

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the October/November 2014 series

9702 PHYSICS

9702/43

Paper 4 (A2 Structured Questions), maximum raw mark 100

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- 1 (a) (i) either $\omega = 2\pi/T$ or $\omega = 2\pi f$ and $f = 1/T$
 $\omega = 2\pi/0.30$
 $= 20.9 \text{ rad s}^{-1}$ (accept 2 s.f.)
- (ii) kinetic energy $= \frac{1}{2}m\omega^2x_0^2$ or $v = \omega x_0$ and $\frac{1}{2}mv^2$
 $= \frac{1}{2} \times 0.130 \times 20.9^2 \times (1.5 \times 10^{-2})^2 = 6.4 \times 10^{-3} \text{ J}$
- (b) (i) as magnet moves, flux is cut by cup/aluminium giving rise to induced e.m.f. (in cup)
- induced e.m.f. gives rise to currents and heating of the cup
thermal energy derived from oscillations of magnet so amplitude decreases
or
induced e.m.f. gives rise to currents which generate a magnetic field
the magnetic field opposes the motion of the magnet so amplitude decreases
- (ii) either use of $\frac{1}{2}m\omega^2x_0^2$ and $x_0 = 0.75 \text{ cm}$ or x_0 is halved so $\frac{1}{4}$ energy to give new energy = 1.6 mJ
- either loss in energy = $6.4 - 1.6$ or loss = $\frac{3}{4} \times 6.4$ giving loss = 4.8 mJ
- (c) $q = mc\Delta\theta$
 $4.8 \times 10^{-3} = 6.2 \times 10^{-3} \times 910 \times \Delta\theta$
 $\Delta\theta = 8.5 \times 10^{-4} \text{ K}$
- 2 (a) smooth curve with decreasing gradient, not starting at $x = 0$
end of line not at $g = 0$ or horizontal
- (b) straight line with positive gradient
line starts at origin
- (c) sinusoidal shape
only positive values and peak/trough height constant
4 'loops'
- 3 (a) initially, $pV/T = (2.40 \times 10^5 \times 5.00 \times 10^{-4})/288 = 0.417$
finally, $pV/T = (2.40 \times 10^5 \times 14.5 \times 10^{-4})/835 = 0.417$
ideal gas because pV/T is constant
(allow 2 marks for two determinations of V/T and then 1 mark for V/T and p constant, so ideal)

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- (b) (i) work done = $p\Delta V$
 $= 2.40 \times 10^5 \times (14.5 - 5.00) \times 10^{-4}$
 $= 228 \text{ J (ignore sign, not 2 s.f.)}$ C1
A1 [2]
- (ii) $\Delta U = q + w = 569 - 228$
 $= 341 \text{ J}$ M1
increase A1 [2]
- 4 (a) acceleration / force proportional to displacement (from a fixed point)
either acceleration and displacement in opposite directions
or acceleration always directed towards a fixed point M1
A1 [2]
- (b) (i) zero & 0.625 s *or* 0.625 s & 1.25 s *or* 1.25 s & 1.875 s *or* 1.875 s & 2.5 s A1 [1]
- (ii) 1. $\omega = 2\pi / T$ and $v_0 = \omega x_0$ C1
 $\omega = 2\pi / 1.25$
 $= 5.03 \text{ rad s}^{-1}$ C1
- $v_0 = 5.03 \times 3.2$
 $= 16.1 \text{ cm s}^{-1}$ (allow 2 s.f.) A1 [3]
2. $v = \omega\sqrt{(x_0^2 - x^2)}$
either $\frac{1}{2}\omega a = \omega\sqrt{(x_0^2 - x^2)}$ *or* $\frac{1}{2} \times 16.1 = 5.03\sqrt{(3.2^2 - x^2)}$ C1
 $x_0^2 / 4 = x_0^2 - x^2$ $2.58 = 3.2^2 - x^2$
 $x = 2.8 \text{ cm}$ $x = 2.8 \text{ cm}$ A1 [2]
- (c) sketch: loop with origin at its centre M1
correct intercepts & shape based on (b)(ii) A1 [2]
- 5 (a) work done / energy in moving unit positive charge
from infinity (to the point) M1
A1 [2]
- (b) (i) $V = q / 4\pi\epsilon_0 r$
at 16 kV, $q = 3.0 \times 10^{-8} \text{ C}$
- $r = (3.0 \times 10^{-8}) / (4\pi \times 8.85 \times 10^{-12} \times 16 \times 10^3)$ C1
 $= 1.69 \times 10^{-2} \text{ m}$ (allow 2 s.f.) A1 [2]
(allow any answer which rounds to 1.7×10^{-2})
- (ii) energy is / represented by area 'below' line C1
energy = $\frac{1}{2}qV$
 $= \frac{1}{2} \times 24 \times 10^3 \times 4.5 \times 10^{-8}$ C1
 $= 5.4 \times 10^{-4} \text{ J}$ A1 [3]
- (c) $V = q / 4\pi\epsilon_0 r$ and $E = q / 4\pi\epsilon_0 r^2$ giving $Er = V$ B1
 $2.0 \times 10^6 \times 1.7 \times 10^{-2} = V$ C1
 $V = 3.4 \times 10^4 \text{ V}$ A1 [3]

