

MARK SCHEME for the October/November 2012 series

9702 PHYSICS

9702/21

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

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Page 2	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – October/November 2012	9702	21

- 1 (a) (i) acceleration = change in velocity / time (taken)
or acceleration = rate of change of velocity B1 [1]
- (ii) a body continues at constant velocity unless acted on by a resultant force B1 [1]
- (b) (i) distance is represented by the area under graph C1
distance = $\frac{1}{2} \times 29.5 \times 3 = 44.3 \text{ m}$ (accept 43.5 m for 29 to 45 m for 30) A1 [2]
- (ii) resultant force = weight – frictional force B1
frictional force increases with speed B1
at start frictional force = 0 / at end weight = frictional force B1 [3]
- (iii) 1. frictional force increases B1 [1]
2. frictional force (constant) and then decreases B1 [1]
- (iv) 1. acceleration = $(v_2 - v_1) / t = (20 - 50) / (17 - 15)$ C1
= $(-)$ 15 m s^{-2} A1 [2]
2. $W - F = ma$ C1
 $W = 95 \times 9.81 (= 932)$ C1
 $F = (95 \times 15) + 932 = 2400 (2360) (2357) \text{ N}$ A1 [3]
- 2 (a) resistance = potential difference / current B1 [1]
- (b) (i) metal wire in series with power supply and ammeter B1
voltmeter in parallel with metal wire B1
rheostat in series with power supply or potential divider arrangement
or variable power supply B1 [3]
- (ii) 1. intercept on graph B1 [1]
2. scatter of readings about the best fit line B1 [1]
- (iii) correction for zero error explained B1
use of V and corrected I values from graph C1
resistance = $V/I = 22.(2) \Omega$ [e.g. $4.0 / 0.18$] A1 [3]
- (c) $R = 6.8 / 0.64 = 10.625$ C1
- $\%R = \%V + \%I$
= $(0.1 / 6.8) \times 100 + (0.01 / 0.64) \times 100$ C1
= $1.47\% + 1.56\%$
- $\Delta R = 0.0303 \times 10.625 = 0.32 \Omega$
- $R = 10.6 \pm 0.3 \Omega$ A1 [3]

Page 3	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – October/November 2012	9702	21

- 3 (a) pressure = force / area B1 [1]
- (b) molecules collide with object / surface and rebound B1
molecules have change in momentum hence force acts B1
fewer molecules per unit volume on top of mountain / temperature is less B1
hence lower speed of molecules A0 [3]
hence less pressure
- (c) (i) $\rho = m / V$ C1
 $W = V\rho g = 0.25 \times 0.45 \times 9.81 \times 13600$ C1
 $= 15000 \text{ (15009) N}$ A1 [3]
- (ii) $p = W / A$ (or using $p = \rho gh$) $= 15009 / 0.45$
 $= 3.3 \times 10^4 \text{ Pa}$ A1 [1]
- (iii) pressure will be greater due to the air pressure (acting on the surface of the liquid) B1 [1]
- 4 (a) waves pass through the elements / gaps / slits in the grating M1
spread into geometric shadow A1 [2]
- (b) (i) 1. displacements add to give resultant displacement B1
each wavelength travels the same path difference or are in phase B1
hence produce a maximum A0 [2]
2. to obtain a maximum the path difference must be λ or phase difference $360^\circ / 2\pi$ rad B1
 λ of red and blue are different B1
hence maxima at different angles / positions A0 [2]
- (ii) $n\lambda = d \sin \theta$ C1
 $N = \sin 61^\circ / (2 \times 625 \times 10^{-9}) = 7.0 \times 10^5$ A1 [2]
- (iii) $n\lambda = 2 \times 625$ is a constant (1250) C1
 $n = 1 \rightarrow \lambda = 1250$ outside visible
 $n = 3 \rightarrow \lambda = 417$ in visible
 $n = 4 \rightarrow \lambda = 312.5$ outside visible
 $\lambda = 420 \text{ nm}$ A1 [2]
- 5 (a) when the load is removed then the wire / body object does not return to its original shape / length B1 [1]
- (b) (i) stress = force / area C1
 $F = 220 \times 10^6 \times 1.54 \times 10^{-6} = 340 \text{ (338.8) N}$ A1 [2]
- (ii) $E = (F \times l) / (A \times e)$ C1
 $e = (90 \times 10^6) \times 1.75 / (1.2 \times 10^{11}) = 1.31 \times 10^{-3} \text{ m}$ A1 [2]
- (c) the stress is no longer proportional to the extension B1 [1]

Page 4	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – October/November 2012	9702	21

