
PHYSICS

9702/21

Paper 2 AS Level Structured Questions

May/June 2019

MARK SCHEME

Maximum Mark: 60

Published

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Question	Answer	Marks
1(a)	(velocity =) change in displacement / time (taken)	B1
1(b)(i)	$k = [1.29 \times (3.3 \times 10^2)^2] / 9.9 \times 10^4$	C1
	= 1.4	A1
1(b)(ii)	percentage uncertainty = $(3 \times 2) + 4 + 2$ (= 12%) or fractional uncertainty = $(0.03 \times 2) + 0.04 + 0.02$ (= 0.12)	C1
	$\Delta k = 0.12 \times 1.42$ = 0.17 (<i>allow to 1 significant figure</i>)	C1
	$k = 1.4 \pm 0.2$	A1

Question	Answer	Marks
2(a)	(momentum =) mass $\times$ velocity	B1
2(b)(i)	time = 40 ms	A1
2(b)(ii)	1. (the magnitude of the acceleration is) constant	B1
	2. (the magnitude of the acceleration is) zero	B1
2(c)	$F = \Delta p / (\Delta)t$ or $F = \text{gradient}$	C1
	e.g. $F = 0.50 / 40 \times 10^{-3}$ = 13 N	A1
2(d)	horizontal line from (0, 0.40) to (60, 0.40)	B1
	straight line from (60, 0.40) to (100, -0.10)	B1
	horizontal line from (100, -0.10) to (160, -0.10)	B1

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Question	Answer	Marks
3(a)(i)	$E = \frac{1}{2}Fx$ or $E = \frac{1}{2}kx^2$ or $E = \text{area under graph}$	C1
	$E = \frac{1}{2} \times 4.0 \times 0.32 = 0.64 \text{ J}$ or $E = \frac{1}{2} \times 12.5 \times (0.32)^2 = 0.64 \text{ J}$	A1
3(a)(ii)	$E = mgh$ or $E = Wh$ $= 2.5 \times 0.32$	C1
	$= 0.80 \text{ J}$	A1
3(b)(i)	kinetic energy $= 0.80 - 0.64$ $= 0.16 \text{ J}$	A1
3(b)(ii)	$E = \frac{1}{2}mv^2$ $0.16 = \frac{1}{2} \times (2.5 / 9.81) \times v^2$	C1
	$v = 1.1 \text{ m s}^{-1}$	A1

Question	Answer	Marks
4(a)(i)	$m = \rho \times V$	C1
	$= (4 / 3) \times \pi \times (1.2 \times 10^{-6})^3 \times 940 = 6.8 \times 10^{-15} \text{ (kg)}$	A1
4(a)(ii)	minimum charge (on drop) is $1.6 \times 10^{-19} \text{ C}$	B1
4(b)(i)	$V = Ed$	C1
	$V = 2.1 \times 10^5 \times 8.0 \times 10^{-3}$	A1
	$= 1.7 \times 10^3 \text{ V}$	
4(b)(ii)	constant velocity so no resultant force (so in equilibrium)	B1
4(b)(iii)	$mg = Eq$ or $mg = (V / d)q$ or $F = mg$ and $F = Eq$	C1
	$q = (6.8 \times 10^{-15} \times 9.81) / 2.1 \times 10^5$ $= 3.2 \times 10^{-19} \text{ C}$	A1
	sign of charge is negative	A1
4(c)(i)	<u>electric</u> force decreases	B1
	weight > electric force or resultant force acts downwards	B1
4(c)(ii)	(field line) separation increases	B1
4(d)(i)	upthrust (force)	B1
4(d)(ii)	air resistance/drag/viscous (force)	B1

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Question	Answer	Marks
5(a)(i)	1. $N\lambda$	B1
	2. N/f	B1
5(a)(ii)	v (= distance / time) = $N\lambda / (N/f)$ so $v = f\lambda$	B1
5(b)	$T = 4.0 \times 0.20 = 0.80$ (ms) or 8.0×10^{-4} (s)	C1
	$f = 1 / 8.0 \times 10^{-4}$ $= 1300$ Hz	A1
5(c)(i)	constant phase difference (between the waves)	B1
5(c)(ii)	180°	A1
5(c)(iii)	path difference = 2λ or $S_1Y - S_2Y = 2\lambda$	C1
	distance = $7.40 + (0.85 \times 2)$ $= 9.1$ m	A1

