

Markscheme

November 2020

Physics

Higher level

Paper 2

19 pages

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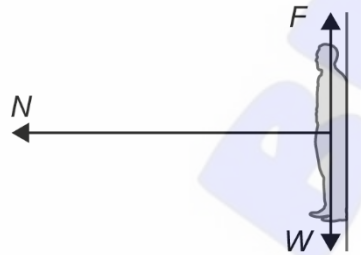
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Question			Answers	Notes	Total
1.	a	i	zero ✓		1
1	a	ii	Blades exert a downward force on the air ✓ air exerts an equal and opposite force on the blades «by Newton's third law» OR air exerts a reaction force on the blades «by Newton's third law» ✓	<i>Downward direction required for MP1.</i>	2
1	a	iii	«lift force/change of momentum in one second» = $1.7v$ ✓ $1.7v = (0.95 + 0.45) \times 9.81$ ✓ $v = 8.1$ «ms ⁻¹ » AND answer expressed to 2 sf only ✓	<i>Allow 8.2 from $g = 10 \text{ ms}^{-2}$.</i>	3
1	a	iv	ALTERNATIVE 1 power «=rate of energy transfer to the air = $\frac{1}{2} \frac{\Delta m}{\Delta t} v^2$ » = $\frac{1}{2} \times 1.7 \times 8.1^2$ ✓ = 56 «W» ✓ ALTERNATIVE 2 Power« = Force x v ave» = $(0.95 + 0.45) \times 9.81 \times \frac{8.1}{2}$ ✓ = 56 «W» ✓		2

Question		Answers	Notes	Total
1	b	vertical force= lift force – weight OR $= 0.45 \times 9.81$ OR $= 4.4$ «N» ✓ acceleration = $\frac{0.45 \times 9.81}{0.95} = 4.6$ «ms ⁻² » ✓		2

Question		Answers	Notes	Total
2.	a	<p>arrow downwards labelled weight/W/mg and arrow upwards labelled friction/F ✓ arrow horizontally to the left labelled «normal» reaction/N ✓</p> 	<p><i>Ignore point of application of the forces but do not allow arrows that do not touch the object.</i></p> <p><i>Do not allow horizontal force to be labelled 'centripetal' or R.</i></p>	2
2	b	<p>See $F = \mu N$ AND $N = mR\omega^2$ ✓</p> <p>«substituting for N» $\mu m\omega^2 R = mg$ ✓</p>		2

Question		Answers	Notes	Total
2	c	<p>ALTERNATIVE 1</p> <p>minimum required angular velocity « = $\sqrt{\frac{9.81}{0.40 \times 3.5}}$ » = 2.6 « rad s⁻¹ » ✓</p> <p>actual angular velocity « = $\frac{2\pi}{\left(\frac{60}{28}\right)}$ » = 2.9 « rad s⁻¹ » ✓</p> <p>actual angular velocity is greater than the minimum, so the person does not slide ✓</p> <p>ALTERNATIVE 2</p> <p>minimum friction force = $mg = \text{« } 9.81\text{m »}$ ✓</p> <p>actual friction force « = $\mu m R \omega^2 = 0.40 \text{ m} \times 3.5 \left(2\pi \frac{28}{60}\right)^2$ » = 12.0 m ✓</p> <p>actual friction force is greater than the minimum frictional force so the person does not slide ✓</p>	<p>Allow 2.7 from $g = 10 \text{ ms}^{-2}$.</p>	3

Question			Answers	Notes	Total
3.	a	i	« $15 \times 30 \times 60$ » = 27000 «J» ✓		1
3	a	ii	$27 \times 10^3 = 0.32 \times c \times (290 - 250)$ OR 2100 ✓ J kg ⁻¹ K ⁻¹ OR J kg ⁻¹ °C ⁻¹ ✓	Allow any appropriate unit that is $\frac{\text{energy}}{\text{mass} \times \text{temperature}}$	2
3	b		«intermolecular» bonds are formed during freezing ✓ bond-forming process releases energy OR «intermolecular» PE decreases «and the difference is transferred as heat» ✓ «average random» KE of the molecules does not decrease/change ✓ temperature is related to «average» KE of the molecules «hence unchanged» ✓	To award MP3 or MP4 molecules/particles/atoms must be mentioned.	3 max
3	c		mass of frozen oil « $= \frac{27 \times 10^3}{130 \times 10^3}$ » = 0.21 «kg» ✓ unfrozen mass « $= 0.32 - 0.21$ » = 0.11 «kg» ✓		2

