) / (4.7 \times 10^5)$ $= 6.0 \times 10^{-2}$ T	B1 C1 A1	[3]
	(c) (i)	no change / not deviated	B1	[1]
	(ii)	deviated upwards	B1	[1]
	(iii)	no change / not deviated	B1	[1]
7	**(a) (i)**	minimum photon energy minimum energy to remove an electron (from the surface)	B1 B1	[2]
	(ii)	*either* maximum KE is photon energy – work function energy *or* max KE when electron ejected from the surface energies lower than max because energy required to bring electron to the surface	 B1 B1	[2]
	(b) (i)	threshold frequency = 1.0×10^{15} Hz (*allow* $\pm 0.05 \times 10^{15}$) work function energy $= hf_0$ $= 6.63 \times 10^{-34} \times 1.0 \times 10^{15}$ $= 6.63 \times 10^{-19}$ J (*allow alternative approaches based on use of co-ordinates of points on the line*)	C1 C1 A1	[3]
	(ii)	sketch: straight line with same gradient displaced to right	M1 A1	[2]
	(iii)	intensity determines number of photons arriving per unit time intensity determines number of electrons per unit time (not energy)	B1 B1	[2]
8	**(a)**	probability of decay (of a nucleus) / fraction of number of nuclei in sample that decay per unit time (*allow* $\lambda = (dN / dt) / N$ *with symbols explained – (M1), (A1)*)	M1 A1	[2]
	(b) (i)	number $= (1.2 \times 6.02 \times 10^{23}) / 235$ $= 3.1 \times 10^{21}$	C1 A1	[2]

(ii) $N = N_0 e^{-\lambda t}$

negligible activity from the krypton — B1

for barium, $N = (3.1 \times 10^{21}) \exp(-6.4 \times 10^{-4} \times 3600)$

$= 3.1 \times 10^{20}$ — C1

activity $= \lambda N$

$= 6.4 \times 10^{-4} \times 3.1 \times 10^{20}$ — C1

$= 2.0 \times 10^{17}$ Bq — A1 [4]

Section B

9 (a) e.g. zero output impedance / resistance
infinite input impedance / resistance
infinite (open loop) gain
infinite bandwidth
infinite slew rate
(*1 each, max. 3*) — B3 [3]

(b) (i) gain = 1 + (10.8 / 1.2) — C1
= 10 — A1 [2]

(ii) graph: straight line from (0,0) towards V_{IN} = 1.0 V, V_{OUT} = 10 V — B1
horizontal line at V_{OUT} = 9.0 V to V_{IN} = 2.0 V — B1
correct +9.0 V → –9.0 V (and correct shape to V_{IN} = 0) — B1 [3]

10 (a) nuclei spin / precess — B1
spin / precess about direction of magnetic field — B1
either frequency of precession depends on magnetic field strength
or large field means frequency in radio frequency range — B1 [3]

(b) non-uniform field means frequency of precession different in different regions of subject — B1
enables location of precessing nuclei to be determined — B1
enables thickness of slice to be varied / location of slice to be changed — B1 [3]

11 (a) (i) *either* series of 'highs' and 'lows' *or* two discrete values — M1
with no intermediate values — A1 [2]

(ii) e.g. noise can be eliminated (NOT 'no noise')
signal can be regenerated
addition of extra data to check for errors
larger data carrying capacity
cheaper circuits
more reliable circuits (*any three, 1 each*) — B3 [3]

	(b)	(i) 1. amplifier	B1	[1]
		2. digital-to-analogue converter (*allow DAC*)	B1	[1]
		(ii) output of ADC is number of digits all at one time	B1	
		parallel-to-serial sends digits one after another	B1	[2]
12	(a)	e.g. no / little ionospheric reflection		
		large information carrying capacity		
		(*any two sensible suggestions, 1 each*)	B2	[2]
	(b)	prevents (very) low power signal received at satellite	M1	
		being swamped by high-power transmitted signal	A1	[2]
	(c)	attenuation / dB = 10 lg(P_2/P_1)	C1	
		185 = 10 lg({3.1×10^3}/P)	C1	
		$P = 9.8 \times 10^{-16}$ W	A1	[3]