

## **MARK SCHEME for the October/November 2015 series**

### **9702 PHYSICS**

**9702/42**

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

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### Section A

- 1 (a) (i) gravitational force provides/is the centripetal force B1
- $GMm_S/x^2 = m_S v^2/x$  (allow  $x$  or  $r$ ; allow  $m$  or  $m_S$ ) M1
- $E_K = \frac{1}{2}m_S v^2$  and clear algebra leading to  $E_K = GMm_S/2x$  A1 [3]
- (ii)  $E_P = -GMm_S/x$  (sign essential) B1 [1]
- (iii)  $E_T = E_K + E_P$   
 $= GMm_S/2x - GMm_S/x$  C1  
 $= -GMm_S/2x$  (allow ECF from (a)(ii)) A1 [2]
- (b) (i) decreases B1 [1]
- (ii) decreases B1 [1]
- (iii) decreases B1 [1]
- (iv) increases B1 [1]
- (for answers in (b) allow ECF from (a)(iii))
- 2 (a) obeys the equation  $pV = nRT$  or  $pV/T = \text{constant}$  M1  
all symbols explained;  $T$  in kelvin/thermodynamic temperature A1 [2]
- (b) (i) temperature rise = 48 K A1 [1]
- (ii)  $\langle c^2 \rangle \propto T$  or equivalent C1  
 $\langle c^2 \rangle = (353/305) \times 1.9 \times 10^6$  C1  
 $c_{r.m.s.} = 1480 \text{ m s}^{-1}$  A1 [3]
- 3 (a) heat/thermal energy gained by system or energy transferred to system by heating B1  
plus work done on the system or minus work done by the system B1 [2]
- (b) (i) either volume decreases so work done on the system M1  
or small volume change so work done on system negligible M1  
(thermal) energy absorbed to break lattice structure A1 [3]  
internal energy increases
- (ii) gas expands so work done by gas (against atmosphere) M1  
no time for thermal energy to enter or leave the gas M1  
internal energy decreases A1 [3]
- 4 (a) free: (body oscillates) without any loss of energy/no resistive forces/no external forces applied B1  
forced: continuous energy input (required)/body is made to vibrate by an (external) periodic force/driving oscillator B1 [2]

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	(b) (i) idea of resonance	B1	
	maximum amplitude at natural frequency	B1	
	frequency = 2.1 Hz ( <i>allow 2.08 to 2.12 Hz</i> )	B1	[3]
	(ii) peak not very sharp/amplitude not infinite so frictional forces are present	B1	[1]
	(c) $v = \omega x_0$	C1	
	$= 2\pi \times 2.1 \times 4.7 \times 10^{-2}$ ( <i>allow ECF from (b)(i)</i> )	A1	[2]
	$= 0.62 \text{ ms}^{-1}$		
5	(a) (i) force proportional to the product of the two/point charges and inversely proportional to the square of their separation	B1	
		B1	[2]
	(ii) 1. force radially away from sphere/to right/to east	B1	[1]
	2. (maximum) at/on surface of sphere or $x = r$	B1	[1]
	3. $F \propto 1/x^2$ or $F = q_1 q_2 / (4\pi \epsilon_0 x^2)$	C1	
	ratio = 16	A1	[2]
	(b) $E = q / (4\pi \epsilon_0 x^2)$ or $E \propto q$	C1	
	maximum charge = $(2.0 / 1.5) \times 6.0 \times 10^{-7}$	C1	
	$= 8.0 \times 10^{-7} \text{ C}$		
	additional charge = $2.0 \times 10^{-7} \text{ C}$	A1	[3]
6	(a) (i) force = $mg$	M1	
	along the direction of the field/of the motion	A1	[2]
	(ii) no force	B1	[1]
	(b) (i) force due to $E$ -field downwards so force due to $B$ -field upwards into the plane of the paper	B1	
		B1	[2]
	(ii) force due to magnetic field = $Bqv$	B1	
	force due to electric field = $Eq$	B1	
	( <i>use of <math>F_B</math> and <math>F_E</math> not explained, allow 1/2</i> )		
	forces are equal (and opposite) so $Bv = E$ or $Eq = Bqv$ so $E = Bv$	B1	[3]
	(c) sketch: smooth curved path in 'upward' direction	M1	
		A1	[2]
7	(a) minimum frequency of e.m. radiation/a photon (not "light") for emission of electrons from a surface	M1	
	( <i>reference to light/UV rather than e.m. radiation, allow 1/2</i> )	A1	[2]