Question		Answers	Notes	Total
4.	a	wavelength = $\frac{340}{850} = 0.40$ «m» ✓ path difference = 1.8 «m» ✓ 1.8 «m» = 4.5λ OR $\frac{1.8}{0.20} = 9$ «half-wavelengths» ✓ waves meet in antiphase «at P» OR destructive interference/superposition «at P» ✓	Allow approach where path length is calculated in terms of number of wavelengths; along path A (56.25) and path B (60.75) for MP2, hence path difference 4.5 wavelengths for MP3	4
4	b	«equally spaced» maxima and minima ✓ a maximum at Q ✓ four «additional» maxima «between P and Q» ✓		2 max
4	c	the amplitude of sound at Q is halved ✓ «intensity is proportional to amplitude squared hence» $\frac{I_A}{I_0} = \frac{1}{4}$ ✓		2

Question			Answers	Notes	Total
4.	d	i	speed of sound relative to the microphone is less ✓ wavelength unchanged «so frequency is lower» OR fewer waves recorded in unit time/per second «so frequency is lower» ✓		2
4	d	ii	$845 = 850 \times \frac{340 - v}{340} \quad \checkmark$ $v = 2.00 \text{ «m s}^{-1}\text{»} \quad \checkmark$		2

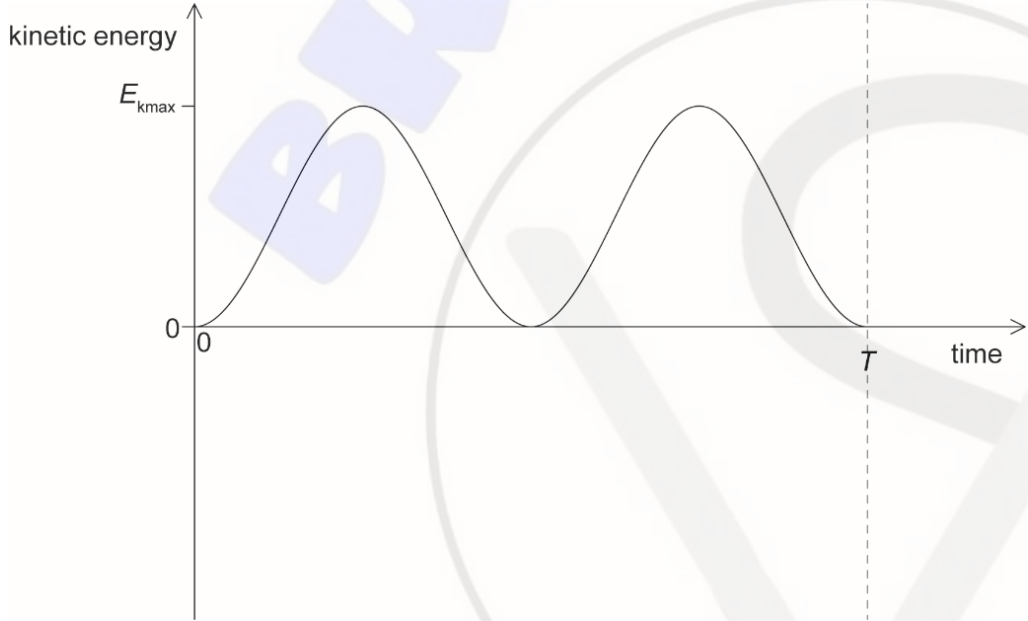
Question			Answers	Notes	Total
5.	a		current is not «directly» proportional to the potential difference OR resistance of X is not constant OR resistance of X changes «with current/voltage» ✓		1
5	b	i	ALTERNATIVE 1 voltage across X = 2.3 «V» ✓ voltage across R «= 4.0 – 2.3» = 1.7 «V» ✓ resistance of variable resistor «= $\frac{1.7}{0.020}$ » = 85 «Ω» ✓ ALTERNATIVE 2 overall resistance «= $\frac{4.0}{0.020}$ » = 200«Ω» ✓ resistance of X «= $\frac{2.3}{0.020}$ » = 115 «Ω» ✓ resistance of variable resistor «= 200 – 115» = 85 «Ω» ✓		3
5	b	ii	power «= 4.0 × 0.020» = 0.080 «W» ✓		1

