
PHYSICS

9702/21

Paper 2 AS Level Structured Questions

October/November 2017

MARK SCHEME

Maximum Mark: 60

Published

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Question	Answer	Marks
1(a)	units of F : kg ms^{-2}	C1
	units of ρ : kg m^{-3} and units of v : ms^{-1}	C1
	units of K : $\text{kg ms}^{-2} / [\text{kg m}^{-3} (\text{ms}^{-1})^2]$ $= \text{m}^2$	A1
1(b)(i)	$K\rho = 1.5 / 33^2$	C1
	$= 1.38 \times 10^{-3}$	A1
	$F_D = 1.38 \times 10^{-3} \times 25^2$ or $F_D / 1.5 = 25^2 / 33^2$ $F_D = 0.86 \text{ N}$	
1(b)(ii)	$a = (1.5 - 0.86) / (1.5 / 9.81)$ or $a = 9.81 - [0.86 / (1.5 / 9.81)]$	C1
	$a = 4.2 \text{ ms}^{-2}$	A1
1(c)	initial acceleration is $g/9.81 (\text{ms}^{-2})$ /acceleration of free fall	B1
	acceleration decreases	B1
	final acceleration is zero	B1

Question	Answer	Marks
2(a)	$30 \text{ ms}^{-1} = 108 \text{ km h}^{-1}$ or $100 \text{ km h}^{-1} = 28 \text{ ms}^{-1}$ and so exceeds speed limit	B1
2(b)	acceleration = gradient or $\Delta v / (\Delta t)$ or $(v - u) / t$	C1
	e.g. acceleration = $(24 - 20) / 12$ [other points on graph line may be used] $= 0.33 \text{ ms}^{-2}$	A1
2(c)	distance travelled by Q = $\frac{1}{2} \times 12 \times 30$ (= 180 m)	C1
	distance travelled by P = $\frac{1}{2} \times (20 + 24) \times 12$ (= 264 m)	C1
	distance between cars = $264 - 180$ $= 84 \text{ m}$	A1
2(d)	$30 - 24 = 6 \text{ ms}^{-1}$ 'extra' time $T = 84 / 6$ (= 14 s) or $180 + 30T = 264 + 24T$ 'extra' time $T = 84 / 6$ (= 14 s)	C1
	$t = 12 + 14 = 26 \text{ s}$	A1

Question	Answer	Marks
3(a)(i)	in a stationary wave energy is not transferred or in a progressive wave energy is transferred	B1
3(a)(ii)	in a stationary wave (adjacent) particles are in phase or in a progressive wave (adjacent) particles are out of phase/have a phase difference/not in phase	B1
3(b)(i)	(position where) maximum amplitude	B1
3(b)(ii)	distance = 0.10 m	B1
3(b)(iii)	1. $\lambda = 0.60/1.5$ = 0.40 m	A1
	2. $v = f\lambda$	C1
	$f = 340/0.40$ = 850 Hz	A1
3(b)(iv)	$\lambda = 2 \times 0.60$ or $\lambda = 3 \times 0.40$ or $f = 850/3$	C1
	$f = 280$ (283) Hz	A1

Question	Answer	Marks
4(a)	(strain =) extension / <u>original</u> length	B1
4(b)(i)	$E = \sigma / \varepsilon$	C1
	maximum stress = $2.1 \times 10^{11} \times 4.0 \times 10^{-4}$ $= 8.4 \times 10^7 \text{ Pa}$	A1
4(b)(ii)	$\sigma = F/A$	C1
	minimum area = $8.0 \times 10^3 / 8.4 \times 10^7$ $= 9.5 \times 10^{-5} \text{ m}^2$	A1

Question	Answer	Marks
5(a)	$I_1 + I_2 = I_3$ [any subject]	B1
5(b)	$E_1 + E_3 = I_1 R_1 + I_3 R_3 + I_3 R_4$ [any subject]	B1
5(c)	$E_1 - E_2 = I_1 R_1 - I_2 R_2$ [any subject]	B1

