
PHYSICS

9702/42

Paper 4 A Level Structured Questions

May/June 2016

MARK SCHEME

Maximum Mark: 100

Published

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- 1 (a) (i) gravitational force provides/is the centripetal force B1
same gravitational force (by Newton III) B1 [2]
- (ii) $\omega = 2\pi/T$
 $= 2\pi/(4.0 \times 365 \times 24 \times 3600)$ C1
 $= 5.0 (4.98) \times 10^{-8} \text{ rad s}^{-1}$ A1 [2]
- (b) (i) (centripetal force $=$) $M_A d \omega^2 = M_B (2.8 \times 10^8 - d) \omega^2$
or
 $M_A d_A = M_B d_B$ C1
 $M_A / M_B = 3.0 = (2.8 \times 10^8 - d) / d$ C1
 $d = 7.0 \times 10^7 \text{ km}$ A1 [3]
- (ii) $GM_A M_B / (2.8 \times 10^{11})^2 = M_A d \omega^2$ B1
 $M_B = (2.8 \times 10^{11})^2 \times d \omega^2 / G$
 $= (2.8 \times 10^{11})^2 \times (7.0 \times 10^{10}) \times (4.98 \times 10^{-8})^2 / (6.67 \times 10^{-11})$ C1
 $= 2.0 \times 10^{29} \text{ kg}$ A1 [3]
- 2 (a) (i) number of atoms/nuclei in 12 g of carbon-12 B1 [1]
(ii) amount of substance M1
containing N_A (or 6.02×10^{23}) particles/molecules/atoms
or
which contains the same number of particles/atoms/molecules as there
are atoms in 12 g of carbon-12 A1 [2]
- (b) $pV = nRT$
 $2.0 \times 10^7 \times 1.8 \times 10^4 \times 10^{-6} = n \times 8.31 \times 290$, so $n = 149 \text{ mol}$ or 150 mol A1 [1]
- (c) (i) V and T constant and so pressure reduced by 5.0%
pressure $= 0.95 \times 2.0 \times 10^7$ C1
or
calculation of new n ($= 142.5 \text{ mol}$) and correct substitution into $pV = nRT$ (C1)
pressure $= 1.9 \times 10^7 \text{ Pa}$ A1 [2]

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- (ii) loss is $5/100 \times 150 \text{ mol} = 7.5 \text{ mol}$
or
 $\Delta N = 4.52 \times 10^{24}$ C1
- $t = (7.5 \times 6.02 \times 10^{23}) / 1.5 \times 10^{19}$
or
 $t = 4.52 \times 10^{24} / 1.5 \times 10^{19}$ C1
- $= 3.0 \times 10^5 \text{ s}$ A1 [3]
- 3 (a)** no net energy transfer between the bodies
or
bodies are at the same temperature B1 [1]
- (b) (i)** thermocouple, platinum/metal resistance thermometer, pyrometer B1 [1]
- (ii)** thermistor, thermocouple B1 [1]
- (c) (i)** change = 11.5 K B1 [1]
- (ii)** final temperature = 311.2 K B1 [1]
- 4 (a) (i)** $T = 0.60 \text{ s}$ and $\omega = 2\pi/T$ C1
- $\omega = 10(10.47) \text{ rad s}^{-1}$ A1 [2]
- (ii)** energy = $\frac{1}{2}m\omega^2x_0^2$ or $\frac{1}{2}mv^2$ and $v = \omega x_0$ C1
- $= \frac{1}{2} \times 120 \times 10^{-3} \times (10.5)^2 \times (2.0 \times 10^{-2})^2$
- $= 2.6 \times 10^{-3} \text{ J}$ A1 [2]
- (b)** sketch: smooth curve in correct directions B1
- peak at f M1
- amplitude never zero and line extends from $0.7f$ to $1.3f$ A1 [3]
- (c)** sketch: peaked line always below a peaked line A M1
- peak not as sharp and at (or slightly less than) frequency of peak in line A A1 [2]

