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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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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

$d = 7.0 \times 10^7$ 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

$= 2.0 \times 10^{29}$ 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 $n = 149$ 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 mol) and correct substitution into $pV = nRT$ — (C1)

pressure $= 1.9 \times 10^7$ 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 $= \frac{1}{2}m\omega^2 x_0^2$ 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)** $24 = 10 \lg (P_{MIN} / \{5.0 \times 10^{-13}\})$ C1

$P_{MIN} = 1.3\ (1.26) \times 10^{-10}$ W A1 [2]

(ii) $45 \times 2 = 10 \lg (\{500 \times 10^{-3}\} / P)$

$P = 5.0 \times 10^{-10}$ (W) M1

$P > P_{MIN}$ 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 <u>appear</u> to come from centre A1 [2]

(b) **(i)** $F_E = (1.6 \times 10^{-19})^2 / 4\pi\varepsilon_0 x^2$ C1

$F_G = G \times (1.67 \times 10^{-27})^2 / x^2$ C1

$F_E / F_G = (1.6 \times 10^{-19})^2 \times (8.99 \times 10^9) / [(1.67 \times 10^{-27})^2 \times (6.67 \times 10^{-11})]$
$= 1.2\ (1.24) \times 10^{36}$ 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

$C = 24\,\mu F$ A1 [2]

(ii) $Q = CV$
$= 4.0 \times 10^{-6} \times 12$ C1

$= 48\,\mu C$ A1 [2]

(iii) **1.** $48\,\mu C$ A1

2. $24\,\mu C$ A1 [2]

8 **(a)** **(i)** gain = <u>voltage</u> output / <u>voltage</u> input B1 [1]

(ii) changes in V_{OUT} M1
occur immediately when V_{IN} changes A1

or

changes in V_{IN} (M1)
result in immediate changes to V_{OUT} (A1) [2]

(b) $12 = 1 + R/(1.5 \times 10^3)$ C1

$R = 16.5\,k\Omega$ A1 [2]

(c) straight line from (0,0) to ($0.75t_1$, 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/<u>free</u> electrons *or* number per unit volume of charge carriers/<u>free</u> 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 <u>flux</u> <u>in coil Q</u> 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)		$V_{r.m.s.} = 6.0 / \sqrt{2} = 4.24\,V$	C1	
			$I_{r.m.s.} = 4.24 / (2.4 \times 10^3)$ $= 1.8 \times 10^{-3}\,A$	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) <u>photon</u> 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]

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