Question	Answer	Marks
6(a)	force <u>per</u> unit positive charge	B1
6(b)(i)	$E_K = \frac{1}{2}mv^2$	C1
	$2.4 \times 10^{-16} = \frac{1}{2} \times 1.7 \times 10^{-27} \times v^2$	A1
	$v = 5.3 \times 10^5 \text{ ms}^{-1}$	
6(b)(ii)	work done = $2.4 \times 10^{-16} \text{ J}$	A1
6(b)(iii)	$W = Fs$	C1
	$F = 2.4 \times 10^{-16} / 15 \times 10^{-3}$	A1
	$= 1.6 \times 10^{-14} \text{ N}$	
6(b)(iv)	$V = Fd / Q$ or $V = W / Q$ or $E = V/d$ and $E = F/Q$	C1
	$V = (1.6 \times 10^{-14} \times 15 \times 10^{-3}) / 1.6 \times 10^{-19}$ or $2.4 \times 10^{-16} / 1.6 \times 10^{-19}$	C1
	$= 1500 \text{ V}$	A1
6(b)(v)	straight line with positive gradient starting at the origin and going as far as $x = 15 \text{ mm}$	B1

Question	Answer	Marks
7(a)	(the ohm is) volt / ampere	B1
7(b)(i)	$R = \rho L / A$	C1
	ratio = $[\rho L / (\pi d^2 / 4)] / [0.028 \rho \times 7.0 L / \{\pi (14d)^2 / 4\}] = 1000$ or ratio = $14^2 / (0.028 \times 7) = 1000$	A1
7(b)(ii)	same current (in connecting and filament wires) and the lamp/filament (wire) has greater resistance	B1
7(b)(iii)	$P = V^2 / R$ or $P = VI$ or $P = I^2 R$	C1
	(for filament wire) $R = 12^2 / 6.0$ or $R = 6.0 / 0.50^2$ or $R = 12 / 0.50$	C1
	(for filament wire) $R = 24 \Omega$	A1
	(for connecting wire) $R = 24 / 1000$ $= 2.4 \times 10^{-2} \Omega$	
7(b)(iv)	resistance of connecting wire increases	B1
	current in circuit/lamp/filament (wire) decreases or potential difference across lamp/filament (wire) decreases	M1
	(so) resistance of lamp/filament (wire) decreases	A1

Question	Answer	Marks
8(a)	(quark structure is) up, down, down/udd	B1
	up/u has charge $+\frac{2}{3}(e)$, down/d has charge $-\frac{1}{3}(e)$	C1
	$+\frac{2}{3}e - \frac{1}{3}e - \frac{1}{3}e = 0$	A1
8(b)	charge: p $+1.6(0) \times 10^{-19}$ (C) or $+e$ β^- $-1.6(0) \times 10^{-19}$ (C) or $-e$ $\bar{\nu}$ zero/0	B1
	mass: p 1.67×10^{-27} (kg)/ 1.7×10^{-27} (kg) β^- $9.1(1) \times 10^{-31}$ (kg) $\bar{\nu}$ very small/zero/0	B1

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Question	Answer	Marks
1(a)(i)	micrometer (screw gauge)/digital calipers	B1
1(a)(ii)	take several readings (and average)	M1
	along the wire or around the circumference	A1
1(b)(i)	$\sigma = 4 \times 25 / [\pi \times (0.40 \times 10^{-3})^2] = 1.99 \times 10^8 \text{ N m}^{-2}$ or $\sigma = 25 / [\pi \times (0.20 \times 10^{-3})^2] = 1.99 \times 10^8 \text{ N m}^{-2}$	A1
1(b)(ii)	%F = 2% and %d = 5% or $\Delta F / F = \frac{0.5}{25} \text{ and } \Delta d / d = \frac{0.02}{0.4}$	C1
	%σ = 2% + (2 × 5%) or %σ = [0.02 + (2 × 0.05)] × 100 %σ = 12%	A1
1(b)(iii)	absolute uncertainty = $(12 / 100) \times 1.99 \times 10^8$ $= 2.4 \times 10^7$	C1
	$\sigma = 2.0 \times 10^8 \pm 0.2 \times 10^8 \text{ N m}^{-2} \text{ or } 2.0 \pm 0.2 \times 10^8 \text{ N m}^{-2}$	A1

Question	Answer	Marks
2(a)	force $\times$ <u>perpendicular</u> distance (of line of action of force) to/from a point	B1
2(b)(i)	$2.4r$ or $(1.2 \times 2r)$ or $(1.2r + 1.2r)$	A1
2(b)(ii)	(anticlockwise moment $\Rightarrow$) $6.0 \times r/2 \times \sin \theta$	C1
	$6.0 \times r/2 \times \sin \theta = 2.4r$ $\theta = 53^\circ$	A1
2(b)(iii)	6.0 N	A1

