**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.

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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]

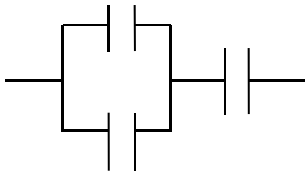
**(iv)** $V = 0.43$ V (*allow 0.42 V → 0.44 V*) M1
energy $= 2 \times 1.6 \times 10^{-19} \times 0.43$ A1
$= 1.4 \times 10^{-19}$ J A1 [3]

**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 and $Q = CV$ B1 [1]

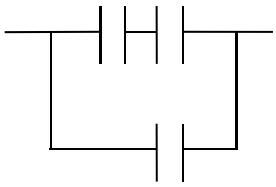
**(ii)** total charge $Q = Q_1 + Q_2 + Q_3$ M1
$CV = C_1V + C_2V + C_3V$ M1
(*allow* $Q = CV$ *here* or in **(i)**)
so $C = C_1 + C_2 + C_3$ A0 [2]

**(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)** ($\Phi$ =) $BA \sin\theta$ 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 B1
so not circular A0 [1]

**(b)** **(i)** direction of force due to magnetic field opposite to that due to electric field B1
magnetic field into plane of page B1 [2]

**(ii)** force due to magnetic field = force due to electric field B1
$Bqv = qE$
$B = E / v$ C1
$= (2.8 \times 10^4) / (4.7 \times 10^5)$
$= 6.0 \times 10^{-2}$ T 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 B1
minimum energy to remove an electron (from the surface) B1 [2]

**(ii)** *either* maximum KE is photon energy – work function energy
*or* max KE when electron ejected from the surface B1
energies lower than max because energy required to bring electron to the surface B1 [2]

**(b)** **(i)** threshold frequency = $1.0 \times 10^{15}$ Hz (*allow* $\pm 0.05 \times 10^{15}$) C1
work function energy $= hf_0$ C1
$= 6.63 \times 10^{-34} \times 1.0 \times 10^{15}$
$= 6.63 \times 10^{-19}$ J A1 [3]
(*allow alternative approaches based on use of co-ordinates of points on the line*)

**(ii)** sketch: straight line with same gradient M1
displaced to right A1 [2]

**(iii)** intensity determines number of photons arriving per unit time B1
intensity determines number of electrons per unit time (not energy) B1 [2]

**8** **(a)** probability of decay (of a nucleus) / fraction of number of nuclei in sample that decay M1
per unit time A1 [2]
(*allow* $\lambda = (dN / dt) / N$ *with symbols explained – (M1), (A1)* )

**(b)** **(i)** number $= (1.2 \times 6.02 \times 10^{23}) / 235$ C1
$= 3.1 \times 10^{21}$ 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({$3.1 \times 10^3$}/$P$) C1
$P = 9.8 \times 10^{-16}$ W A1 [3]