UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2009 question paper for the guidance of teachers

9702 PHYSICS

9702/42 Paper 42 (A2 Structured Questions),

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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UNIVERSITY of CAMBRIDGE International Examinations

Section A

1 **(a)** **(i)** force per (unit) mass ……(*ratio idea essential*) .... B1 [1]

(ii) $g = GM / R^2$ C1
$9.81 = (6.67 \times 10^{-11} \times M) / (6.38 \times 10^6)^2$ ……(*all 3 s.f*) M1
$M = 5.99 \times 10^{24}$ kg .... A0 [2]

(b) **(i)** *either* $GM = \omega^2 r^3$ *or* $gR^2 = \omega^2 r^3$ C1
either $6.67 \times 10^{-11} \times 5.99 \times 10^{24} = \omega^2 \times (2.86 \times 10^7)^3$
or $9.81 \times (6.38 \times 10^6)^2 = \omega^2 \times (2.86 \times 10^7)^3$ C1
$\omega = 1.3 \times 10^{-4}$ rad s^{-1} .... A1 [3]
(*use of $r = 2.22 \times 10^7$m scores max 2 marks*)

(ii) period of orbit = $2\pi / \omega$ C1
$= 4.8 \times 10^4$ s (= 13.4 hours) A1
period for geostationary satellite is 24 hours (= 8.6×10^4 s) A1
so no .... A0 [3]

(c) satellite can then provide cover at Poles .... B1 [1]

[Total: 10]

2 **(a)** sum of kinetic and potential energies of molecules / particles / atoms M1
random (distribution) .... A1 [2]

(b) $+\Delta U$: increase in internal energy B1
$+q$: heating of / heat supplied to system B1
$+w$: work done on system .... B1 [3]

(c) **(i)** work done = $p\Delta V$ C1
$= 1.0 \times 10^5 \times (2.1 - 1.8) \times 10^{-3}$
$= 30$ J M1
$w = 30$ J, $q = 0$ so $\Delta U = 30$ J .... A1 [3]

(ii) these three marks were removed, as insufficient data was given in the question.

[Total: 8]

3 **(a)** straight line through origin B1
negative gradient .... B1 [2]

(b) $a = -\omega^2 x$ and $\omega = 2\pi f$ C1
$750 = (2\pi f)^2 \times 0.3 \times 10^{-3}$ C1
$f = 250$ Hz .... A1 [3]

(c) straight line between(-0.3,+190) and (+0.3,-190) .... A2 [2]
(*allow 1 mark for end of line incorrect by one grid square or line does not extend to +/- 0.3 mm*)

[Total: 7]

4 **(a)** charge / potential ………(*ratio must be clear*) .... B1 [1]

(b) potential (at surface of sphere) $= Q / 4\pi\varepsilon_0 R$ M1
$C = Q / V = 4\pi\varepsilon_0 R$ .... A0 [1]

(c) **(i)** $C = 4\pi \times 8.85 \times 10^{-12} \times 0.63$ C1
$= 7.0 \times 10^{-11}$ A1
farad / F .... B1 [3]

(ii) energy $= ½CV^2$ C1
$0.25 \times ½C \times (1.2 \times 10^6)^2 = ½CV^2$ C1
$V = 6.0 \times 10^5$ V .... A1 [3]
(*use of 0.75 rather than 0.25, allow max 2 marks*)

[Total: 8]

5 **(a)** **(i)** concentric circles, anticlockwise ……(*minimum 3 circles*) M1
separation of lines increases with distance from wire .... A1 [2]

(ii) direction from Y towards X .... A1 [1]

(b) **(i)** flux density at wire Y $= (4\pi \times 10^{-7} \times 5.0) / (2\pi \times 2.5 \times 10^{-2})$ C1
$= 4.0 \times 10^{-5}$ T C1
force per unit length $= BI$
$= 4.0 \times 10^{-5} \times 7.0$ C1
$= 2.8 \times 10^{-4}$ N .... A1 [4]

(ii) *either* force depends on product of the currents in the two wires M1
so equal A1
or (isolated system so) Newton's 3rd law applies .... (M1)
so equal .... (A1) [2]

[Total: 9]

6 **(a)** **(i)** e.m.f. induced proportional / equal to M1
rate of change of (magnetic) flux (linkage) .... A1 [2]