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- 5 (a) amplitude of the carrier wave varies M1
in synchrony with displacement of the information/audio signal A1 [2]
- (b) (i) 10 kHz A1 [1]
(ii) 5 kHz A1 [1]
- (c) (i) $24 = 10 \lg (P_{\text{MIN}} / \{5.0 \times 10^{-13}\})$ C1
 $P_{\text{MIN}} = 1.3 (1.26) \times 10^{-10} \text{ W}$ A1 [2]
- (ii) $45 \times 2 = 10 \lg (\{500 \times 10^{-3}\} / P)$
 $P = 5.0 \times 10^{-10} \text{ (W)}$ M1
 $P > P_{\text{MIN}}$ so yes A1
- or*
- maximum attenuation calculated to be 96 (dB) (M1)
96 dB > 2 × 45 dB so yes (A1)
- or*
- maximum length of wire calculated to be 48 (km) (M1)
actual length 45 km < 48 km so yes (A1)
- or*
- maximum attenuation per unit length calculated to be 2.2 dB km⁻¹ (M1)
2.2 dB km⁻¹ > 2.0 dB km⁻¹ so yes (A1) [2]
- 6 (a) lines perpendicular to surface
or
lines are radial M1
lines appear to come from centre A1 [2]
- (b) (i) $F_E = (1.6 \times 10^{-19})^2 / 4\pi\epsilon_0 x^2$ C1
 $F_G = G \times (1.67 \times 10^{-27})^2 / x^2$ C1
 $F_E / F_G = (1.6 \times 10^{-19})^2 \times (8.99 \times 10^9) / [(1.67 \times 10^{-27})^2 \times (6.67 \times 10^{-11})]$
= 1.2 (1.24) × 10³⁶ A1 [3]
- (ii) $F_E \gg F_G$ B1 [1]

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- 7 (a) e.g. storing energy
blocking d.c.
in oscillator circuits
in tuning circuits
in timing circuits
- any two* B2 [2]
- (b) (i) $1/6 + 1/C + 1/C = 1/4$ C1
 $C = 24 \mu\text{F}$ A1 [2]
- (ii) $Q = CV$ C1
 $= 4.0 \times 10^{-6} \times 12$
 $= 48 \mu\text{C}$ A1 [2]
- (iii) 1. $48 \mu\text{C}$ A1
2. $24 \mu\text{C}$ A1 [2]
- 8 (a) (i) gain = voltage output / voltage input B1 [1]
- (ii) changes in V_{OUT} occur immediately when V_{IN} changes M1
A1
- or*
- changes in V_{IN} result in immediate changes to V_{OUT} (M1)
(A1) [2]
- (b) $12 = 1 + R/(1.5 \times 10^3)$ C1
 $R = 16.5 \text{ k}\Omega$ A1 [2]
- (c) straight line from (0,0) to (0.75 t_1 , 9.0V) B1
horizontal line from endpoint of straight line to t_1 B1
+9V to -9V (or v.v.) at t_1 B1
correct line to t_2 B1 [4]

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- 9 (a) (i) number density of charge carriers/free electrons
or
number per unit volume of charge carriers/free electrons B1 [1]
- (ii) PX or QY or RZ B1 [1]
- (b) (i) V_H is inversely proportional to n B1
for semiconductors, n is (much) smaller than for metals B1 [2]
- (ii) magnetic field would deflect holes and electrons in same direction B1
(because) electrons are (-)ve, holes are (+)ve M1
so V_H has opposite polarity/opposite sign A1 [3]
- 10 (a) iron rod changes flux (density)/field B1
change of flux in coil Q causes induced e.m.f. B1 [2]
- (b) constant reading (either polarity) from time zero to near t_1 B1
spike in one direction near t_1 clearly showing a larger voltage M1
of opposite polarity A1
zero reading from near t_1 to t_2 B1 [4]
- 11 (a) point P shown at 'lower end' of load B1 [1]
- (b) $V_{r.m.s.} = 6.0/\sqrt{2} = 4.24\text{ V}$ C1
 $I_{r.m.s.} = 4.24/(2.4 \times 10^3)$
 $= 1.8 \times 10^{-3}\text{ A}$ A1 [2]
- (c) (i) capacitor in parallel with load B1 [1]
- (ii) line from peak to curve at 3.0V for either half- or full-wave rectified M1
correct curvature on line (gradient becoming more shallow) A1
line drawn as for full-wave rectified A1 [3]

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- 12 (a) (i)** (X-ray) photon produced when electron/charged particle is stopped/accelerated (suddenly) B1
- range of accelerations (in target) M1
- hence distribution of wavelengths A1 [3]
- (ii)** electron gives all its energy to one photon B1
- electron stopped in single collision B1 [2]
- (iii)** de-excitation of (orbital) electrons in target/anode/metal B1 [1]
- (b) (i)** aluminium sheet/filter/foil (placed in beam from tube) B1 [1]
- (ii)** (long wavelength X-rays) do not pass through the body B1 [1]
- 13 (a)** (photons of) electromagnetic radiation M1
- emitted from nuclei A1 [2]
- (b)** line of best fit drawn B1
- recognises μ as given by the gradient of best-fit line
- or*
- $\ln C = \ln C_0 - \mu x$ B1
- $\mu = 0.061 \text{ mm}^{-1}$ (within $\pm 0.004 \text{ mm}^{-1}$, 1 mark; within $\pm 0.002 \text{ mm}^{-1}$, 2 marks) A2 [4]
- (c)** aluminium is less absorbing (than lead)
- or*
- gradient of graph would be less M1
- so μ is smaller A1 [2]