Markscheme

November 2020

Physics

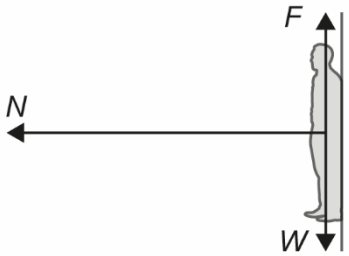
Higher level

Paper 2

19 pages

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**»** ✓	*Downward direction required for **MP1**.*	**2**
1	**a**	**iii**	**«**lift force/change of momentum in one second**»** $= 1.7\,\text{v}$ ✓ $1.7v = (0.95 + 0.45) \times 9.81$ ✓ $v = 8.1\,\text{«ms}^{-1}\text{»}$ ***AND*** answer expressed to 2 sf only ✓	*Allow 8.2 from g = 10 ms^{-2}.*	**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**		arrow downwards labelled weight/W/*mg* and arrow upwards labelled friction/*F* ✓ arrow horizontally to the left labelled **«**normal**»** reaction/*N* ✓ 	*Ignore point of application of the forces but do not allow arrows that do not touch the object.* *Do not allow horizontal force to be labelled 'centripetal' or R.*	**2**
2	**b**		See $F = \mu N$ ***AND*** $N = mR\omega^2$ ✓ **«**substituting for N**»** $\mu m\omega^2 R = mg$ ✓		**2**

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

Question			Answers	Notes	Total
3.	**a**	**i**	**«**$15\times30\times60$**»** $=27000$ **«J»** ✓		**1**
3	**a**	**ii**	$27\times10^{3}=0.32\times c\times(290-250)$ ***OR*** 2100 ✓ J kg^{-1} K^{-1} ***OR*** J kg^{-1} ^{0}C^{-1} ✓	*Allow any appropriate unit that is* $\frac{energy}{mass\times temperature}$	**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 **«**$=\frac{27\times10^{3}}{130\times10^{3}}$**»** $=0.21$**«**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**	$845 = 850 \times \frac{340 - v}{340}$ ✓ $v = 2.00$ **«**m s^{-1}**»** ✓		**2**

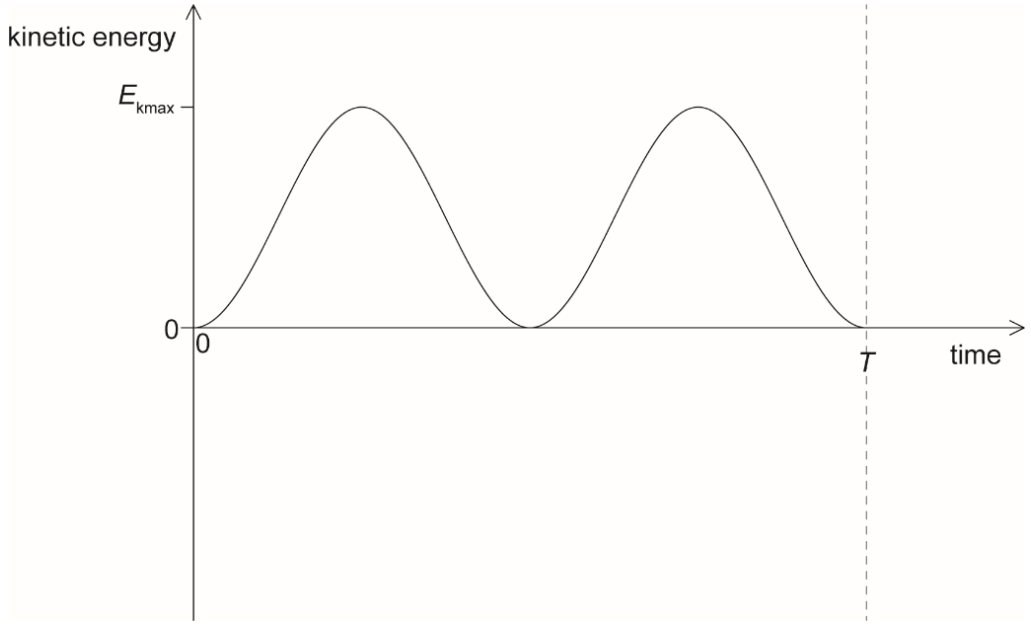
Question			Answers	Notes	Total
5.	**a**		current is not «directly» proportional to the potential difference ***OR*** resistance of X is not constant ***OR*** resistance of X changes «with current/voltage» ✓		**1**
5	**b**	**i**	***ALTERNATIVE 1*** voltage across X = 2.3 «V» ✓ voltage across R «$= 4.0 - 2.3$» $= 1.7$ «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 «$= 4.0 \times 0.020$» $= 0.080$ «W» ✓		**1**

Question			Answers	Notes	Total
5.	**c**	**i**	from 0 to 60 mA ✓		**1**
5	**c**	**ii**	***ALTERNATIVE 1*** 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)**»** ✓ ***ALTERNATIVE 2*** total/overall resistance decreases ✓ because SQ and X are in parallel ✓ overall power greater **«**than in part (b)**»** ✓	*Allow the reverse argument.*	**3**