- 6 (a) 92 protons in the nucleus and 92 electrons around nucleus B1
143 neutrons (in the nucleus) B1 [2]
- (b) (i) α -particle travels short distance in air B1 [1]
- (ii) very small proportion in backwards direction / large angles B1
majority pass through with no /small deflections B1
either most of mass is in very small volume (nucleus) and is charged or most of atom is empty space B1 [3]
- (c) $I = Q / t$ C1
 $n/t = (1.5 \times 10^{-12}) / (2 \times 1.6 \times 10^{-19})$ C1
 $n/t = 4.7 \times 10^6 \text{ s}^{-1}$ A1 [3]

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- 1 (a) units for D identified as kg m s^{-2} M1
all other units shown: units for A : m^2 units for v^2 : $\text{m}^2 \text{s}^{-2}$ units for ρ : kg m^{-3}
- $$C = \frac{\text{kg m s}^{-2}}{\text{kg m}^{-3} \text{m}^2 \text{m}^2 \text{s}^{-2}}$$
 with cancelling / simplification to give C no units A1 [2]
- (b) (i) straight line from (0,0) to (1,9.8) $\pm$ half a square B1 [1]
- (ii) $\frac{1}{2} mv^2 = mgh$ or using $v^2 = 2as$ C1
 $v = (2 \times 9.81 \times 1000)^{1/2} = 140 \text{ m s}^{-1}$ A1 [2]
- (c) (i) weight = drag (D) (+ upthrust) B1 [1]
Allow mg or W for weight and D or expression for D for drag
- (ii) 1. $mg = 1.4 \times 10^{-5} \times 9.81$ C1
 $1.4 \times 10^{-5} \times 9.81 = 0.5 \times 0.6 \times 1.2 \times 7.1 \times 10^{-6} \times v^2$ M1
 $v = 7.33 \text{ m s}^{-1}$ A0 [2]
2. line from (0,0) correct curvature to a horizontal line at velocity of 7 m s^{-1} M1
line reaches 7 m s^{-1} between 1.5 s and 3.5 s A1 [2]
- 2 (a) (resultant) force = rate of change of momentum / allow proportional to or change in momentum / time (taken) B1 [1]
- (b) (i) $\Delta p = (-) 65 \times 10^{-3} (5.2 + 3.7)$ C1
 $= (-) 0.58 \text{ N s}$ A1 [2]
- (ii) $F = 0.58 / 7.5 \times 10^{-3}$
 $= 77(.3) \text{ N}$ A1 [1]
- (c) (i) 1. force on the wall from the ball is equal to the force on ball from the wall M1
but in the opposite direction A1 [2]
(statement of Newton's third law can score one mark)
2. momentum change of ball is equal and opposite to momentum change of the wall / change of momentum of ball and wall is zero B1 [1]
- (ii) kinetic energy (of ball and wall) is reduced / not conserved so inelastic B1 [1]
(Allow relative speed of approach does not equal relative speed of separation.)

Page 3	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – October/November 2012	9702	22

- 3 (a) metal: regular / repeated / ordered arrangement / pattern / lattice or long range order (of atoms / molecules / ions) B1
- polymer: tangled chains (of atoms / molecules) or long chains (of atoms / molecules / ions) B1
- amorphous: disordered / irregular arrangement or short range order (of atoms / molecules / ions) B1 [3]
- (b) metal: straight line or straight line then curving with less positive gradient B1
- polymer: curve with decreasing gradient with steep increasing gradient at end B1 [2]
- 4 (a) waves (travels along tube) reflect at closed end / end of tube B1
- incident and reflected waves or these two waves are in opposite directions M1
- interfere or stationary wave formed if tube length equivalent to $\lambda / 4, 3\lambda / 4$, etc. A1 [3]
- (b) (i) 1. no motion (as node) / zero amplitude B1 [1]
2. vibration backwards and forwards / maximum amplitude along length B1 [1]
- (ii) $\lambda = 330 / 880 (= 0.375 \text{ m})$ C1
- $L = 3\lambda / 4$ C1
- $L = 3 / 4 \times (0.375) = 0.28 (0.281) \text{ m}$ A1 [3]
- 5 (a) (i) $I_1 = I_2 + I_3$ B1 [1]
- (ii) $I = V / R$ or $I_2 = 12 / 10 (= 1.2 \text{ A})$ C1
- $R = [1/6 + 1 / 10]^{-1}$ [total $R = 3.75 \Omega$] or $I_3 = 12 / 6 (= 2.0 \text{ A})$ C1
- $I_1 = 12 / 3.75 = 3.2 \text{ A}$ or $I_1 = 1.2 + 2.0 = 3.2 \text{ A}$ A1 [3]
- (iii) power = VI or I^2R or V^2 / R C1
- $$x = \frac{\text{power in wire}}{\text{power in series resistors}} = \frac{I_2^2 R_w}{I_3^2 R_s} \text{ or } \frac{VI_2}{VI_3} \text{ or } \frac{V^2/R_w}{V^2/R_s}$$
 C1
- $x = 12 \times 1.2 / 12 \times 2.0 = 0.6(0)$ allow 3 / 5 or 3:5 A1 [3]
- (b) p.d. BC: $12 - 12 \times 0.4 = 7.2 \text{ (V)}$ / p.d. AC = 4.8 (V) C1
- p.d. BD: $12 - 12 \times 4 / 6 = 4.0 \text{ (V)}$ / p.d. AD = 8.0 (V) C1
- p.d. = 3.2 V A1 [3]
- 6 (a) extension is proportional to force / load B1 [1]
- (b) $F = mg$ C1
- $x = (mg / k) = 0.41 \times 9.81 / 25 = (4.02 / 25)$ M1
- $x = 0.16 \text{ m}$ A0 [2]

