

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the October/November 2014 series

9702 PHYSICS

9702/21

Paper 2 (AS Structured Questions), maximum raw mark 60

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- 1 (a) temperature B1
current B1 [2]
(allow amount of substance and luminous intensity)
- (b) base units of force constant: $\text{kg m s}^{-2} \text{m}^{-1}$ or kg s^{-2} B1
base units of time and mass: s and kg C1
base units of C: $\text{s (kg s}^{-2} / \text{kg)}^{1/2}$ cancelling to show no units B1 [3]
- 2 (a) pressure = force / area (normal to the force) [clear ratio essential] B1 [1]
- (b) (i) $P = mg / A = (5.09 \times 9.81) / A$ C1
 $A = (\pi d^2 / 4) = \pi \times (9.4 \times 10^{-2})^2 / 4 (= 0.00694 \text{ m}^2)$ C1
 $P = 49.93 / 0.00694$
 $= 7200 (7195) \text{ Pa}$ (minimum of 2 s.f. required) A1 [3]
- (ii) $\Delta P / P = \Delta m / m + 2\Delta d / d$ C1
 $= 0.01 / 5.09 + (2 \times 0.1) / 9.4 (= 0.0020 + 0.021 \text{ or } 2.3\%)$ C1
 $\Delta P = 170 (165 \text{ to } 167) \text{ Pa}$ A1 [3]
- (iii) $P = 7200 \pm 200 \text{ Pa}$ A1 [1]
- 3 (a) random error (in the measurements) of the length OR resistance B1 [1]
- (b) gradient = $(3.6 - 1.9) / (0.8 - 0.4)$ C1
 $= 4.25$ A1 [2]
- (c) $R = \rho l / A$ C1
 $\rho = \text{gradient} \times \text{area} = 4.25 \times 0.12 \times 10^{-6}$ C1
 $= 5.1(0) \times 10^{-7} \Omega \text{ m}$ A1 [3]
- (d) resistance decreasing with increasing area B1
correct shape with curve being asymptote to both axes B1 [2]

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- 4 (a) (i) acceleration = $(v - u) / t$ or $(12 - 0.5) / 4$ C1
 $= (12 - 0.5) / 4 = 2.9$ (2.875) (= approximately 3 ms^{-2}) M1 [2]
- (ii) $x = (u + v)t / 2$
 $= [(12 + 0.5) \times 4] / 2$ C1
 $= 25 \text{ m}$ A1 [2]
- (iii) line with increasing gradient M1
non-zero gradient at origin A1 [2]
- (b) (i) weight down slope = $2 \times 9.81 \times \sin 25^\circ = 8.29 / 8.3$ M1 [1]
- (ii) ($F = ma$) $8.3 - F_R = 2 \times 2.9$ C1
 $F_R = 2.5$ (2.3 if 3 used for a) N A1 [2]
- 5 (a) (i) change in kinetic energy = $\frac{1}{2}mv^2$ C1
 $= 0.5 \times 25 \times (0.64)^2 = 5.1(2) \text{ J}$ A1 [2]
- (ii) zero A1 [1]
- (iii) $(-)5.1(2) \text{ J}$ A1 [1]
- (b) (i) $PE = mgh$ C1
 $= 350 \times 0.64 \times 25$ C1
 $= 5600 \text{ J}$ A1 [3]
- (If full length used allow 1/3)
- (ii) $P = Fv$ or gain in PE / t , E_p / t or work done / t , W / t C1
 $= 350 \times 0.64$ or $5600 / 25$
 $= 220$ (224) W A1 [2]
- 6 melting: solid to liquid B1
at a specific/one temperature/at the melting point B1
- evaporation: liquid to vapour/gas OR molecules escape from surface of liquid B1
at all temperatures B1 [4]

