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**PHYSICS**

**9702/42**

Paper 4 A Level Structured Questions

**May/June 2016**

MARK SCHEME

Maximum Mark: 100

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**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  $6.02 \times 10^{23}$ ) 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  $150 \text{ mol}$  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)  
 $96 \text{ dB} > 2 \times 45 \text{ dB}$  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<sup>-1</sup> (M1)  
 $2.2 \text{ dB km}^{-1} > 2.0 \text{ dB km}^{-1}$  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)**  $F_{\text{E}} = (1.6 \times 10^{-19})^2 / 4\pi\epsilon_0 x^2$  C1  
 $F_{\text{G}} = G \times (1.67 \times 10^{-27})^2 / x^2$  C1  
 $F_{\text{E}} / F_{\text{G}} = (1.6 \times 10^{-19})^2 \times (8.99 \times 10^9) / [(1.67 \times 10^{-27})^2 \times (6.67 \times 10^{-11})]$   
 $= 1.2 (1.24) \times 10^{36}$  A1 [3]
- (ii)**  $F_{\text{E}} \gg F_{\text{G}}$  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)  $Q = CV$   
 $= 4.0 \times 10^{-6} \times 12$  C1
- $= 48\ \mu\text{C}$  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  $V_{\text{OUT}}$   
occur immediately when  $V_{\text{IN}}$  changes M1  
A1
- or*
- changes in  $V_{\text{IN}}$  (M1)  
result in immediate changes to  $V_{\text{OUT}}$  (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 $t_1$ , 9.0 V) B1
- horizontal line from endpoint of straight line to  $t_1$  B1
- +9 V to –9 V (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 3.0 V 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  $\mu$  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  $\mu$  is smaller A1 [2]