Question	Answer	Marks
6(a)	energy is dissipated in the internal resistance	B1
6(b)	$E = V + Ir$	B1
6(c)(i)	(graph shows) maximum value of potential difference is 2.8 (V) or (graph shows) when current/ I (from battery) is zero, V is 2.8 (V) / E	B1
6(c)(ii)	$r = (-)\text{gradient}$ or $r = (E - V) / I$ or substituted values from the graph for E , V and I	C1
	$r = 1.4 \Omega$	A1
6(d)(i)	$R = 2.1 / 0.50$ $= 4.2 \Omega$	A1
6(d)(ii)	number = $0.50 / 1.60 \times 10^{-19}$ $= 3.1 \times 10^{18}$	A1
6(d)(iii)	energy = EIt or $P = EI$ and $P = W / t$	C1
	$(9.2 - 1.6) \times 10^3 = 2.8 \times 0.50 \times t$	C1
	$t = 5.4 \times 10^3 \text{ s}$	A1

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Question	Answer	Marks
7(a)	nucleus is charged	B1
	the mass is <u>concentrated</u> in (very small) nucleus or the <u>majority</u> of the mass is in (very small) nucleus	B1
7(b)(i)	$-(1/3)e$	B1
7(b)(ii)	$2q - (1/3)e = e$ so $q = (2/3)e$	M1
	up / u (quarks) (<i>allow charm or top quarks</i>)	A1

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1(a)	absolute uncertainty = $(1.6 / 100) \times 0.0125$ $= 2 \times 10^{-4} \text{ m}$	A1
1(b)(i)	$p = (4 \times 0.38) / (\pi \times 0.0125^2)$ $= 3100 \text{ N m}^{-2}$	A1
1(b)(ii)	percentage uncertainty = $2.8 + (2 \times 1.6)$ (= 6%) or fractional uncertainty = $0.028 + (2 \times 0.016)$ (= 0.06)	C1
	absolute uncertainty = 0.06×3100 $= 190 \text{ N m}^{-2}$ (<i>allow to 1 significant figure</i>)	A1

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Question	Answer	Marks
2(a)	(resultant) force proportional/equal to/is rate of change of momentum	B1
2(b)(i)	distance = area under graph or $s = \frac{1}{2} (u + v) t$ $= \frac{1}{2} \times (9 + 13) \times 10$ or $s = ut + \frac{1}{2}at^2$ $= (9 \times 10) + (\frac{1}{2} \times 0.40 \times 10^2)$ or $s = vt - \frac{1}{2}at^2$ $= (13 \times 10) - (\frac{1}{2} \times 0.40 \times 10^2)$ or $v^2 = u^2 + 2as$ $13^2 = 9^2 + (2 \times 0.40 \times s)$	C1
	distance = 110 m	A1

Question	Answer	Marks
2(b)(ii)	1. $a = \text{gradient}$ or $a = (v - u) / t$ or $a = \Delta v / (\Delta)t$ e.g. $a = (14 - 9) / 12.5$ or $(13 - 9) / 10$	C1
	$a = 0.40 \text{ m s}^{-2}$	A1
	2. resultant force $= 850 \times 0.40$ $= 340 \text{ N}$	A1
	3. $(F =) 510 + 440 + 340 = 1300 \text{ (N)}$	A1
	4. $P = Fv$	C1
	$= 1300 \times 13$ $= 1.7 \times 10^4 \text{ W}$	A1
2(c)	$E = \sigma / \epsilon$	C1
	$E = (F / A) / (\Delta L / L)$ or $E = FL / A\Delta L$	C1
	$\Delta L = (480 \times 0.48) / (3.0 \times 10^{-4} \times 2.2 \times 10^{11})$ $= 3.5 \times 10^{-6} \text{ m}$	A1
2(d)	$f_o = f_s v / (v - v_s)$ $480 = f_s \times 340 / (340 - 14)$	C1
	$f_s = 460 \text{ Hz}$	A1