Question	Answer	Marks
3(a)	$p = 1000 \times 9.81 \times 7.0 \times 10^{-2}$ or $1000 \times 9.81 \times 1.9 \times 10^{-2}$	C1
	$\Delta p = 1000 \times 9.81 \times (7.0 \times 10^{-2} - 1.9 \times 10^{-2})$ or $686 - 186$ $= 500 \text{ Pa}$	A1
3(b)	$F = pA$ or $(\Delta)F = \Delta p \times A$	C1
	upthrust $= 500 \times (5.1 \times 10^{-2})^2 = 1.3 \text{ N}$ or upthrust $= (686 - 186) \times (5.1 \times 10^{-2})^2 = 1.3 \text{ N}$ or upthrust $= 1000 \times 9.81 \times 5.1 \times 10^{-2} \times (5.1 \times 10^{-2})^2 = 1.3 \text{ N}$	A1
3(c)	force $= 4.0 - 1.3$ $= 2.7 \text{ N}$	A1

Question	Answer	Marks
3(d)	extension/x/e = $2.7/30$	C1
	= 0.09 (m) or 9 (cm)	C1
	height above surface = $9 - 7$ = 2 cm	A1
3(e)(i)	mass = $4.0/9.81$	C1
	acceleration = $2.7/(4.0/9.81)$ = 6.6 ms^{-2}	A1
3(e)(ii)	viscous force <u>increases</u> (and then becomes constant)	M1
	(weight and upthrust constant so) acceleration decreases (to zero)	A1

Question	Answer	Marks
4(a)	(two) waves travelling (at same speed) in opposite directions overlap	B1
	waves (are same type and) have same frequency/wavelength	B1
4(b)(i)	5	A1
4(b)(ii)	$T = 1/40 (= 2.5 \times 10^{-2})$	C1
	time taken = $2.5 \times 10^{-2} / 2$ $= 1.3 \times 10^{-2} \text{ s } (1.25 \times 10^{-2} \text{ s})$	A1
4(b)(iii)	180°	A1
4(b)(iv)	$v = f\lambda$	C1
	$\lambda = 2.0/2.5 (= 0.80 \text{ m})$ $v = 0.80 \times 40$ $= 32 \text{ m s}^{-1}$	A1

Question	Answer	Marks
5(a)	(coulomb is) ampere second	B1
5(b)(i)	$E = V/d$ or $E = F/Q$	C1
	$F = VQ/d$	A1
	$F = (2.0 \times 10^2 \times 8.0 \times 10^{-19})/4.0 \times 10^{-2} = 4.0 \times 10^{-15} \text{ N}$	
5(b)(ii)	arrow pointing to the left labelled 'electric force' and arrow pointing downwards labelled 'weight'	B1
5(b)(iii)	1. resultant force = $\sqrt{[(3.9 \times 10^{-15})^2 + (4.0 \times 10^{-15})^2]}$	C1
	$= 5.6 \times 10^{-15} \text{ N}$	A1
	2. angle = $\tan^{-1} (3.9 \times 10^{-15}/4.0 \times 10^{-15})$ $= 44^\circ$	A1
5(c)	downward sloping line from (0, 2.0)	M1
	magnitude of gradient of line increases with time and line ends at (T, 0)	A1

Question	Answer	Marks
6(a)	flow of charge carriers	B1
6(b)(i)	$nALe$	B1
6(b)(ii)	(t is time taken for electrons to move length L) $I = Q/t$	B1
	$I = nALe/t$ or $I = nALe/(L/v)$ or $I = nAvte/t$ and $I = nAve$	B1
6(c)(i)	ratio = area at X/area at Y $= [\pi d^2/4]/[\pi(0.69d)^2/4]$ or $d^2/(0.69d)^2$ or $1/0.69^2$	C1
	$= 2.1$	A1
6(c)(ii)	1. $R = \rho L/A$ or $R/L \propto 1/A$	C1
	resistance per unit length $= 1.7 \times 10^{-2} \times (\text{area at X/area at Y})$ $= 1.7 \times 10^{-2} \times 2.1$ $= 3.6 \times 10^{-2} \Omega \text{ m}^{-1}$	A1
	2. $P = I^2 R$ or $P = V^2/R$	C1
	$R = 3.6 \times 10^{-2} \times 3.0 \times 10^{-3} (= 1.08 \times 10^{-4} \Omega)$ $P = 0.50^2 \times 1.08 \times 10^{-4}$ or $P = (5.4 \times 10^{-5})^2 / 1.08 \times 10^{-4}$ $= 2.7 \times 10^{-5} \text{ W}$	A1