(ii) e.m.f. (induced) only when flux is changing / cut B1
direct current gives constant flux .... B1 [2]

(b) **(i)** (induced) e.m.f. / current acts in such a direction <u>to produce effects</u> B1
to oppose the change causing it .... B1 [2]

(ii) (induced) current in <u>secondary</u> produces magnetic field M1
opposes (changing) field produced in <u>primary</u> M1
so not in phase .... A0 [2]

(c) **(i)** alternating means that voltage / current is easy to change .... B1 [1]

(ii) high voltage means less power / energy loss (during transmission) .... B1 [1]

[Total: 10]

7 **(a)** each line corresponds to a (specific) photon energy B1
photon emitted when electron changes its energy level B1
discrete energy changes so discrete levels .... B1 [3]

(b) **(i)** $E = hc / \lambda$ …(*allow ratio ideas*) C1
$= (6.63 \times 10^{-34} \times 3.0 \times 10^{8}) / (486 \times 10^{-9})$
$= 4.09 \times 10^{-19}$ J .... A1 [2]

(ii) four transitions to/from -5.45×10^{-19} J level B1
all transitions shown from higher to lower energy (level) .... B1 [2]

[Total: 7]

8 **(a)** (constant) probability of decay M1
per unit time .... A1 [2]
(*reference to decay of isotope / mass / sample / nuclide, allow max 1 mark*)

(b) *either* when time $= t_{½}$, $N = ½N_0$
or $½N_0 = N \exp(-\lambda t_{½})\ t_{½}$ M1
either $2 = \exp(\lambda t_{½})$
or $½ = \exp(-\lambda t_{½})$ M1
(taking logs), <u>$\ln 2 = 0.693 = \lambda t_{½}$</u> .... A1 [3]

(c) $A = \lambda N$
$1.8 \times 10^{5} = N \times (0.693 / \{1.66 \times 10^{8}\})$ C1
$N = 4.3 \times 10^{13}$
mass $= 60 \times (N / N_A)$ or $60 \times N \times u$ C1
$= (60 \times 4.3 \times 10^{11}) / (6.02 \times 10^{23})$
$= 4.3 \times 10^{-9}$ g .... A1 [3]

[Total: 8]

Section B

9 **(a)** e.g. reduces gain
increases bandwidth
less distortion
greater stability ………(*1 each, max 2*) .... B2 [2]

(b) gain = $-R_F / R_I$
= $-8.0 / 4.0$ M1
numerical value is 2 .... A0 [1]

(c) **(i)** 2, 6 and 7 .... A1 [1]

(ii) e.g. digital-to-analogue converter (*allow DAC*)
adding / mixing signals with 'weighting' .... B1 [1]

[Total: 5]

10 **(a)** **(i)** e.m. radiation / photons is produced whenever a charged particle
is accelerated M1
wavelength depens on magnitude of acceleration A1
electrons have a distribution of accelerations A1
so continuous spectrum .... A0 [3]

(ii) *either* when electron loses all its energy in one collision
or when energy of electron produces a single photon .... B1 [1]

(b) **(i)** parallel beam (in matter) B1
$I = I_0 \exp(-\mu x)$ M1
I, I_0, (μ) and x explained .... A1 [3]

(ii) *either* low-energy photons absorbed (much) more readily
or low-energy photons (far) less penetrating B1
low-energy photons do not contribute to X-ray <u>image</u> B1
low energy photons could cause tissue damage .... B1 [3]

[Total: 10]

11 **(a)** amplitude modulation ……(*allow AM*) .... B1 [1]

(b) **(i)** frequency = 1 / period C1
= 100 kHz .... A1 [2]

(ii) frequency = 10 kHz .... A1 [1]

(c) **(i)** vertical line at 100 kHz B1
vertical lines at 90 kHz and 110 kHz B1
lines at 90 kHz and 110 kHz same length and shorter than at 100 kHz .... B1 [3]

(ii) 20 kHz .... B1 [1]

[Total: 8]

12 **(a)** **(i)** base stations .... B1 [1]

(ii) cellular exchange .... B1 [1]

(b) base station / X sends / receives signal to / from handset B1
call relayed to cellular exchange / Y (and on to PSTN) B1
<u>computer</u> at cellular exchange monitors signal from base station<u>s</u> B1
selects base station with strongest signal B1
allocates a (carrier) frequency / time slot for the call .... B1 [5]

[Total: 7]