Question			Answers	Notes	Total
5.	c	i	from 0 to 60 mA ✓		1
5	c	ii	<p>ALTERNATIVE 1</p> <p>current from the cell is greater «than 20 mA» ✓ because some of the current must flow through section SQ of the potentiometer ✓ overall power greater «than in part (b)» ✓</p> <p>ALTERNATIVE 2</p> <p>total/overall resistance decreases ✓ because SQ and X are in parallel ✓ overall power greater «than in part (b)» ✓</p>	<i>Allow the reverse argument.</i>	3

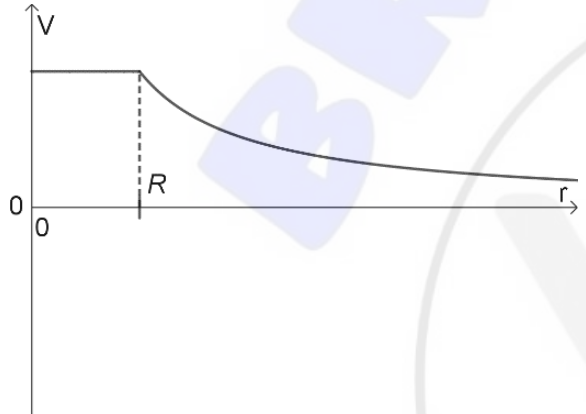
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6.	a	i	energy required to «completely» separate the nucleons OR energy released when a nucleus is formed from its constituent nucleons ✓	<i>Allow protons AND neutrons.</i>	1
6	a	ii	the values «in SI units» would be very small ✓		1
6	a	iii	$140 \times 8.29 + 94 \times 8.59 - 235 \times 7.59$ OR 184 «MeV» ✓		1
6	b	i	see «energy \Rightarrow » $180 \times 10^6 \times 1.60 \times 10^{-19}$ AND «mass \Rightarrow » $235 \times 1.66 \times 10^{-27}$ ✓ 7.4×10^{13} «J kg ⁻¹ » ✓		2
6	b	ii	energy produced in one day = $\frac{1.2 \times 10^9 \times 24 \times 3600}{0.36} = 2.9 \times 10^{14}$ «J» ✓ mass = $\frac{2.9 \times 10^{14}}{7.4 \times 10^{13}} = 3.9$ «kg» ✓		2
6	b	iii	«specific energy of uranium is much greater than that of coal, hence» more energy can be produced from the same mass of fuel / per kg OR less fuel can be used to create the same amount of energy ✓		1

Question			Answers	Notes	Total
6	c	i	39 ✓	Do not allow ${}_{39}^{94}\text{X}$ unless the proton number is indicated.	1
6	c	ii	75 «s» ✓		1
6.	c	iii	<p>ALTERNATIVE 1</p> <p>10 min = 8 $t_{1/2}$ ✓</p> <p>mass remaining = $1.0 \times \left(\frac{1}{2}\right)^8 = 3.9 \times 10^{-3}$ «kg» ✓</p> <p>ALTERNATIVE 2</p> <p>decay constant = « $\frac{\ln 2}{75}$ = » 9.24×10^{-3} «s⁻¹» ✓</p> <p>mass remaining = $1.0 \times e^{-9.24 \times 10^{-3} \times 600} = 3.9 \times 10^{-3}$ «kg» ✓</p>		2