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- 7 (a) due to the lost volts in internal resistance / cell or energy losses in the internal resistance / cell B1 [1]
- (b) (i) $V = IR$ C1
 $= 1.2 \times 6 = 7.2 \text{ V}$ A1 [2]
- (ii) p.d. across Y and internal resistance $r = 4.8 \text{ (V)}$ [12 – 7.2] C1
resistance of Y + $r = 4.8 / 1.2 = 4 \text{ (}\Omega\text{)}$ C1
resistance of Y = $4 - 0.5 = 3.5 \text{ }\Omega$ A1 [3]
or
 $R_{\text{total}} = 12 / 1.2 = 10 \text{ (}\Omega\text{)}$ (C1)
 $X + r = 6.5 \text{ (}\Omega\text{)}$ (C1)
resistance of Y = $3.5 \text{ }\Omega$ (A1)
- (iii) $P = I^2 r$ C1
 $= (1.2)^2 \times 0.5 = 0.72 \text{ W}$ A1 [2]
- (c) terminal p.d. increases as R is increased B1 [1]
current decreases so there are less lost volts
- 8 (a) two waves (of the same kind) travelling in opposite directions overlap B1
waves have same frequency / wavelength and speed B1 [2]
- (b) (i) $T = 0.8 \text{ (ms)}$ C1
 $f = 1 / (0.8 \times 10^{-3}) = 1250 \text{ (Hz)}$ A1 [2]
- (ii) microphone is moved from plate to loudspeaker or vice versa B1
wavelength is the twice the distance between adjacent maxima or minima (seen on c.r.o.) B1 [2]
- (iii) $v = f\lambda$ C1
 $= 1250 \times 0.26$
 $= 330 \text{ (325) ms}^{-1}$ A1 [2]

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- 1 (a) stress = Young modulus $\times$ strain
- $$= 1.8 \times 10^{11} \times 8.2 \times 10^{-4} \text{ or } 1.476 \times 10^8$$
- C1
- $$= 0.15 \text{ (0.148) GPa}$$
- A1 [2]
- (b) (i) wavelength = $3 \times 10^8 / 12 \times 10^{12}$
- $$= 25 \mu\text{m}$$
- C1
A1 [2]
- (ii) infra-red / IR
- B1 [1]
- (c) (i) arrow drawn up to the left of 7.5 N force
approximately 5° to 40° to west of north
- A1 [1]
- (ii) 1. correct vector triangle or working to show
magnitude of resultant force = 6.6 N
allow 6.5 to 6.7 N if scale diagram
- M1 [1]
2. magnitude of acceleration = $6.6 / 0.75$
[scale diagram: $(6.5 \text{ to } 6.7) / 0.75$]
- C1
- $$= 8.8 \text{ ms}^{-2} \text{ [scale diagram: } 8.7 - 8.9 \text{ ms}^{-2}]$$
- A1 [2]
- (iii) 19° [use of scale diagram allow 17° to 21° (a diagram must be seen)]
- B1 [1]
- 2 (a) (i) straight line from $t = 0.60 \text{ s}$ to $t = 1.2 \text{ s}$ and $|V_v| = 5.9$ at $t = 1.2 \text{ s}$
 $V_v = -5.9$ at $t = 1.2 \text{ s}$ i.e. line is for negative values of V_v
- M1
A1 [2]
- (ii) $s = 0 + \frac{1}{2} \times 9.81 \times (0.6)^2$ or area of graph = $(5.9 \times 0.6) / 2$
- C1
- $$= 1.8 \text{ (1.77) m} \qquad \qquad \qquad = 1.8 \text{ (1.77) m}$$
- A1 [2]
- (iii) $V_h = V \cos 60^\circ$ and $V_v = V \sin 60^\circ$ or $V_h = 5.9 / \tan 60^\circ$ or $V_h = 5.9 \tan 30^\circ$
- C1
- $$V_h = 3.4 \text{ ms}^{-1}$$
- A1 [2]
- (iv) horizontal line at 3.4 from $t = 0$ to $t = 1.2 \text{ s}$ [to half a small square]
- B1 [1]
- (b) (i) $\text{KE} = \frac{1}{2}mv^2$
- C1
- $$= \frac{1}{2} \times 0.65 \times (6.81)^2 \quad \text{[allow if valid method to find } v]$$
- C1
- $$= 15 \text{ (15.1) J}$$
- A1 [3]
- (ii) $\text{PE} = 0.65 \times 9.81 \times 1.77$
- C1
- $$= 11 \text{ (11.3) J}$$
- A1 [2]