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Question	Answer	Marks
3(a)	the point where (all) the weight (of the body) is taken to act	B1
3(b)(i)	vertical component = $54 \sin 35^\circ$ = 31 N	A1
3(b)(ii)	the (line of action of the) force (at B) passes through (point) A or the (line of action of the) force (at B) has zero (perpendicular) distance from (point) A	B1
3(b)(iii)	$54 \sin 35^\circ \times 0.68$ or $54 \cos 35^\circ \times 0.68$ or $W \times 0.34$	C1
	$54 \sin 35^\circ \times 0.68 + 54 \cos 35^\circ \times 0.68 = W \times 0.34$ so $W = 150$ (N)	A1
3(b)(iv)	total vertical force = $150 - 31$ = 120 N	A1
3(c)	$(\Delta)E = mg(\Delta)h$	C1
	$E = \frac{1}{2}mv^2$	C1
	ratio = $(m \times 9.81 \times 4.8) / (\frac{1}{2} \times m \times 9.2^2)$ or $(9.81 \times 4.8) / (\frac{1}{2} \times 9.2^2)$	C1
	= 1.1	A1

Question	Answer	Marks
4(a)(i)	distance (in a specified direction of particle/point on wave) from the equilibrium position	B1
4(a)(ii)	the maximum distance (of particle/point on wave) from the equilibrium position or the maximum displacement (of particle/point on wave)	B1
4(b)	$I \propto A^2$	C1
	$I_R / I = (3.6 - 1.2)^2 / (1.2)^2$ resultant intensity = $4.0I$	A1
4(c)(i)	as wave(s) pass through the slit(s)	B1
	wave(s) spread (into geometric shadow)	B1
4(c)(ii)	$n\lambda = d \sin \theta$	C1
	$3\lambda = d \sin 90^\circ$ or $3\lambda = d$	C1
	$d = 3 \times 630 \times 10^{-9}$ $= 1.9 \times 10^{-6} \text{ m}$	A1
4(c)(iii)	wavelength of blue light is shorter (than 540 nm/630 nm/wavelengths of original light)	M1
	(so) third order diffraction maximum is produced	A1

Question	Answer	Marks
5(a)	<u>sum of</u> e.m.f.(s) = <u>sum of</u> p.d.(s)	M1
	around a loop/around a closed circuit	A1
5(b)(i)	1. $1/R = 1/R_1 + 1/R_2$ $1/R = 1/90 + 1/18$	C1
	$R = 15\ \Omega$	A1
	2. $I = V/R$	C1
	$I = 4.8/15$ or $I = 4.8/90 + 4.8/18$ $I = 0.32\text{ A}$	A1
5(b)(ii)	$E = V + Ir$ or $E = I(R + r)$	C1
	$5.6 = 4.8 + 0.32\ r$ so $r = 2.5\ (\Omega)$ or $5.6 = 0.32 \times (15 + r)$ so $r = 2.5\ (\Omega)$	A1
5(b)(iii)	$P = EI$ or $P = VI$ or $P = I^2R$ or $P = V^2/R$	C1
	ratio = $(0.32^2 \times 2.5) / (5.6 \times 0.32)$ or $0.256 / 1.792$	C1
	= 0.14	A1

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Question	Answer	Marks
5(c)	$7.2 - 5.6 - 2.5I - 3.5I = 0$	C1
	$I = 0.27 \text{ A}$	A1

Question	Answer	Marks
6(a)	path/direction in which a (free) <u>positive</u> charge will move	B1
6(b)	(lines) closer together in Y/further apart in X	B1
6(c)(i)	$a = Eq / m$ or $F = Eq$ and $F = ma$	C1
	ratio = $(1e / 0.15 \text{ u}) \times (4 \text{ u} / 2e)$ or $1 / 0.15 \times 4 / 2$	C1
	ratio = 13	A1
6(c)(ii)	down quark charge is $-(1/3)e$	C1
	$-(1/3)e + q = -1e$ so $q = -(2/3)e$	A1
	$-(2/3)e$ is anti-up / $\bar{u}$ (quark) (<i>allow charm or top antiquark</i>)	B1

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1(a)(i)	potential difference / current	B1
1(a)(ii)	$R = 4.0 \times 10^9 (\Omega)$	C1
	$I = 0.60 / 4.0 \times 10^9 = 1.5 \times 10^{-10} (\text{A})$	A1
	$I = 150 \text{ pA}$	
1(b)	units of energy: $\text{kg m}^2 \text{s}^{-2}$	C1
	units of charge: As	C1
	units of potential difference: $(\text{kg m}^2 \text{s}^{-2} / \text{As} =) \text{kg m}^2 \text{A}^{-1} \text{s}^{-3}$	A1