Question	Answer	Marks
6(c)(iii)	(cross-sectional area decreases so) resistance increases	M1
	($P = I^2R$, so) power increases	A1

Question	Answer	Marks
7(a)	lepton(s)	B1
7(b)	protons: 7 and neutrons: 6	A1
7(c)	$E = \frac{1}{2}mv^2$	C1
	$= 0.80 \times 10^6 \times 1.60 \times 10^{-19}$	C1
	$= 1.28 \times 10^{-13} \text{ (J)}$	A1
	$v^2 = 2 \times 1.28 \times 10^{-13} / 2.2 \times 10^{-26}$ $v = 3.4 \times 10^6 \text{ ms}^{-1}$	
7(d)	an (electron) neutrino/ $\nu_{(e)}$ is also produced (and this has energy)	B1

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Question	Answer	Marks
1(a)(i)	work (done) / time (taken) or energy (transferred) / time (taken)	B1
1(a)(ii)	Correct substitution of base units of all quantities into any correct equation for power. Examples: $(P = E / t \text{ or } W / t \text{ gives}) \text{ kg m}^2 \text{ s}^{-2} / \text{s} = \text{kg m}^2 \text{ s}^{-3}$ $(P = Fs / t \text{ or } mgh / t \text{ gives}) \text{ kg m s}^{-2} \text{ m} / \text{s} = \text{kg m}^2 \text{ s}^{-3}$ $(P = \frac{1}{2}mv^2 / t \text{ gives}) \text{ kg (m s}^{-1})^2 / \text{s} = \text{kg m}^2 \text{ s}^{-3}$ $(P = Fv \text{ gives}) \text{ kg m s}^{-2} \text{ m s}^{-1} = \text{kg m}^2 \text{ s}^{-3}$ $(P = VI \text{ gives}) \text{ kg m}^2 \text{ s}^{-2} \text{ A}^{-1} \text{ s}^{-1} \text{ A} = \text{kg m}^2 \text{ s}^{-3}$	A1
1(b)(i)	units of A : m^2 and units of T : K	C1
	units of k : $\text{kg m}^2 \text{ s}^{-3} / \text{m}^2 \text{ K}^4$ $= \text{kg s}^{-3} \text{ K}^{-4}$	A1
1(b)(ii)	curve from the origin with increasing gradient	B1

Question	Answer	Marks
2(a)	$\rho = m / V$ or $\rho = m / Ah$	B1
	$p = F / A$ or $p = W / A$	B1
	$p = [\rho Ahg] / A$ or $p = [\rho Vg] / [V / h]$ (so) $p = \rho gh$	A1

Question	Answer	Marks
2(b)(i)	1. weight/gravitational (force) upthrust (force)/buoyancy (force) drag/viscous/frictional (force)/fluid resistance/resistance	B1
	2. weight = upthrust + viscous (force)	B1
2(b)(ii)	- decrease in (gravitational) potential energy (of sphere) due to decrease in height (since $E_p = mgh$) - increase in thermal energy due to work done against viscous force/drag - loss/change of (total) E_p equal to gain/change in thermal energy <i>Any 2 points.</i>	B2
2(c)(i)	atmospheric pressure = $9.1(0) \times 10^4$ Pa	A1
2(c)(ii)	$(\Delta)p = \rho g(\Delta)h$ $(9.15 - 9.10) \times 10^4 = \rho \times 9.81 \times (0.17 - 0.10)$	C1
	$\rho = 730$ (728) kg m^{-3}	A1

Question	Answer	Marks
3(a)	<u>sum/total</u> momentum (of system of bodies) is constant or <u>sum/total</u> momentum before = <u>sum/total</u> momentum after	M1
	for an isolated system/no (resultant) <u>external</u> force	A1
3(b)(i)	$p = mv$	C1
	$(4.0 \times 6.0 \times \sin \theta) - (12 \times 3.5 \times \sin 30^\circ) = 0$ or $(m_A v_A \times \sin \theta) - (m_B v_B \times \sin 30^\circ) = 0$	M1
	$\theta = 61^\circ$	A1