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- 6 (a) for the two capacitors in parallel, capacitance = 96 μF
for complete arrangement, $1/C_T = 1/96 + 1/48$
 $C_T = 32 \mu\text{F}$ C1
A1 [2]
- (b) p.d. across parallel combination is one half p.d. across single capacitor
total p.d. = 9V C1
A1 [2]
- 7 (a) *either* charge exists in discrete and equal quantities
or multiples of elementary charge / $e / 1.6 \times 10^{-19} \text{ C}$ B1 [1]
- (b) (i) force due to magnetic field must be upwards
B-field into the plane of the paper B1
B1 [2]
- (ii) sketch showing: deflection consistent with force in (b)(i)
reasonable curve B1
B1 [2]
- 8 (a) discrete amount / packet / quantum of energy
of electromagnetic radiation / EM radiation M1
A1 [2]
- (b) (i) $E = hc/\lambda$
 $= (6.63 \times 10^{-34} \times 3.0 \times 10^8) / (570 \times 10^{-9}) = 3.49 \times 10^{-19} \text{ J}$ A1 [1]
- (ii) 1. number = $(2.7 \times 10^{-3}) / (3.5 \times 10^{-19})$
 $= 7.7 \times 10^{15}$ C1
A1 [2]
2. momentum of photon = h/λ
 $= (6.63 \times 10^{-34}) / (570 \times 10^{-9})$
 $= 1.16 \times 10^{-27} \text{ kg m s}^{-1}$ C1
C1
- change in momentum = $1.16 \times 10^{-27} \times 7.7 \times 10^{15}$
 $= 8.96 \times 10^{-12} \text{ kg m s}^{-1}$ A1 [3]
- (allow $E = pc$ route to 9×10^{-12})
- (c) pressure = (change in momentum per second) / area C1
 $= (8.96 \times 10^{-12}) / (1.3 \times 10^{-5})$
 $= 6.9 \times 10^{-7} \text{ Pa}$ A1 [2]
- 9 (a) activity = $(1.7 \times 10^{14}) / (2.5 \times 10^6)$
 $= 6.8 \times 10^7 \text{ Bq kg}^{-1}$ A1 [1]
- (b) (i) energy released per second in 1.0 kg of steel
 $= 6.8 \times 10^7 \times 0.067 \times 1.6 \times 10^{-13}$
 $= 7.3 \times 10^{-7} \text{ J}$ B1 [1]

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(ii) this is a very small quantity of energy so steel will not be warm B1 [1]

(iii) $A = A_0 e^{-\lambda t}$ and $\lambda t_{1/2} = \ln 2$ C1
 $400 = (6.8 \times 10^7) \exp(-[\ln 2 \times t]/92)$ C1
 $t = 1600$ years A1

or

$A = A_0 / 2^n$ (C1)
 $n = 17.4$ (C1)
 $t = 17.4 \times 92 = 1600$ years (A1) [3]

Section B

10 (a) (i) thermistor/thermocouple B1 [1]

(ii) quartz crystal/piezoelectric crystal or transducer/microphone B1 [1]

(b) (i) $V_{OUT} = -5V$ A1
 inverting input is positive or V_- is positive or $V_- > V_+$ so V_{OUT} is negative B1
 op-amp has very large/infinite gain and so saturates B1 [3]

(ii) sketch: V_{OUT} switches from (+) to (-) when V_{IN} is zero B1
 V_{OUT} is +5V or -5V M1
 V_{OUT} is negative when V_{IN} is positive (or v.v.) A1 [3]

11 (a) product of density and speed M1
 density of medium, speed of wave in medium A1 [2]
 (not "speed of light", 0/2)

(b) (i) $\alpha = (6.4 - 1.7)^2 / (6.4 + 1.7)^2$ C1
 $= 0.34$ A1 [2]

(ii) $I/I_0 = e^{-\mu x}$ C1
 $= \exp(-23 \times 3.4 \times 10^{-2})$ C1
 $= 0.46$ A1 [3]

(iii) $I_R/I = (0.46)^2 \times 0.34$ C1
 $= 0.072$ A1 [2]

12 (a) analogue: continuously variable B1
 digital: two/distinct levels only or 1 s and 0 s or highs and lows B1 [2]

(b) (i) 5 A1 [1]

(ii) 1 1 0 1 A1 [1]

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- (c) greater number of voltage/signal levels
 smaller step heights in reproduced signal
 smaller voltage/signal changes can be seen
 B1
 B1
 B1 [3]
- 13 (a) same carrier frequencies can be re-used
 but not in neighbouring cells/possible to use more handsets
 M1
 A1 [2]
- (b) e.g. wavelength is short
 so aerial on mobile phone conveniently short
 (M1)
 (A1)
- e.g. limited range
 so low power/less interference between cells
 (M1)
 (A1)
- e.g. large number of channels/greater bandwidth
 so more simultaneous callers
 (M1)
 (A1) [4]