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

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UNIVERSITY of CAMBRIDGE
International Examinations

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 α $-1/r$ 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 B1
(allow atoms/molecules, overcome forces)
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) B1 [1]
(do not allow 'prevent'/'stop')

(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) pulse 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 B2
(each error or omission, deduct 1 mark)
5 blocks in correct order B2 [4]
(4 or 3 blocks in correct order, allow 1 mark)

(b) phone transmits signal (to identify itself) (1)
signal received by (several) base stations (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]