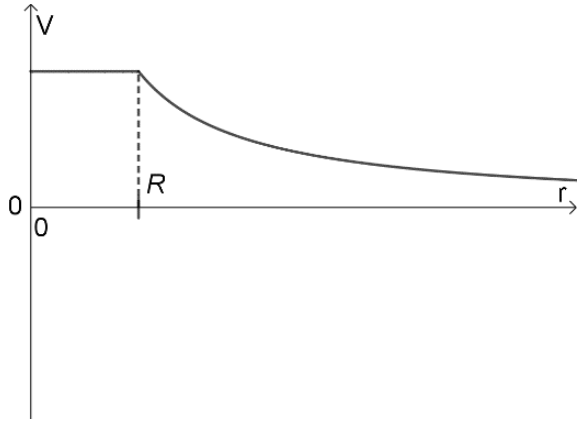
Question			Answers	Notes	Total
6.	a	i	energy required to «completely» separate the nucleons ***OR*** energy released when a nucleus is formed from its constituent nucleons ✓	*Allow protons **AND** neutrons.*	**1**
6	a	ii	the values «in SI units» would be very small ✓		**1**
6	a	iii	$140 \times 8.29 + 94 \times 8.59 - 235 \times 7.59$ ***OR*** 184 «MeV» ✓		**1**
6	b	i	see «energy =» $180 \times 10^{6} \times 1.60 \times 10^{-19}$ ***AND*** «mass =» $235 \times 1.66 \times 10^{-27}$ ✓ 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* $^{94}_{39}\mathrm{X}$ *unless the proton number is indicated.*	**1**
6	**c**	**ii**	75 **«**s**»** ✓		**1**
6.	**c**	**iii**	***ALTERNATIVE 1*** 10 min $= 8\ t_{1/2}$ ✓ mass remaining $= 1.0 \times \left(\frac{1}{2}\right)^8 = 3.9 \times 10^{-3}$ **«**kg**»** ✓ ***ALTERNATIVE 2*** decay constant $=$ **«** $\frac{\ln 2}{75} =$ **»** 9.24×10^{-3} **«** s^{-1} **»** ✓ mass remaining $= 1.0 \times e^{-9.24 \times 10^{-3} \times 600} = 3.9 \times 10^{-3}$ **«**kg**»** ✓		**2**

Question			Answers	Notes	Total
7.	**a**		the **«**restoring**»** force/acceleration is proportional to displacement ✓	*Allow use of symbols* *i.e. $F \propto -x$ or $a \propto -x$*	**1**
7	**b**		Evidence of equating $m\omega^2 x = \rho A g x$ **«**to obtain $\frac{\rho A g}{m} = \omega^2$ **»** ✓ $\omega = \sqrt{\frac{1.03\times10^3 \times 2.29\times10^{-1} \times 9.81}{118}}$ ***OR*** 4.43 **«**rad s^{-1}**»** ✓	*Answer to at least 3 s.f.*	**2**
7	**c**	**i**	**«**E_K is a maximum when $x = 0$ hence**»** $E_{K,\,max} = \frac{1}{2}\times118\times4.4^2\left(0.250^2 - 0^2\right)$ ✓ 71.4 **«**J**»** ✓		**2**

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

Question			Answers	Notes	Total
8.	a		***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**»** ✓ ***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**»** ✓ ***ALTERNATIVE 3*** $V = \frac{kQ}{R}$ so as *r* increases *V* decreases ✓ *V* is positive as *Q* is positive ✓ ***ALTERNATIVE 4*** the work done per unit charge in bringing a positive charge from infinity ✓ to point B is less than point A ✓		**2**

Question			Answers	Notes	Total
8.	**b**		curve decreasing asymptotically for $r > R$ ✓ non – zero constant between 0 and R ✓  		**2**
8	**c**	**i**	« $\frac{W}{q} = \frac{1.7\times10^{-16}}{1.60\times10^{-19}}$ =» 11×10^{3} «V» ✓		**1**
8	**c**	**ii**	$8.99\times10^{9}\times Q\times\left(\frac{1}{5.0\times10^{-2}}-\frac{1}{1.0\times10^{-1}}\right)=1.1\times10^{3}$ ✓ $Q = 1.2\times10^{-8}$ «C» ✓		**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 ✓	*Do not award MP2 or 3 for answers that don't discuss flux.*	**3**
9	**b**	**i**	$V_{\text{rms}} = \frac{25\times10^3}{\sqrt{2}}$ **«**$= 17.7\times10^3$ V**»** ✓ $I_{\text{rms}} = \frac{8.5\times10^5}{17.7\times10^3} = 48$ **«**A**»** ✓		**2**
9	**b**	**ii**	**«**power loss proportional to I^2 hence the step-up factor is $\sqrt{2.5\times10^2}$ **»**16 ✓		**1**
9	**b**	**iii**	peak emf doubles ✓ *T* halves ✓	*Must show at least 1 cycle.*	**2**

Question			Answers	Notes	Total
10.	**a**		$\lambda = \frac{6.63\times10^{-34}\times3\times10^{8}}{1.60\times10^{-19}\times4.2\times10^{8}}$ ***OR*** $= 2.96\times10^{-15}$ **«**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**	$\sin\theta_0 = \frac{2.96\times10^{-15}}{4.94\times10^{-15}}$ **«**$= 0.599$**»** ✓ 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**