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- 3 (a) electric field strength is force per unit positive charge B1 [1]
- (b) mass = volume $\times$ density (any subject, allow usual symbols or defined symbols) C1
- $$= \frac{4}{3} \times \pi \times (1.2 \times 10^{-6})^3 \times 930 (= 6.73 \times 10^{-15})$$
- weight = $\frac{4}{3} \times \pi \times (1.2 \times 10^{-6})^3 \times 930 \times 9.81 = 6.6 \times 10^{-14} \text{ N}$ M1 [2]
- (c) (i) $E = 1.9 \times 10^3 / 14 \times 10^{-3}$ C1
 $= 1.4 (1.36) \times 10^5 \text{ V m}^{-1}$ A1 [2]
- (ii) $F = QE$
- $$Q = 6.6 \times 10^{-14} / 1.36 \times 10^5$$
- $$= 4.9 (4.86) \times 10^{-19} \text{ C [allow } 4.7 \times 10^{-19} \text{ C if } 1.4 \times 10^5 \text{ used]}$$
- C1 A1 [2]
- (iii) electric force increases/is greater (than weight) B1
charge (on S) is negative to give resultant/net/sum/total force up B1 [2]
- 4 (a) (i) solid: (molecules) vibrate B1
no translational motion/fixed position, liquid: translational motion B1 [2]
- (ii) gas: molecules have random (and translational) motion B1 [1]
- (b) (i) ductile: straight line through origin then curving towards x-axis B1 [1]
- (ii) brittle: straight line through origin with no or negligible curved region B1 [1]
- (c) similarity: obey Hooke's law / $F \propto x$ or have elastic regions B1
- difference: brittle no or (very) little plastic region
ductile has (large(r)) plastic region B1 [2]
- 5 (a) (i) in series $2X$ or in parallel $X/2$ M1
other relationship given and $4\times$ greater in series (than in parallel) A1 [2]
- (ii) due to the internal resistance B1
- total resistance for series circuit is not four times greater than resistance for parallel circuit B1 [2]
- (iii) 1. $E = I_1(2X + r)$ or $12 = 1.2(2X + r)$ A1
2. $E = I_2(X/2 + r)$ or $12 = 3.0(X/2 + r)$ A1 [2]
- (iv) $2X + r = 10$ and $X/2 + r = 4$
 $X = 4.0 \Omega$ A1 [1]

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- (b) $P = I^2 R$ or V^2 / R or VI C1
- ratio = $[(1.2)^2 \times 4] / [(1.5)^2 \times 4]$
= 0.64 A1 [2]
- (c) the resistance (of a lamp) changes with V or I B1
- V or I is greater in parallel circuit or circuit 2
or V or I is less in series circuit or circuit 1 B1 [2]
- 6 (a) difference: vibration / oscillation (of particles) / displacement of particles is parallel to energy transfer / wavefronts in longitudinal and perpendicular for transverse B1
or
transverse can be polarised, longitudinal cannot be polarised
- similarity: both transfer / propagate energy B1 [2]
- (b) (i) waves from slits are coherent / constant phase relationship (B1)
waves overlap (at screen) with a phase difference or have a path difference (B1)
maxima where phase difference is integer $\times 360^\circ$ (or $\times 2\pi$ rad)
or path difference is integer $\times \lambda$
or equivalent explanation of minima e.g. $(n + \frac{1}{2}) \times 360^\circ$ (B1)
max. 2 [2]
- (ii) maxima spacing = $\lambda D / a$ C1
= $(6.3 \times 10^{-7} \times 2.5) / 0.35 \times 10^{-3}$
= $4.5 \times 10^{-3} \text{ m}$ A1 [2]
- (c) (ultra-violet has) shorter wavelength, hence smaller separation / distance A1 [1]
- 7 (a) (i) A: 206, nucleon(s) or neutron(s) and proton(s) }
B: 82, proton(s) } all correct A1 [1]
- (ii) kinetic / E_K / KE B1 [1]
- (b) energy = $5.3 \times 1.6 \times 10^{-13} \text{ (J)}$ [= $8.48 \times 10^{-13} \text{ (J)}$] C1
- power = $(7.1 \times 10^{18} \times 5.3 \times 1.6 \times 10^{-13}) / (3600 \times 24)$
= 70 (69.7) W A1 [2]