Page 4	Mark Scheme	Syllabus	Paper
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- (c) (i) weight and (reaction) force from spring (which is equal to tension in spring) B1 [1]
- (ii) $F = \text{weight}$ or $0.06 \times 25 = ma$ C1
 $F = 0.2209 \times 25 = 5.52 \text{ (N)}$ or $0.22 \times 25 = 5.5$
 $a = (5.52 - 0.41 \times 9.81) / 0.41$ or $1.5 / 0.41$ and $(5.5 - 4.02)$ C1
 $a = 3.7 \text{ (3.66) ms}^{-2}$ gives 3.6 ms^{-2} A1 [3]
- (d) elastic potential energy / strain energy to kinetic energy and gravitational potential energy B1
stretching / extension reduces and velocity increases / height increases B1 [2]
- 7 (a) ${}^3_2\text{He} + {}^3_2\text{He} \rightarrow {}^4_2\text{He} + 2 {}^1_1\text{p} + Q$
A numbers correct (4 and 1) B1
Z numbers correct (2 and 1) B1 [2]
- (b) both nuclei have 2 protons B1
the two isotopes have 1 neutron and two neutrons B1 [2]
[allow 1 for 'same number of protons but different number of neutrons']
- (c) proton number and neutron number B1
energy – mass B1
momentum B1 [2]
- (d) (i) γ radiation B1 [1]
- (ii) product(s) must have kinetic energy B1 [1]
- (e) $13.8 \text{ MeV} = 13.8 \times 1.6 \times 10^{-19} \times 10^6 (= 2.208 \times 10^{-12})$ C1
 $60 = n \times 13.8 \times 1.6 \times 10^{-13}$
 $n = 2.7(2) \times 10^{13} \text{ s}^{-1}$ A1 [2]

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- 1 (a) spacing = 380 or 3.8×10^2 pm B1 [1]
- (b) time = 24×3600
time = 0.086 (0.0864) Ms B1 [1]
- (c) time = distance / speed = $\frac{1.5 \times 10^{11}}{3 \times 10^8}$ C1
= 500 (s) = 8.3 min A1 [2]
- (d) momentum and weight B1 [1]
- (e) (i) arrow to the right of plane direction (about 4° to 24°) B1 [1]
- (ii) scale diagram drawn
or use of cosine formula $v^2 = 250^2 + 36^2 - 2 \times 250 \times 36 \times \cos 45^\circ$
or resolving $v = [(36 \cos 45^\circ)^2 + (250 - 36 \sin 45^\circ)^2]^{1/2}$ C1
resultant velocity = 226 (220 – 240 for scale diagram) m s^{-1}
allow one mark for values 210 to 219 or 241 to 250 m s^{-1}
or use of formula ($v^2 = 51068$) $v = 230$ (226) m s^{-1} A1 [2]
- 2 (a) (i) accelerations (A to B and B to C) are same magnitude B1
accelerations (A to B and B to C) are opposite directions B1
or both accelerations are toward B B1
(A to B and B to C) the component of the weight down the slope provides the acceleration B1 [3]
- (ii) acceleration = $g \sin 15^\circ$ C1
 $s = 0 + \frac{1}{2} at^2$ $s = 0.26 / \sin 15^\circ = 1.0$ C1
 $t^2 = \frac{1.0 \times 2}{9.8 \times \sin 15^\circ}$ $t = 0.89$ s A1 [3]
- (iii) $v = 0 + g \sin 15^\circ t$ or $v^2 = 0 + 2g \sin 15^\circ \times 1.0$ C1
 $v = 2.26 \text{ m s}^{-1}$ A1 [2]
(using loss of GPE = gain KE can score full marks)
- (b) loss of GPE at A = gain in GPE at C or loss of KE at B = gain in GPE at C B1
 $h_1 = h_2 = 0.26$ m or $\frac{1}{2} mv^2 = mgh$ $h_2 = 0.5 \times (2.26)^2 / 9.81 = 0.26$ m
 $x = 0.26 / \sin 30^\circ = 0.52$ m A1 [2]
- 3 (a) power is the rate of doing work or power = work done / time (taken) or
power = energy transferred / time (taken) B1 [1]
- (b) (i) as the speed increases drag / air resistance increases B1
resultant force reduces hence acceleration is less B1
constant speed when resultant force is zero B1 [3]
(allow one mark for speed increases and acceleration decreases)

