

MARK SCHEME for the May/June 2013 series

9702 PHYSICS

9702/41

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

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Section A

- 1 (a) region of space area / volume where a mass experiences a force B1 B1 [2]
- (b) (i) force proportional to product of two masses M1
force inversely proportional to the square of their separation M1
either reference to point masses *or* separation \gg 'size' of masses A1 [3]
- (ii) field strength = GM / x^2 **or** field strength $\propto 1 / x^2$ C1
ratio = $(7.78 \times 10^8)^2 / (1.5 \times 10^8)^2$ C1
= 27 A1 [3]
- (c) (i) *either* centripetal force = $mR\omega^2$ and $\omega = 2\pi / T$ B1
or centripetal force = mv^2 / R and $v = 2\pi R / T$ B1
gravitational force provides the centripetal force M1
either $GMm / R^2 = mR\omega^2$ *or* $GMm / R^2 = mv^2 / R$ A0 [3]
 $M = 4\pi^2 R^3 / GT^2$
(allow working to be given in terms of acceleration)
- (ii) $M = \{4\pi^2 \times (1.5 \times 10^{11})^3\} / \{6.67 \times 10^{-11} \times (3.16 \times 10^7)^2\}$ C1
= 2.0×10^{30} kg A1 [2]
- 2 (a) obeys the equation $pV = \text{constant} \times T$ *or* $pV = nRT$ M1
 p , V and T explained A1
at all values of p , V and T /fixed mass/ n is constant A1 [3]
- (b) (i) $3.4 \times 10^5 \times 2.5 \times 10^3 \times 10^{-6} = n \times 8.31 \times 300$ M1
 $n = 0.34$ mol A0 [1]
- (ii) for total mass/amount of gas
 $3.9 \times 10^5 \times (2.5 + 1.6) \times 10^3 \times 10^{-6} = (0.34 + 0.20) \times 8.31 \times T$ C1
 $T = 360$ K A1 [2]
- (c) when tap opened B1
gas passed (from cylinder B) to cylinder A M1
work done on gas in cylinder A (and no heating) A1 [3]
so internal energy and hence temperature increase

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- 3 (a) (i) 1. amplitude = 1.7 cm A1 [1]
2. period = 0.36 cm C1
frequency = 1/0.36 A1 [2]
= 2.8 Hz
- (ii) $a = (-)\omega^2 x$ and $\omega = 2\pi/T$ C1
acceleration = $(2\pi/0.36)^2 \times 1.7 \times 10^{-2}$ M1
= 5.2 ms^{-2} A0 [2]
- (b) graph: straight line, through origin, with negative gradient M1
from $(-1.7 \times 10^{-2}, 5.2)$ to $(1.7 \times 10^{-2}, -5.2)$ A1 [2]
(if scale not reasonable, do not allow second mark)
- (c) either kinetic energy = $\frac{1}{2}m\omega^2(x_0^2 - x^2)$ B1
or potential energy = $\frac{1}{2}m\omega^2 x^2$ and potential energy = kinetic energy C1
 $\frac{1}{2}m\omega^2(x_0^2 - x^2) = \frac{1}{2} \times \frac{1}{2}m\omega^2 x_0^2$ or $\frac{1}{2}m\omega^2 x^2 = \frac{1}{2} \times \frac{1}{2}m\omega^2 x_0^2$
 $x_0^2 = 2x^2$
 $x = x_0 / \sqrt{2} = 1.7 / \sqrt{2}$
= 1.2 cm A1 [3]
- 4 (a) work done moving unit positive charge M1
from infinity (to the point) A1 [2]
- (b) (gain in) kinetic energy = change in potential energy B1
 $\frac{1}{2}mv^2 = qV$ leading to $v = (2Vq/m)^{1/2}$ B1 [2]
- (c) either $(2.5 \times 10^5)^2 = 2 \times V \times 9.58 \times 10^7$ C1
 $V = 330 \text{ V}$ M1
this is less than 470 V and so 'no' A1 [3]
- or $v = (2 \times 470 \times 9.58 \times 10^7)$ (C1)
 $v = 3.0 \times 10^5 \text{ ms}^{-1}$ (M1)
this is greater than $2.5 \times 10^5 \text{ ms}^{-1}$ and so 'no' (A1)
- or $(2.5 \times 10^5)^2 = 2 \times 470 \times (q/m)$ (C1)
 $(q/m) = 6.6 \times 10^7 \text{ C kg}^{-1}$ (M1)
this is less than $9.58 \times 10^7 \text{ C kg}^{-1}$ and so 'no' (A1)

