

Markscheme

November 2017

Physics

Higher level

Paper 2

15 pages

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Question		Answers	Notes	Total
1.	a	arrow vertically downwards labelled weight «of sledge and/or girl»/W/mg/gravitational force/ $F_g/F_{\text{gravitational}}$ AND arrow perpendicular to the snow slope labelled reaction force/R/normal contact force/N/ F_N ✓ friction force/F/f acting up slope «perpendicular to reaction force» ✓	Do not allow G/g/“gravity”. Do not award MP1 if a “driving force” is included. Allow components of weight if correctly labelled. Ignore point of application or shape of object. Ignore “air resistance”. Ignore any reference to “push of feet on sledge”. Do not award MP2 for forces on sledge on horizontal ground The arrows should contact the object	2
1.	b	gravitational force/weight from the Earth «downwards» ✓ reaction force from the sledge/snow/ground «upwards» ✓ no vertical acceleration/remains in contact with the ground/does not move vertically as there is no resultant vertical force ✓	Allow naming of forces as in (a) Allow vertical forces are balanced/equal in magnitude/cancel out	3
1.	c	mention of conservation of momentum OR $5.5 \times 4.2 = (55 + 5.5) \llcorner v \llcorner$ ✓ $0.38 \llcorner \text{m s}^{-1} \llcorner$ ✓	Allow $p = p'$ or other algebraically equivalent statement Award [0] for answers based on energy	2
1.	d	same change in momentum/impulse ✓ the time taken «to stop» would be greater «with the snow» ✓ $F = \frac{\Delta p}{\Delta t}$ therefore F is smaller «with the snow» OR force is proportional to rate of change of momentum therefore F is smaller «with the snow» ✓	Allow reverse argument for ice	3

(continued...)

(Question 1 continued)

Question			Answers	Notes	Total
1.	e	i	<p>«friction force down slope» = $\mu mg \cos(6.5) = \text{«}5.9\text{N}\text{»}$ ✓</p> <p>«component of weight down slope» = $mg \sin(6.5) = \text{«}6.1\text{N}\text{»}$ ✓</p> <p>«so $a = \frac{F}{m}$ » acceleration = $\frac{12}{5.5} = 2.2 \text{ «ms}^{-2}\text{»}$ ✓</p>	<p>Ignore negative signs</p> <p>Allow use of $g = 10 \text{ms}^{-2}$</p>	3
1.	e	ii	<p>correct use of kinematics equation ✓</p> <p>distance = 4.4 or 4.0 «m» ✓</p> <p>Alternative 2</p> <p>KE lost = work done against friction + GPE ✓</p> <p>distance = 4.4 or 4.0 «m» ✓</p>	<p>Allow ECF from (e)(i)</p> <p>Allow [1 max] for GPE missing leading to 8.2 «m»</p>	2
1.	f		<p>calculates a maximum value for the frictional force = «$\mu R = \text{«}7.5 \text{N}\text{»}$» ✓</p> <p>sledge will not move as the maximum static friction force is greater than the component of weight down the slope ✓</p>	<p>Allow correct conclusion from incorrect MP1</p> <p>Allow $7.5 > 6.1$ so will not move</p>	2
2.	a		<p>«$v = \sqrt{\frac{Gm_E}{r}}$» = $\sqrt{\frac{6.67 \times 10^{-11} \times 6.0 \times 10^{24}}{6600 \times 10^3}}$ ✓</p> <p>7800 «ms⁻¹» ✓</p>	<p>Full substitution required</p> <p>Must see 2+ significant figures.</p>	2
2.	b	i	<p>Y has smaller orbit/orbital speed is greater so time period is less ✓</p>	<p>Allow answer from appropriate equation</p> <p>Allow converse argument for X</p>	1

(continued...)