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- (b)  $E_{\text{MAX}}$  corresponds to electron emitted from surface  
electron (below surface) requires energy to bring it to surface, so less than  $E_{\text{MAX}}$  B1  
B1 [2]
- (c) (i)  $1/\lambda_0 = 1.85 \times 10^6$  (allow 1.82 to 1.88) C1
- $$f_0 = c/\lambda_0$$
- $$= 3.00 \times 10^8 \times 1.85 \times 10^6$$
- $$= 5.55 \times 10^{14} \text{ Hz}$$
- A1 [2]
- (ii)  $\Phi = hf_0$   
 $= 6.63 \times 10^{-34} \times 5.55 \times 10^{14}$  (allow ECF from (c)(i)) C1  
 $= 3.68 \times 10^{-19} \text{ J}$  A1 [2]
- (d) sketch: straight line with same gradient M1  
intercept between 1.0 and 1.5 A1 [2]
- 8 (a) nucleus: small central part/core of an atom B1  
nucleon: proton or a neutron B1  
particle contained within a nucleus B1 [3]
- (b) (i) 1. decay constant  $= \ln 2 / (3.8 \times 24 \times 3600)$  C1  
 $= 2.1 \times 10^{-6} \text{ s}^{-1}$  A1 [2]
2.  $A = \lambda N$   
 $97 = 2.1 \times 10^{-6} \times N$  C1  
 $N = 4.6 \times 10^7$  A1 [2]
- (ii)  $1.0 \text{ m}^3$  contains  $(6.02 \times 10^{23}) / (2.5 \times 10^{-2})$  air molecules C1
- $$\text{ratio} = (4.6 \times 10^7 \times 2.5 \times 10^{-2}) / (6.02 \times 10^{23})$$
- $$= 1.9 \times 10^{-18}$$
- A1 [2]

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### Section B

- 9 (a) (i)** (+) 3.0V B1 [1]
- (ii)** potential =  $6.0 \times \{2.0 / (2.0 + 2.8)\}$   
= 2.5V C1  
A1 [2]
- (iii)** potential =  $6.0 \times \{2.0 / (2.0 + 1.8)\}$   
= 3.2V A1 [1]
- (b)** at 10°C,  $V_A > V_B$  M1  
 $V_{OUT}$  is -9.0V (allow "negative saturation") A1
- at 20°C,  $V_{OUT}$  is +9.0V B1  
(if 20°C considered initially, mark as M1,A1,B1)
- sudden switch (from -9V to +9V) when  $V_A = V_B$  B1 [4]
- 10 (a)** sharpness: clarity of edges/resolution (of image) B1  
contrast: difference in degree of blackening (of structures) B1 [2]
- (b) (i)** X-rays produced when (high speed) electrons hit target/anode B1  
*either* electrons have been accelerated through 80kV  
*or* electrons have (kinetic) energy of 80keV B1 [2]
- (ii)**  $I_T/I = e^{-3.0 \times 1.4}$  C1  
= 0.015 A1 [2]
- (c)** for good contrast,  $\mu_X$  or  $e^{\mu_X}$  or  $e^{-\mu_X}$  must be very different B1  
 $\mu_X$  or  $e^{\mu_X}$  or  $e^{-\mu_X}$  for bone and muscle will be different than that for muscle M1  
so good contrast A1 [3]
- 11 (a)** frequency of carrier wave varies M1  
in synchrony with the displacement of the signal/information wave A1 [2]
- (b) (i)** 5.0V A1 [1]
- (ii)** 720kHz A1 [1]
- (iii)** 780kHz A1 [1]
- (iv)** 7500 A1 [1]

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- 12 (a) (i) (gradual) loss of power/intensity/amplitude (not “signal”) B1 [1]
- (ii) e.g. noise can be eliminated (not “there is no noise”) M1  
because pulses can be regenerated A1
- e.g. much greater data handling/carrying capacity M1  
because many messages can be carried at the same time/greater bandwidth A1
- e.g. more secure (M1)  
because it can be encrypted (A1)
- e.g. error checking (M1)  
because extra information/parity bit can be added (A1) [4]
- (allow any two sensible suggestions with ‘state’ M1 and ‘explain’ A1)*
- (b) attenuation =  $10 \lg(145/29)$  (= 7.0) C1
- attenuation per unit length =  $7.0/36$   
=  $0.19 \text{ dB km}^{-1}$  A1 [2]