Question	Answer	Marks
3(b)(ii)	shows the horizontal <u>momentum</u> component of ball A or of ball B as $(4.0 \times 6.0 \times \cos \theta)$ or $(12 \times 3.5 \times \cos 30^\circ)$	C1
	$(4.0 \times 6.0 \times \cos 61^\circ) + (12 \times 3.5 \times \cos 30^\circ) = 4.0v$ so $v = 12 \text{ (ms}^{-1}\text{)}$	A1
3(b)(iii)	initial $E_K (= \frac{1}{2} \times 4.0 \times 12^2) = 290 \text{ (288) (J)}$	M1
	final $E_K (= \frac{1}{2} \times 4.0 \times 6.0^2 + \frac{1}{2} \times 12 \times 3.5^2) = 150 \text{ (145.5) (J)}$	M1
	(initial $E_K >$ final E_K) so inelastic [both M1 marks required to award this mark]	A1

Question	Answer	Marks
4(a)	displacement of particles/vibration(s)/oscillation(s) is parallel to/along the direction of energy/propagation	B1
4(b)	period = $1 / 800 (= 1.25 \times 10^{-3} \text{ s})$	C1
	time-base setting = $1.25 \times 10^{-3} / 2.5$	C1
	$= 5.0 \times 10^{-4} \text{ s cm}^{-1}$	A1
4(c)(i)	$I \propto A^2$	C1
	$(I_X / I_Y =) [r_Y / r_X]^2 = [A_X / A_Y]^2$	C1
	ratio $A_Y / A_X = 120 / 30$ $= 4.0$	A1

Question	Answer	Marks
4(c)(ii)	1. $v = f\lambda$	C1
	minimum $\lambda = 330 / (800 + 16) = 0.40 \text{ m}$	A1
	2. $f_o / f_s = v / (v - v_s)$ $816 / 800 = 330 / (330 - v_s)$	C1
	$v_s = 6.5 \text{ m s}^{-1}$	A1

Question	Answer	Marks
5(a)	force <u>per</u> unit positive charge	B1
5(b)(i)	$s = \frac{1}{2}at^2$	C1
	$a = (2 \times 0.045) / (1.5 \times 10^{-7})^2 = 4(.0) \times 10^{12} \text{ m s}^{-2}$	A1
5(b)(ii)	$F = 1.67 \times 10^{-27} \times 4.0 \times 10^{12} = 6.7 (6.68) \times 10^{-15} \text{ N}$	A1
5(b)(iii)	1. $E = F / Q$	C1
	$= 6.68 \times 10^{-15} / 1.6 \times 10^{-19}$ $= 4.2 (4.18) \times 10^4 \text{ NC}^{-1}$	A1
	2. $E = V / d$	C1
	$V = 4.18 \times 10^4 \times 0.045$ $= 1.9 \times 10^3 \text{ V}$	A1

Question	Answer	Marks
5(c)	$a = Eq / m$ or $F = ma$ and $F = Eq$	C1
	ratio = $\frac{(2 \times 1.6 \times 10^{-19}) \times (1.67 \times 10^{-27})}{(1.6 \times 10^{-19}) \times (4 \times 1.66 \times 10^{-27})}$ or $\frac{2 \times 1}{1 \times 4}$ = 0.50	A1

Question	Answer	Marks
6(a)(i)	$P = VI$	C1
	$I = 30 / 120$ = 0.25 A	A1
6(a)(ii)	$Q = 0.25 \times 3.0 \times 3600 (= 2700)$	C1
	number = $(0.25 \times 3.0 \times 3600) / 1.60 \times 10^{-19}$ = 1.7×10^{22}	A1
6(b)	$R = V / I$ or $R = P / I^2$ or $R = V^2 / P$	C1
	= $120 / 0.25$ or = $30 / 0.25^2$ or = $120^2 / 30$ = 480Ω	A1

Question	Answer	Marks
6(c)	$R = \rho l / A$	C1
	$A = (6.1 \times 10^{-7} \times 580 \times 10^{-3}) / 480 (= 7.37 \times 10^{-10})$	C1
	$d = [(4 \times 7.37 \times 10^{-10}) / \pi]^{1/2}$ $= 3.1 \times 10^{-5} \text{ m}$	A1
6(d)	temperature decreases and so resistance decreases	B1

Question	Answer	Marks
7(a)	nucleons = 23	B1
	neutrons = 11	B1
7(b)	similarity: same (rest) mass or equal (magnitude of) charge	B1
	difference: opposite (sign of) charge or one is matter and one is antimatter or one is an electron and one is an antielectron	B1