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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 $f = 1/T$ C1
$\omega = 2\pi / 0.30$
$= 20.9\,\text{rad s}^{-1}$ (*accept 2 s.f.*) A1 [2]

(ii) kinetic energy $= \frac{1}{2}m\omega^2 x_0^2$ *or* $v = \omega x_0$ and $\frac{1}{2}mv^2$ C1
$= \frac{1}{2} \times 0.130 \times 20.9^2 \times (1.5 \times 10^{-2})^2 = 6.4 \times 10^{-3}\,\text{J}$ A1 [2]

(b) (i) as magnet moves, flux is cut by cup / aluminium giving rise to induced e.m.f. (in cup) B1

induced e.m.f. gives rise to currents and heating of the cup B1
thermal energy derived from oscillations of magnet so amplitude decreases B1
or
induced e.m.f. gives rise to currents which generate a magnetic field (B1)
the magnetic field opposes the motion of the magnet so amplitude decreases (B1) [3]

(ii) *either* use of $\frac{1}{2}m\omega^2 x_0^2$ and $x_0 = 0.75\,\text{cm}$ *or* x_0 is halved so ¼ energy to give new energy = 1.6 mJ C1

either loss in energy = 6.4 – 1.6 *or* loss = ¾ × 6.4 giving loss = 4.8 mJ A1 [2]

(c) $q = mc\Delta\theta$
$4.8 \times 10^{-3} = 6.2 \times 10^{-3} \times 910 \times \Delta\theta$ C1
$\Delta\theta = 8.5 \times 10^{-4}\,\text{K}$ A1 [2]

2 (a) smooth curve with decreasing gradient, not starting at $x = 0$ M1
end of line not at $g = 0$ or horizontal A1 [2]

(b) straight line with positive gradient M1
line starts at origin A1 [2]

(c) sinusoidal shape B1
only positive values and peak / trough height constant B1
4 'loops' B1 [3]

3 (a) initially, $pV/T = (2.40 \times 10^5 \times 5.00 \times 10^{-4}) / 288 = 0.417$ M1
finally, $pV/T = (2.40 \times 10^5 \times 14.5 \times 10^{-4}) / 835 = 0.417$ M1
ideal gas because pV/T is constant A1 [3]
(*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 $= p\Delta V$
$= 2.40 \times 10^5 \times (14.5 - 5.00) \times 10^{-4}$ C1
$= 228\,\text{J}$ (*ignore sign, not 2 s.f.*) 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) M1
either acceleration and displacement in opposite directions
or acceleration always directed towards a fixed point 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 M1
from infinity (to the point) A1 [2]

(b) (i) $V = q / 4\pi\varepsilon_0 r$
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) $V = q / 4\pi\varepsilon_0 r$ and $E = q / 4\pi\varepsilon_0 r^2$ 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 C1
for complete arrangement, $1/C_T = 1/96 + 1/48$
$C_T = 32\,\mu F$ A1 [2]

(b) p.d. across parallel combination is one half p.d. across single capacitor C1
total p.d. = 9 V A1 [2]

7 **(a)** *either* charge exists in discrete and equal quantities
or multiples of elementary charge / e / 1.6×10^{-19} C B1 [1]

(b) **(i)** force due to magnetic field must be upwards B1
B-field into the plane of the paper B1 [2]

(ii) sketch showing: deflection consistent with force in **(b)(i)** B1
reasonable curve B1 [2]

8 **(a)** discrete amount / packet / quantum of energy M1
of electromagnetic radiation / EM radiation A1 [2]

(b) **(i)** $E = hc/\lambda$
$= (6.63 \times 10^{-34} \times 3.0 \times 10^{8})/(570 \times 10^{-9}) = 3.49 \times 10^{-19}$ J A1 [1]

(ii) **1.** number $= (2.7 \times 10^{-3})/(3.5 \times 10^{-19})$ C1
$= 7.7 \times 10^{15}$ A1 [2]

2. momentum of photon $= h/\lambda$ C1
$= (6.63 \times 10^{-34})/(570 \times 10^{-9})$
$= 1.16 \times 10^{-27}$ kg m s^{-1} C1

change in momentum $= 1.16 \times 10^{-27} \times 7.7 \times 10^{15}$
$= 8.96 \times 10^{-12}$ kg m s^{-1} A1 [3]

(*allow $E = pc$ route to 9×10^{-12}*)

(c) pressure = (change in momentum per second) / area C1
$= (8.96 \times 10^{-12})/(1.3 \times 10^{-5})$
$= 6.9 \times 10^{-7}$ Pa A1 [2]

9 **(a)** activity $= (1.7 \times 10^{14})/(2.5 \times 10^{6})$
$= 6.8 \times 10^{7}$ Bq kg^{-1} A1 [1]

(b) **(i)** energy released per second in 1.0 kg of steel
$= 6.8 \times 10^{7} \times 0.067 \times 1.6 \times 10^{-13}$
$= 7.3 \times 10^{-7}$ 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 $\lambda t_{½} = \ln 2$ — 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) $V_{OUT} = -5$ V — 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 +5 V or –5 V — 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 — B1
smaller step heights in reproduced signal — B1
smaller voltage / signal changes can be seen — B1 [3]

13 (a) same carrier frequencies can be re-used — M1
but not in neighbouring cells / possible to use more handsets — A1 [2]

(b) e.g. wavelength is short — (M1)
so aerial on mobile phone conveniently short — (A1)

e.g. limited range — (M1)
so low power / less interference between cells — (A1)

e.g. large number of channels / greater bandwidth — (M1)
so more simultaneous callers — (A1) [4]

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