

**MARK SCHEME for the May/June 2010 question paper**  
**for the guidance of teachers**

**9702 PHYSICS**

**9702/41**

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

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### Section A

- 1 (a) angle (subtended) at centre of circle B1  
 (by) arc equal in length to radius B1 [2]
- (b) (i) point S shown below C B1 [1]
- (ii) (max) force / tension = weight + centripetal force C1  
 centripetal force =  $m\omega^2 r$  C1  
 $15 = 3.0/9.8 \times 0.85 \times \omega^2$  C1  
 $\omega = 7.6 \text{ rad s}^{-1}$  A1 [4]
- 2 (a) (i) 27.2 + 273.15 or 27.2 + 273.2 C1  
 300.4 K A1 [2]
- (ii) 11.6 K A1 [1]
- (b) (i) ( $\langle c^2 \rangle$  is the) mean / average square speed B1 [1]
- (ii)  $\rho = Nm/V$  with N explained B1  
 so,  $pV = 1/3 Nm\langle c^2 \rangle$  B1  
 and  $pV = NkT$  with k explained B1  
 so mean kinetic energy /  $\langle E_K \rangle = 1/2 m\langle c^2 \rangle = 3/2 kT$  B1 [4]
- (c) (i)  $pV = nRT$   
 $2.1 \times 10^7 \times 7.8 \times 10^{-3} = n \times 8.3 \times 290$  C1  
 $n = 68 \text{ mol}$  A1 [2]
- (ii) mean kinetic energy =  $3/2 kT$   
 $= 3/2 \times 1.38 \times 10^{-23} \times 290$  C1  
 $= 6.0 \times 10^{-21} \text{ J}$  A1 [2]
- (iii) realisation that total internal energy is the total kinetic energy C1  
 energy =  $6.0 \times 10^{-21} \times 68 \times 6.02 \times 10^{23}$  C1  
 $= 2.46 \times 10^5 \text{ J}$  A1 [3]
- 3 (a) (i) to-and-fro / backward and forward motion (between two limits) B1 [1]
- (ii) no energy loss or gain / no external force acting / constant energy / constant amplitude B1 [1]
- (iii) acceleration directed towards a fixed point B1  
 acceleration proportional to distance from the fixed point / displacement B1 [2]
- (b) acceleration is constant (magnitude) M1  
 so cannot be s.h.m. A1 [2]

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- 4 (a) ability to do work as a result of the position/shape, etc. of an object B1 B1 [2]
- (b) (i) 1  $\Delta E_{gpe} = GMm / r$   
 $= (6.67 \times 10^{-11} \times \{2 \times 1.66 \times 10^{-27}\}^2) / (3.8 \times 10^{-15})$   
 $= 1.93 \times 10^{-49} \text{ J}$  C1 C1 A1 [3]
- 2  $\Delta E_{epe} = Qq / 4\pi\epsilon_0 r$   
 $= (1.6 \times 10^{-19})^2 / (4\pi \times 8.85 \times 10^{-12} \times 3.8 \times 10^{-15})$   
 $= 6.06 \times 10^{-14} \text{ J}$  C1 C1 A1 [3]
- (ii) idea that  $2E_K = \Delta E_{epe} - \Delta E_{gpe}$   
 $E_K = 3.03 \times 10^{-14} \text{ J}$   
 $= (3.03 \times 10^{-14}) / 1.6 \times 10^{-13}$   
 $= 0.19 \text{ MeV}$  B1 M1 A0 [2]
- (iii) fusion may occur / may break into sub-nuclear particles B1 [1]
- 5 (a) (i)  $V_H$  depends on angle between (plane of) probe and  $B$ -field B1  
either  $V_H$  max when plane and  $B$ -field are normal to each other  
or  $V_H$  zero when plane and  $B$ -field are parallel  
or  $V_H$  depends on sine of angle between plane and  $B$ -field B1 [2]
- (ii) 1 calculates  $V_H r$  at least three times M1  
to 1 s.f. constant so valid or approx constant so valid  
or to 2 s.f., not constant so invalid A1 [2]
- 2 straight line passes through origin B1 [1]
- (b) (i) e.m.f. induced is proportional / equal to M1  
rate of change of (magnetic) flux (linkage) A1  
constant field in coil / flux (linkage) of coil does not change B1 [3]
- (ii) e.g. vary current (in wire) / switch current on or off / use a.c. current  
rotate coil  
move coil towards / away from wire (1 mark each, max 3) B3 [3]
- 6 (a) all four diodes correct to give output, regardless of polarity M1  
connected for correct polarity A1 [2]
- (b)  $N_S / N_P = V_S / V_P$  C1  
 $V_0 = \sqrt{2} \times V_{rms}$  C1  
ratio  $= 9.0 / (\sqrt{2} \times 240)$   
 $= 1/38$  or  $1/37$  or  $0.027$  A1 [3]