Page 3	Mark Scheme	Syllabus	Paper
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	(ii) force from cyclist = drag force / resistive force $P = 12 \times 48$ $P = 576 \text{ W}$	B1 M1 A0	[2]
	(iii) tangent drawn at speed = 8.0 m s^{-1} gradient values that show acceleration between 0.44 to 0.48 m s^{-2}	M1 A1	[2]
	(iv) $F - R = ma$ $600 / 8 - R = 80 \times 0.5$ [using $P = 576$] $576 / 8 - R = 80 \times 0.5$ $R = 75 - 40 = 35 \text{ N}$ $R = 72 - 40 = 32 \text{ N}$	C1 C1 A1	[3]
	(v) at 12 m s^{-1} drag is 48 N , at 8 m s^{-1} drag is 35 or 32 N R / v calculated as 4 and 4 or 4.4 and consistent response for whether R is proportional to v or not	B1	[1]
4	(a) e.m.f. = chemical energy to electrical energy p.d. = electrical energy to thermal energy idea of per unit charge	M1 M1 A1	[3]
	(b) $E = I(R + r)$ or $I = E / (R + r)$ (any subject)	B1	[1]
	(c) (i) $E = 5.8 \text{ V}$	B1	[1]
	(ii) evidence of gradient calculation or calculation with values from graph e.g. $5.8 = 4 + 1.0 \times r$ $r = 1.8 \Omega$	C1 A1	[2]
	(d) (i) $P = VI$ $P = 2.9 \times 1.6 = 4.6$ (4.64) W	C1 A1	[2]
	(ii) power from battery = $1.6 \times 5.8 = 9.28$ or efficiency = VI / EI efficiency = $(4.64 / 9.28) \times 100 = 50 \%$ or $(2.9 / 5.8) \times 100 = 50\%$	C1 A1	[2]
5	(a) travel through a vacuum / free space	B1	[1]
	(b) (i) B : name: microwaves wavelength: 10^{-4} to 10^{-1} m C : name: ultra-violet / UV wavelength: 10^{-7} to 10^{-9} m F : name: X-rays wavelength: 10^{-9} to 10^{-12} m	B1 B1 B1	[3]
	(ii) $f = \frac{3 \times 10^8}{500 \times 10^{-9}}$	C1	
	$f = 6(.0) \times 10^{14} \text{ Hz}$	A1	[2]

Page 4	Mark Scheme	Syllabus	Paper
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- (c) vibrations are in one direction M1
perpendicular to direction of propagation / energy transfer
or good sketch showing this A1 [2]

- 6 (a) (i) electron B1 [1]

- (ii) any **two**:
can be deflected by electric and magnetic fields or negatively charged /
absorbed by few (1 – 4) mm of aluminum / 0.5 to 2 m or metres for range in air /
speed up to 0.99c / range of speeds / energies B2 [2]

- (iii) decay occurs and cannot be affected by external / environmental factors
or two stated factors such as chemical / pressure / temperature / humidity B1 [1]

- (b) 3 and 0 for superscript numbers B1
2 and –1 for subscript numbers B1 [2]

- (c) energy = $5.7 \times 10^3 \times 1.6 \times 10^{-19}$ (= 9.12×10^{-16} J) C1

$$v^2 = \frac{2 \times 9.12 \times 10^{-16}}{9.11 \times 10^{-31}} \quad \text{C1}$$

$$v = 4.5 \times 10^7 \text{ m s}^{-1} \quad \text{A1 [3]}$$

- (d) both have 1 proton and 1 electron B1
1 neutron in hydrogen-2 and 2 neutrons in hydrogen-3 B1 [2]
(special case: for one mark 'same number of protons / atomic number
different number of neutrons')