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- 1 (a) ampere
kelvin
(allow mole and candela) B1
B1 [2]
- (b) (i) stress: N m^{-2}
 $\text{kg m s}^{-2} / \text{m}^2 = \text{kg m}^{-1} \text{s}^{-2}$ C1
A1 [2]
- (ii) Young modulus = stress/strain and strain has no units
hence units: $\text{kg m}^{-1} \text{s}^{-2}$ B1 [1]
- 2 (a) (i) amplitude scale reading 2.2 (cm)
amplitude = $2.2 \times 2.5 = 5.5 \text{ mV}$ C1
A1 [2]
- (ii) time period scale reading = 3.8 (cm) C1
time period = $3.8 \times 0.5 \times 10^{-3} = 0.0019 \text{ (s)}$ C1
frequency $f = 1 / 0.0019 = 530 \text{ (526) Hz}$ A1 [3]
- (iii) uncertainty in reading = ± 0.2 in 3.8 (cm) or 5.3% or 0.2 in 7.6 (cm)
or 2.6% [allow other variations of the distance on the x-axis] M1
actual uncertainty = 5.3% of 526 = 27.7 or 28 Hz
or 2.6% of 526 = 13 or 14 A1 [2]
- (b) frequency = $530 \pm 30 \text{ Hz}$ or $530 \pm 10 \text{ Hz}$ A1 [1]
- 3 (a) displacement/velocity/acceleration/momentum/etc.
three correct (none wrong) 2, two correct (none or one wrong) 1 A2 [2]
- (b) (i) $Y = 70 \text{ N}$ [allow 71 N as $+1/2$ small square on graph] A1 [1]
- (ii) $\theta = 90^\circ$ M1
(for equilibrium) the direction of Y must be opposite to Z
or using $Y \sin \theta = Z$, hence $\sin \theta = 70 / 70 = 1$, $\theta = 90^\circ$ A1 [2]
- (iii) 1. $Y \cos \theta = 160$ and $Y \sin \theta = 70$ C1
 $\tan \theta = 70 / 160$ hence $\theta = 23.6^\circ$ (24°) A1 [2]
2. $Y = 160 / \cos 23.6^\circ$ or $70 / \sin 23.6^\circ$ C1
 $= 174.6$ or 175 or 170 N A1 [2]
- or:
 $160^2 + 70^2 = Y^2$ (C1)
 $Y = 174.6$ or 175 or 170 N (A1)

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- (c) (equilibrium not possible as) there is no vertical component from Y to balance Z B1 [1]
- 4 (a) for a system (of interacting bodies) the total momentum remains constant provided there is no resultant force acting (on the system) M1 A1 [2]
- (b) (i) total momentum = $m_1v_1 + m_2v_2$ C1
 $= 0.4 \times 0.65 + 0.6 \times 0.45$ C1
 $= 0.26 + 0.27 = 0.53 \text{ N s}$ A1 [3]
- (ii) $0.53 = 0.4 \times 0.41 + 0.6 \times v$ C1
 $v = 0.366 / 0.6 = 0.61 \text{ m s}^{-1}$ A1 [2]
- (iii) $\text{KE} = \frac{1}{2}mv^2$ C1
total initial KE = $\frac{1}{2} \times 0.4 \times (0.65)^2 + \frac{1}{2} \times 0.6 \times (0.45)^2$ C1
 $= 0.0845 + 0.06075 = 0.15 (0.145) \text{ J}$ A1 [3]
- (c) check relative speed of approach equals relative speed of separation
or:
total final kinetic energy equals the total initial kinetic energy B1 [1]
- (d) the forces on the two bodies (or on X and Y) are equal and opposite
time same for both forces and force is change in momentum/time B1 B1 [2]
- 5 evaporation: molecules escape from the surface at all temperatures B1 B1
- boiling: takes place throughout/in the liquid at the boiling point/at specific temperatures B1 B1 [4]
- 6 (a) $R = \rho l / A$ C1
 $A = [\pi \times (0.38 \times 10^{-3})^2] / 4 (= 0.113 \times 10^{-6} \text{ m}^2)$ C1
 $R = (4.5 \times 10^{-7} \times 1.00) / ([\pi \times (0.38 \times 10^{-3})^2] / 4) = 4.0 (3.97) \Omega$ M1 [3]
- (b) (i) $I = V/R$ C1
 $= 2.0 / 5.0 = 0.4(0) \text{ A}$ A1 [2]
- (ii) p.d. across BD = $4 \times 0.4 = 1.6 \text{ V}$ A1 [1]
- (iii) p.d. across BC (l) = $1.5 (V)$ C1
 $BC (l) = (1.5 / 1.6) \times 100 = 94 (93.75) \text{ cm}$ A1 [2]

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- (c) p.d. across wire not balancing e.m.f. of cell OR cell Y has current energy lost or lost volts due to internal resistance B1 B1 [2]

- 7 (a) (i) progressive: energy is moved / transferred / propagated from one place to another (without the bulk movement of the medium) B1
- transverse: (particles) oscillate / vibrate at right angles to the direction of travel of the energy / wavefront B1 [2]

- (ii) number of oscillations per unit time / number of wavefronts passing a point per unit time B1 [1]

- (b) (i) P and T B1 [1]

- (ii) P and S or Q and T B1 [1]

- (c) $\lambda = 1.2 \times 10^{-2} \text{ (m)}$ C1

$$\begin{aligned}
 v &= f\lambda \\
 &= 15 \times 1.2 \times 10^{-2} \\
 &= 0.18 \text{ ms}^{-1}
 \end{aligned}$$

C1 A1 [3]

- (d) ratio = $(1.4)^2 / (2.1)^2$ C1
= 0.44 A1 [2]