(Question 2 continued)

Question			Answers	Notes	Total
2.	b	ii	to stop Y from getting ahead ✓ to remain stationary with respect to X ✓ otherwise will add tension to cable/damage satellite/pull X out of its orbit ✓		2 max
2.	c		cable is a conductor and contains electrons ✓ electrons/charges experience a force when moving in a magnetic field ✓ use of a suitable hand rule to show that satellite Y becomes negative «so X becomes positive» ✓ Alternative 2 cable is a conductor ✓ so current will flow by induction flow when it moves through a B field ✓ use of a suitable hand rule to show current to right so «X becomes positive» ✓	<i>Marks should be awarded from either one alternative or the other.</i> <i>Do not allow discussion of positive charges moving towards X</i>	3
2.	d		electrons would build up at satellite Y/positive charge at X ✓ preventing further charge flow ✓ by electrostatic repulsion ✓ unless a complete circuit exists ✓		3 max
2.	e		« $\varepsilon = Blv =$ » $31 \times 10^{-6} \times 7790 \times 15000$ ✓ 3600 «V» ✓	<i>Allow 3700 «V» from $v = 8000 \text{ ms}^{-1}$.</i>	2

(continued...)

(Question 2 continued)

Question			Answers	Notes	Total
2.	f	i	use of $k = \frac{4\pi^2 m}{T^2} \Rightarrow \frac{4 \times \pi^2 \times 350}{5.2^2} \checkmark$ 510 \checkmark N m ⁻¹ or kg s ⁻² \checkmark	Allow MP1 and MP2 for a bald correct answer Allow 500 Allow N/m etc	3
2.	f	ii	E_p in the cable/system transfers to E_k of Y \checkmark and back again twice in each cycle \checkmark	Exclusive use of gravitational potential energy negates MP1	2

Question			Answers	Notes	Total
3.	a	i	«electron» neutrino ✓ it has a lepton number of 1 «as lepton number is conserved» ✓ it has a charge of zero/is neutral «as charge is conserved» OR it has a baryon number of 0 «as baryon number is conserved» ✓	Do not allow antineutrino Do not credit answers referring to energy	3
3.	a	ii	hadrons experience strong force OR leptons do not experience the strong force ✓ hadrons made of quarks/not fundamental OR leptons are not made of quarks/are fundamental ✓ hadrons decay «eventually» into protons OR leptons do not decay into protons ✓	Accept leptons experience the weak force Allow “interaction” for “force”	2 max

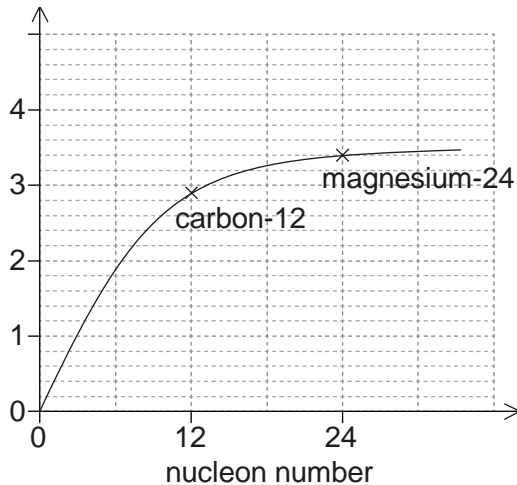
(continued...)

(Question 3 continued)

Question			Answers	Notes	Total
3.	b	i	«high energy particles incident on» thin sample ✓ detect angle/position of deflected particles ✓ reference to interference/diffraction/minimum/maximum/numbers of particles ✓	Allow "foil" instead of thin	2 max
3.	b	ii	$\lambda \propto \frac{1}{\sqrt{E}}$ OR $\lambda \propto \frac{1}{E}$ ✓ so high energy gives small λ ✓ to match the small nuclear size ✓ Alternative 2 $E = hf$ /energy is proportional to frequency ✓ frequency is inversely proportional to wavelength/ $c = f\lambda$ ✓ to match the small nuclear size ✓ Alternative 3 higher energy means closer approach to nucleus ✓ to overcome the repulsive force from the nucleus ✓ so greater precision in measurement of the size of the nucleus ✓	Accept inversely proportional Only allow marks awarded from one alternative	3
3.	c		two analogous situations stated ✓ one element of the analogy equated to an element of physics ✓	eg: moving away from Earth is like climbing a hill where the contours correspond to the equipotentials Atoms in an ideal gas behave like pool balls The forces between them only act during collisions	2

(continued...)

