

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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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
= 4.8×10^4 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]**

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- 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
 $f = 250 \text{ Hz}$ 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 $\pm 0.3 \text{ mm}$)

[Total: 7]

- 4 (a) charge / potential(ratio must be clear) B1 [1]
- (b) potential (at surface of sphere) = $Q / 4\pi\epsilon_0 R$ M1
 $C = Q / V = 4\pi\epsilon_0 R$ 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 = $\frac{1}{2}CV^2$ C1
 $0.25 \times \frac{1}{2}C \times (1.2 \times 10^6)^2 = \frac{1}{2}CV^2$ C1
 $V = 6.0 \times 10^5 \text{ V}$ 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
 $= 4.0 \times 10^{-5} \text{ T}$ C1
 force per unit length = BI
 $= 4.0 \times 10^{-5} \times 7.0$ C1
 $= 2.8 \times 10^{-4} \text{ N}$ 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]

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- 6 (a) (i) e.m.f. induced proportional / equal toM1
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 to produce effects B1
to oppose the change causing it B1 [2]
- (ii) (induced) current in secondary produces magnetic fieldM1
opposes (changing) field produced in primaryM1
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
 $= (6.63 \times 10^{-34} \times 3.0 \times 10^8) / (486 \times 10^{-9})$
 $= 4.09 \times 10^{-19} \text{ J}$ A1 [2]
- (ii) four transitions to/from $-5.45 \times 10^{-19} \text{ J}$ level B1
all transitions shown from higher to lower energy (level) B1 [2]

[Total: 7]

- 8 (a) (constant) probability of decayM1
per unit time A1 [2]
(reference to decay of isotope / mass / sample / nuclide, allow max 1 mark)
- (b) *either* when time = $t_{1/2}$, $N = \frac{1}{2}N_0$
or $\frac{1}{2}N_0 = N \exp(-\lambda t_{1/2})$ M1
either $2 = \exp(\lambda t_{1/2})$
or $\frac{1}{2} = \exp(-\lambda t_{1/2})$ M1
(taking logs), $\ln 2 = 0.693 = \lambda t_{1/2}$ 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
 $= (60 \times 4.3 \times 10^{13}) / (6.02 \times 10^{23})$
 $= 4.3 \times 10^{-9} \text{ g}$ A1 [3]

[Total: 8]

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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 acceleratedM1
 wavelength depends 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 image B1
 low energy photons could cause tissue damage B1 [3]

[Total: 10]

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- 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
 computer at cellular exchange monitors signal from base stations B1
 selects base station with strongest signal B1
 allocates a (carrier) frequency / time slot for the call B1 [5]
- [Total: 7]**