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- 7 (a) arrow pointing up the page B1 [1]
- (b) (i)  $Eq = Bqv$  C1  
 $v = (12 \times 10^3) / (930 \times 10^{-6})$  C1  
 $= 1.3 \times 10^7 \text{ m s}^{-1}$  A1 [3]
- (ii)  $Bqv = mv^2 / r$  C1  
 $q/m = (1.3 \times 10^7) / (7.9 \times 10^{-2} \times 930 \times 10^{-6})$  C1  
 $= 1.8 \times 10^{11} \text{ C kg}^{-1}$  A1 [3]
- 8 (a) momentum conservation hence momenta of photons are equal (but opposite) M1  
same momentum so same energy A1 [2]
- (b) (i)  $(\Delta)E = (\Delta)mc^2$  C1  
 $= 1.2 \times 10^{-28} \times (3.0 \times 10^8)^2$   
 $= 1.08 \times 10^{-11} \text{ J}$  A1 [2]
- (ii)  $E = hc / \lambda$   
 $\lambda = (6.63 \times 10^{-34} \times 3.0 \times 10^8) / (1.08 \times 10^{-11})$  C1  
 $= 1.84 \times 10^{-14} \text{ m}$  A1 [2]
- (iii)  $\lambda = h / p$   
 $p = (6.63 \times 10^{-34}) / (1.84 \times 10^{-14})$  C1  
 $= 3.6 \times 10^{-20} \text{ N s}$  A1 [2]

### Section B

- 9 (a) (i) point X shown correctly B1 [1]
- (ii) op-amp has very large / infinite gain M1  
non-inverting input is at earth (potential) / earthed / at 0 V M1  
if amplifier is not to saturate, inverting input must be (almost)  
at earth potential / 0 (V) same potential as inverting input A1 [3]
- (b) (i) total input resistance = 1.2 k $\Omega$  C1  
(amplifier) gain (=  $-4.2 / 1.2$ ) =  $-3.5$  C1  
(voltmeter) reading =  $-3.5 \times -1.5$   
= 5.25 V A1 [3]  
(total disregard of signs or incorrect sign in answer, max 2 marks)
- (ii) (less bright so) resistance of LDR increases M1  
(amplifier) gain decreases M1  
(voltmeter) reading decreases A1 [3]

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- 10 (a) X-ray taken of slice / plane / section B1  
repeated at different angles B1  
images / data is processed B1  
combined / added to give (2-D) image of slice B1  
repeated for successive slices B1  
to build up a 3-D image B1  
image can be viewed from different angles / rotated B1  
max 6 [6]
- (b) (i) 16 A1 [1]
- (ii) evidence of deducting 16 then dividing by 3 to give C1  
A1 [2]
- |   |   |
|---|---|
| 3 | 2 |
| 6 | 5 |
- 11 (a) frequency of carrier wave varies (in synchrony) with signal M1  
(in synchrony) with displacement of signal A1 [2]
- (b) advantages e.g. less noise / less interference  
greater bandwidth / better quality  
(1 each, max 2)  
disadvantages e.g. short range / more transmitters / line of sight  
more complex circuitry  
greater expense  
(1 each, max 2) B4 [4]
- 12 (a) gain / loss/dB =  $10 \lg(P_1/P_2)$  C1  
 $190 = 10 \lg(18 \times 10^3 / P_2)$   
or  $-190 = 10 \lg P_2 / 18 \times 10^3$  C1  
power =  $1.8 \times 10^{-15}$  W A1 [3]
- (b) (i) 11 GHz / 12 GHz B1 [1]
- (ii) e.g. so that input signal to satellite will not be 'swamped'  
to avoid interference of uplink with / by downlink B1 [1]