(Question 3 continued)

Question			Answers	Notes	Total
3.	d	i	$R = 2.7 \times 10^{-15} \times 2^{\frac{1}{3}} \checkmark$ $3.4 - 3.5 \times 10^{-15} \text{ «m» } \checkmark$	Allow use of the Fermi radius from the data booklet	2
3.	d	ii	correctly plotted \checkmark	Allow ECF from (d)(i)	1
3.	d	iii	<u>single smooth curve</u> passing through both points with decreasing gradient \checkmark through origin \checkmark	nuclear radius / 10^{-15} m 	2

Question			Answers	Notes	Total
4.	a	i	$\left\langle l = \frac{RA}{\rho} = \frac{82 \times 8 \times 10^{-3} \times 2 \times 10^{-6}}{4.1 \times 10^{-5}} \right\rangle$ 0.032 «m» ✓		1
4.	a	ii	power = $1500 \times 8 \times 10^{-3} \times 0.032$ « = 0.384 » ✓ $\left\langle \text{current} \leq \sqrt{\frac{\text{power}}{\text{resistance}}} = \sqrt{\frac{0.384}{82}} \right\rangle$ 0.068 «A» ✓	Be aware of ECF from (a)(i) Award [1] for 4.3 «A» where candidate has not calculated area	2
4.	a	iii	quantities such as resistivity depend on the material OR they allow the selection of the correct material OR they allow scientists to compare properties of materials ✓		1
4.	b		as area is larger and length is smaller ✓ resistance is «very much» smaller ✓	Award [1 max] for answers that involve a calculation	2
5.	a	i	$\left\langle v = c \frac{\sin i}{\sin r} = \right\rangle \frac{3 \times 10^8 \times \sin(33)}{\sin(46)} \checkmark$ 2.3 × 10 ⁸ «ms ⁻¹ » ✓		2

(continued...)

(Question 5 continued)

Question			Answers	Notes	Total
5.	a	ii	light strikes AB at an angle of 57° ✓ critical angle is $\sin^{-1}\left(\frac{2.3}{3}\right) = 50.1^\circ$ ✓ angle of incidence is greater than critical angle so total internal reflection OR light strikes AB at an angle of 57° ✓ calculation showing \sin of "refracted angle" = 1.1 ✓ statement that since $1.1 > 1$ the angle does not exist and the light does not emerge ✓	49.2° from unrounded value	3 max
5.	a	iii	total internal reflection shown ✓ ray emerges at opposite face to incidence ✓	With sensible refraction in correct direction	2
5.	b	i	mass = « volume × density » $(0.75)^3 \times 920 = 388 \text{ kg}$ ✓ energy required to raise temperature = $388 \times 2100 \times 20 = 1.63 \times 10^7 \text{ J}$ ✓ energy required to melt = $388 \times 330 \times 10^3 = 1.28 \times 10^8 \text{ J}$ ✓ $1.4 \times 10^8 \text{ J}$ OR $1.4 \times 10^5 \text{ kJ}$ ✓	Accept any consistent units Award [3 max] for answer which uses density as 1000 kg^{-3} ($1.5 \times 10^8 \text{ J}$)	4
5.	b	ii	in solid state, nearest neighbour molecules cannot exchange places/have fixed positions/are closer to each other/have regular pattern/have stronger forces of attraction ✓ in liquid, bonds between molecules can be broken and re-form ✓	OWTTE Accept converse argument for liquids	1 max