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Question	Answer	Marks
2(a)(i)	1. $W = mas$	B1
	2. $s = (v^2 - u^2) / 2a$	B1
2(a)(ii)	W/work equals energy transferred/ <u>gain or change in</u> kinetic energy	B1
	$W (= mas) = ma(v^2 - u^2) / 2a$	B1
	leading to $W = m(v^2 - u^2) / 2$ (so $KE = \frac{1}{2}mv^2$)	
2(b)(i)	1. solid curved line drawn from X to Y along path of ball and labelled D	B1
	2. solid straight line drawn from X to Y and labelled S	B1
2(b)(ii)	$(\Delta)E = mg(\Delta)h$	C1
	$4.5 = (0.040 \times 9.81 \times h) + (\frac{1}{2} \times 0.040 \times 9.5^2)$	C1
	$h = 6.9 \text{ m}$	A1
2(b)(iii)	line with a negative gradient starting from a non-zero value of kinetic energy when the vertical height is zero	M1
	<u>straight</u> line ends at a non-zero value of kinetic energy when the vertical height is h	A1

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Question	Answer	Marks
3(a)	$P = Fv$	C1
	$P = 8.9 \cos 30^\circ \times 0.60$ $= 4.6 \text{ W}$	A1
3(b)	$p = F / A$	C1
	$F = 8.9 \sin 30^\circ + (0.24 \times 9.81)$ $(= 6.80 \text{ N})$	C1
	$A = 6.80 / 3500$ $= 1.9 \times 10^{-3} \text{ m}^2$	A1
3(c)(i)	upwards/up	B1
3(c)(ii)	the Earth/planet	B1

Question	Answer	Marks
4(a)	straight (horizontal) lines and from the +0.90 kV plate/to the 0 V plate	B1
	(lines are) equally spaced	B1
4(b)	weight/gravitational force and electric force	B1
4(c)	$s = \frac{1}{2}at^2$ or $s = ut + \frac{1}{2}at^2$ and $u = 0$	C1
	$2.0 = \frac{1}{2} \times 9.81 \times t^2$ so $t = 0.64$ s	A1
4(d)	$0.080 = \frac{1}{2} \times a \times 0.64^2$	C1
	$a = 0.39$ m s ⁻²	A1
4(e)(i)	$E = (\Delta)V / (\Delta)d$	C1
	$E = 0.90 \times 10^3 / 0.12$ $= 7.5 \times 10^3$ N C ⁻¹	A1
4(e)(ii)	$ma = Eq$ or $F = ma$ and $F = Eq$	C1
	$q / m = 0.39 / 7.5 \times 10^3$ $= 5.2 \times 10^{-5}$ C kg ⁻¹	A1
4(f)(i)	no effect	B1
4(f)(ii)	decreases/smaller	B1

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Question	Answer	Marks
5(a)	(incident) wave reflects at end/top of tube	B1
	(incident) wave and reflected wave interfere/superpose	B1
5(b)	line has maximum value of amplitude at $h = 0$ and $h = 0.60$ m only	B1
	line has minimum/zero value of amplitude at $h = 0.30$ m only	B1
5(c)(i)	vertical/along length of tube/along axis of tube	B1
5(c)(ii)	phase difference = 0	A1
5(d)	$v = f\lambda$	C1
	$v = 340 / (2 \times 0.60)$ $= 280$ Hz	A1
5(e)	$f = 340 / 0.60$ $= 570$ Hz	A1

Question	Answer	Marks
6(a)	volt / ampere	B1
6(b)(i)	1. $I = 1.8 + 0.60$ $= 2.4 \text{ A}$	A1
	2. $(8.0 \times 0.60) = 1.8 \times (2.0 + R_Z)$	C1
	$R_Z = 0.67 \Omega$	A1
	3. $E - (2.4 \times 1.5) = (0.60 \times 8.0)$ or $E - (2.4 \times 1.5) = 1.8 \times (2.0 + 0.67)$ or $E = 2.4 \times [1.5 + (8.0 \times 2.67) / (8.0 + 2.67)]$	C1
	$E = 8.4 \text{ V}$	A1
6(b)(ii)	1. $R = \rho L / A$ or $R \propto 1 / A$	C1
	ratio $= R_Y / R_X = 2.0 / 8.0$ $= 0.25$	A1
	2. $I \propto Av$ or $I_X / I_Y = A_X v_X / A_Y v_Y$	C1
	ratio $= (0.60 / 1.8) \times (1 / 0.25)$ $= 1.3$	A1

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Question	Answer	Marks
7(a)	beta/ β	B1
7(b)	alpha/ α	B1
7(c)	gamma/ γ	B1
7(d)	beta/ β	B1