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- 5 (a) (uniform magnetic) flux normal to long (straight) wire carrying a current of 1 A (creates) force per unit length of 1 N m^{-1} M1 A1 [2]
- (b) (i) flux density $= 4\pi \times 10^{-7} \times 1.5 \times 10^3 \times 3.5$
 $= 6.6 \times 10^{-3} \text{ T}$ C1 A1 [2]
- (ii) flux linkage $= 6.6 \times 10^{-3} \times 28 \times 10^{-4} \times 160$
 $= 3.0 \times 10^{-3} \text{ Wb}$ C1 A1 [2]
- (c) (i) (induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage) M1 A1 [2]
- (ii) e.m.f. $= (2 \times 3.0 \times 10^{-3}) / 0.80$
 $= 7.4 \times 10^{-3} \text{ V}$ C1 A1 [2]
- 6 (a) (i) to reduce power loss in the core due to eddy currents/induced currents B1 B1 [2]
- (ii) *either* no power loss in transformer
or input power = output power B1 [1]
- (b) *either* r.m.s. voltage across load $= 9.0 \times (8100 / 300)$
peak voltage across load $= \sqrt{2} \times 243$
 $= 340 \text{ V}$ C1 A1 [2]
- or* peak voltage across primary coil $= 9.0 \times \sqrt{2}$
peak voltage across load $= 12.7 \times (8100/300)$
 $= 340 \text{ V}$ (C1) (A1)
- 7 (a) (i) lowest frequency of e.m. radiation giving rise to emission of electrons (from the surface) M1 A1 [2]
- (ii) $E = hf$ C1
threshold frequency $= (9.0 \times 10^{-19}) / (6.63 \times 10^{-34})$
 $= 1.4 \times 10^{15} \text{ Hz}$ A1 [2]
- (b) *either* $300 \text{ nm} \equiv 10 \times 10^{15} \text{ Hz}$ (and $600 \text{ nm} \equiv 5.0 \times 10^{14} \text{ Hz}$)
or $300 \text{ nm} \equiv 6.6 \times 10^{-19} \text{ J}$ (and $600 \text{ nm} \equiv 3.3 \times 10^{-19} \text{ J}$)
or zinc $\lambda_0 = 340 \text{ nm}$, platinum $\lambda_0 = 220 \text{ nm}$ (and sodium $\lambda_0 = 520 \text{ nm}$)
emission from sodium and zinc M1 A1 [2]
- (c) each photon has larger energy M1
fewer photons per unit time M1
fewer electrons emitted per unit time A1 [3]

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- 8 (a) two (light) nuclei combine to form a more massive nucleus M1
A1 [2]
- (b) (i) $\Delta m = (2.01410 \text{ u} + 1.00728 \text{ u}) - 3.01605 \text{ u}$
 $= 5.33 \times 10^{-3} \text{ u}$
energy $= c^2 \times \Delta m$ C1
 $= 5.33 \times 10^{-3} \times 1.66 \times 10^{-27} \times (3.00 \times 10^8)^2$ C1
 $= 8.0 \times 10^{-13} \text{ J}$ A1 [3]
- (ii) speed/kinetic energy of proton and deuterium must be very large so that the nuclei can overcome electrostatic repulsion B1
B1 [2]

Section B

- 9 (a) (i) light-dependent resistor/LDR B1 [1]
- (ii) strain gauge B1 [1]
- (iii) quartz/piezo-electric crystal B1 [1]
- (b) (i) resistance of thermistor decreases as temperature increases M1
either $V_{\text{OUT}} = V \times R / (R + R_T)$
or current increases and $V_{\text{OUT}} = IR$ A1
 V_{OUT} increases A1 [3]
- (ii) *either* change in R_T with temperature is non-linear
or V_{OUT} is not proportional to R_T / change in V_{OUT} with R_T is non-linear
so change is non-linear M1
A1 [2]
- 10 (a) sharpness: how well the edges (of structures) are defined B1
contrast: difference in (degree of) blackening between structures B1 [2]
- (b) e.g. scattering of photos in tissue/no use of a collimator/no use of lead grid
large penumbra on shadow/large area anode/wide beam
large pixel size
(any two sensible suggestions, 1 each) B2 [2]
- (c) (i) $I = I_0 e^{-\mu x}$ C1
ratio $= \exp(-2.85 \times 3.5) / \exp(-0.95 \times 8.0)$ C1
 $= (4.65 \times 10^{-5}) / (5.00 \times 10^{-4})$
 $= 0.093$ A1 [3]
- (ii) *either* large difference (in intensities)
or ratio much less than 1.0
so good contrast M1
A1 [2]
- (answer given in (c)(ii) must be consistent with ratio given in (c)(i))

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- 11 (a) (i) amplitude of the carrier wave varies
(in synchrony) with the displacement of the information signal M1
A1 [2]
- (ii) e.g. more than one radio station can operate in same region/less interference
enables shorter aerial
increased range/less power required/less attenuation
less distortion
(any two sensible answers, 1 each) B2 [2]
- (b) (i) frequency = 909 kHz C1
wavelength = $(3.0 \times 10^8) / (909 \times 10^3)$
= 330 m A1 [2]
- (ii) bandwidth = 18 kHz A1 [1]
- (iii) frequency = 9000 Hz A1 [1]
- 12 (a) for received signal, $28 = 10 \lg(P / \{0.36 \times 10^{-6}\})$ C1
 $P = 2.3 \times 10^{-4} \text{ W}$ A1 [2]
- (b) loss in fibre = $10 \lg(\{9.8 \times 10^{-3}\} / \{2.27 \times 10^{-4}\})$ C1
= 16 dB A1 [2]
- (c) attenuation per unit length = 16 / 85
= 0.19 dB km⁻¹ A1 [1]