Question			Answers	Notes	Total
6.	a	i	<p>the diagram shows the combined effect of «single slit» diffraction and «double slit» interference ✓</p> <p>recognition that there is a minimum of the single slit pattern</p> <p>OR</p> <p>a missing maximum of the double slit pattern at A ✓</p> <p>waves «from the single slit» are in antiphase/cancel/have a path difference of $(n + \frac{1}{2})\lambda$/destructive interference at A ✓</p>		2 max
6.	a	ii	$\theta = \frac{4.1 \times 10^{-2}}{7.0} \quad \text{OR} \quad b = \frac{\lambda}{\theta} \quad \text{«} = \frac{7.0 \times 5.9 \times 10^{-7}}{4.1 \times 10^{-2}} \text{»} \quad \checkmark$ <p>1.0×10^{-4} «m» ✓</p>	<p>Award [0] for use of double slit formula (which gives the correct answer so do not award BCA)</p> <p>Allow use of sin or tan for small angles</p>	2
6.	a	iii	<p>use of $s = \frac{\lambda D}{d}$ with 3 fringes « $\frac{590 \times 10^{-9} \times 7.0}{4.1 \times 10^{-2}}$ » ✓</p> <p>3.0×10^{-4} «m» ✓</p>	Allow ECF.	2

(continued...)

(Question 6 continued)

Question			Answers	Notes	Total
6.	b	i	<p>fringes are further apart because the separation of slits is «much» less intensity does not change «significantly» across the pattern or diffraction envelope is broader because slits are «much» narrower</p> <p>the fringes are narrower/sharper because the region/area of constructive interference is smaller/there are more slits</p> <p>intensity of peaks has increased because more light can pass through</p>	<p>Award [1 max] for stating one or more differences with no explanation</p> <p>Award [2 max] for stating one difference with its explanation</p> <p>Award [MP3] for a second difference with its explanation</p> <p>Allow “peaks” for “fringes”</p>	3
6.	b	ii	<p>$\Delta\lambda = 589.592 - 588.995$</p> <p>OR</p> <p>$\Delta\lambda = 0.597 \text{ «nm» } \checkmark$</p> <p>$N = \left\langle \frac{\lambda}{m\Delta\lambda} \right\rangle = \left\langle \frac{589}{2 \times 0.597} \right\rangle \text{ «493» } \checkmark$</p> <p>beam width = $\left\langle \frac{493}{600} \right\rangle = 8.2 \times 10^{-4} \text{ «m» or } 0.82 \text{ «mm» } \checkmark$</p>		3

Question			Answers	Notes	Total
7.	a	i	$T = \left\langle \frac{2.90 \times 10^{-3}}{\lambda_{\max}} \right\rangle = \left\langle \frac{2.90 \times 10^{-3}}{10.1 \times 10^{-6}} \right\rangle \checkmark$ <p>= 287 «K» or 14 « °C » ✓</p>	<p><i>Award [0] for any use of wavelength from Sun</i></p> <p><i>Do not accept 287 °C</i></p>	2
7.	a	ii	<p>wavelength of radiation from the Sun is shorter than that emitted from Earth «and is not absorbed by the atmosphere» ✓</p> <p>infrared radiation emitted from Earth is absorbed by greenhouse gases in the atmosphere ✓</p> <p>this radiation is re-emitted in all directions «including back to Earth» ✓</p>		3
7.	b		<p>peer review ✓</p> <p>international collaboration ✓</p> <p>full details of experiments published so that experiments can repeated ✓</p>		1 max

Question		Answers	Notes	Total
8.	a	force per unit charge ✓ acting on a small/test positive charge ✓		2
8.	b	horizontally to the left ✓	<i>Arrow does not need to touch X</i>	1
8.	c	proton moves to the right/they move in opposite directions ✓ force on each is initially the same ✓ proton accelerates less than electron initially «because mass is greater» ✓ field is stronger on right than left «as lines closer» ✓ proton acceleration increases «as it is moving into stronger field» OR electron acceleration decreases «as it is moving into weaker field» ✓	<i>Allow ECF from (b)</i> <i>Accept converse argument for electron</i>	4 max