Question		Answers	Notes	Total
7.	a	the «restoring» force/acceleration is proportional to displacement ✓	<i>Allow use of symbols i.e. $F \propto -x$ or $a \propto -x$</i>	1
7	b	Evidence of equating $m\omega^2x = \rho Agx$ «to obtain $\frac{\rho Ag}{m} = \omega^2$ » ✓ $\omega = \sqrt{\frac{1.03 \times 10^3 \times 2.29 \times 10^{-1} \times 9.81}{118}}$ OR 4.43 «rad s ⁻¹ » ✓	<i>Answer to at least 3 s.f.</i>	2
7	c	i « E_k is a maximum when $x = 0$ hence» $E_{k, \max} = \frac{1}{2} \times 118 \times 4.4^2 (0.250^2 - 0^2)$ ✓ 71.4 «J» ✓		2

Question			Answers	Notes	Total
7.	c	ii	<p>energy never negative ✓ correct shape with two maxima ✓</p> 		2

Question		Answers	Notes	Total
8.	a	<p>ALTERNATIVE 1 work done on moving a positive test charge in any outward direction is negative ✓ potential difference is proportional to this work «so V decreases from A to B» ✓</p> <p>ALTERNATIVE 2 potential gradient is directed opposite to the field so inwards ✓ the gradient indicates the direction of increase of V «hence V increases towards the centre/decreases from A to B» ✓</p> <p>ALTERNATIVE 3 $V = \frac{kQ}{R}$ so as r increases V decreases ✓ V is positive as Q is positive ✓</p> <p>ALTERNATIVE 4 the work done per unit charge in bringing a positive charge from infinity ✓ to point B is less than point A ✓</p>		2

Question			Answers	Notes	Total
8.	b		curve decreasing asymptotically for $r > R$ ✓ non – zero constant between 0 and R ✓ 		2
8	c	i	$\ll \frac{W}{q} = \frac{1.7 \times 10^{-16}}{1.60 \times 10^{-19}} = \gg 1.1 \times 10^3 \ll \text{« V »} \gg \checkmark$		1
8	c	ii	$8.99 \times 10^9 \times Q \times \left(\frac{1}{5.0 \times 10^{-2}} - \frac{1}{1.0 \times 10^{-1}} \right) = 1.1 \times 10^3 \checkmark$ $Q = 1.2 \times 10^{-8} \ll \text{« C »} \gg \checkmark$		2
8	d		to highlight similarities between «different» fields ✓		1

Question			Answers	Notes	Total
9.	a		there is a magnetic flux «linkage» in the coil / coil cuts magnetic field ✓ this flux «linkage» changes as the angle varies/coil rotates ✓ «Faraday's law» connects induced emf with rate of change of flux «linkage» with time ✓	<i>Do not award MP2 or 3 for answers that don't discuss flux.</i>	3
9	b	i	$V_{\text{rms}} = \frac{25 \times 10^3}{\sqrt{2}} \text{ «} = 17.7 \times 10^3 \text{ V} \text{» } \checkmark$ $I_{\text{rms}} = \frac{8.5 \times 10^5}{17.7 \times 10^3} = 48 \text{ « A » } \checkmark$		2
9	b	ii	«power loss proportional to I^2 hence the step-up factor is $\sqrt{2.5 \times 10^2}$ » 16 ✓		1
9	b	iii	peak emf doubles ✓ T halves ✓	<i>Must show at least 1 cycle.</i>	2

Question			Answers	Notes	Total
10.	a		$\lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{1.60 \times 10^{-19} \times 4.2 \times 10^8}$ OR $= 2.96 \times 10^{-15}$ «m» ✓	Answer to at least 2 s.f. (i.e. 3.0)	1
10	b	i	«the shape of the graph suggests that» electrons undergo diffraction «with carbon nuclei» ✓ only waves diffract ✓		2
10	b	ii	$\sin \theta_0 = \frac{2.96 \times 10^{-15}}{4.94 \times 10^{-15}}$ «= 0.599» ✓ 37 «degrees» OR 0.64/0.65 «rad» ✓		2
10	b	iii	the de Broglie wavelength of electrons is «much» longer than the size of a nucleus ✓ hence electrons would not undergo diffraction OR no diffraction pattern would be observed ✓		2
10	c		volume of a nucleus proportional to $\left(A^{\frac{1}{3}}\right)^3 = A$ AND mass proportional to A ✓ the ratio $\frac{\text{mass}}{\text{volume}}$ independent of A «hence density the same for all nuclei» ✓	Both needed for MP1	2