Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

November 2017

Physics

Higher level

Paper 2

15 pages

Question			Answers	Notes	Total
1.	a		arrow vertically downwards labelled weight «of sledge and/or girl»/*W*/mg/gravitational force/F_g/$F_{gravitational}$ ***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*** $5.5 \times 4.2 = (55 + 5.5)$ « v » ✓ 0.38 « m s^{-1} » ✓	*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	«friction force down slope» $= \mu mg\cos(6.5) =$ «5.9N» ✓ «component of weight down slope» $= mg\sin(6.5)$ «$= 6.1$N» ✓ «so $a = \frac{F}{m}$ » acceleration $= \frac{12}{5.5} = 2.2$ «m s^{-2}» ✓	*Ignore negative signs* *Allow use of* $g = 10\,m s^{-2}$	**3**
1.	e	ii	correct use of kinematics equation ✓ distance = 4.4 ***or*** 4.0 «m» ✓ ***Alternative 2*** KE lost = work done against friction + GPE ✓ distance = 4.4 ***or*** 4.0 «m» ✓	*Allow ECF from (e)(i)* *Allow* ***[1 max]*** *for GPE missing leading to 8.2 «m»*	**2**
1.	f		calculates a maximum value for the frictional force = «$\mu R =$» 7.5 «N» ✓ sledge will not move as the maximum static friction force is greater than the component of weight down the slope ✓	*Allow correct conclusion from incorrect MP1* *Allow 7.5 > 6.1 so will not move*	**2**
2.	a		«$v = \sqrt{\frac{Gm_E}{r}}$» $= \sqrt{\frac{6.67\times10^{-11}\times6.0\times10^{24}}{6600\times10^{3}}}$ ✓ 7800 «m s^{-1}» ✓	*Full substitution required* *Must see 2+ significant figures.*	**2**
2.	b	i	Y has smaller orbit/orbital speed is greater so time period is less ✓	*Allow answer from appropriate equation* *Allow converse argument for X*	**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» ✓	*Marks should be awarded from either one alternative or the other.* *Do not allow discussion of positive charges moving towards X*	**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		«$\varepsilon = Blv =$» $31\times10^{-6}\times7790\times15\,000$ ✓ 3600 «V» ✓	*Allow 3700 «V» from $v = 8000\ ms^{-1}$.*	**2**

(continued…)

(Question 2 continued)

Question			Answers	Notes	Total
2.	**f**	**i**	use of $k = \text{«}\frac{4\pi^2 m}{T^2} = \text{»}\frac{4 \times \pi^2 \times 350}{5.2^2}$ ✓ 510 ✓ N m^{-1} ***or*** kg s^{-2} ✓	*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 ✓ and back again twice in each cycle ✓	*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**

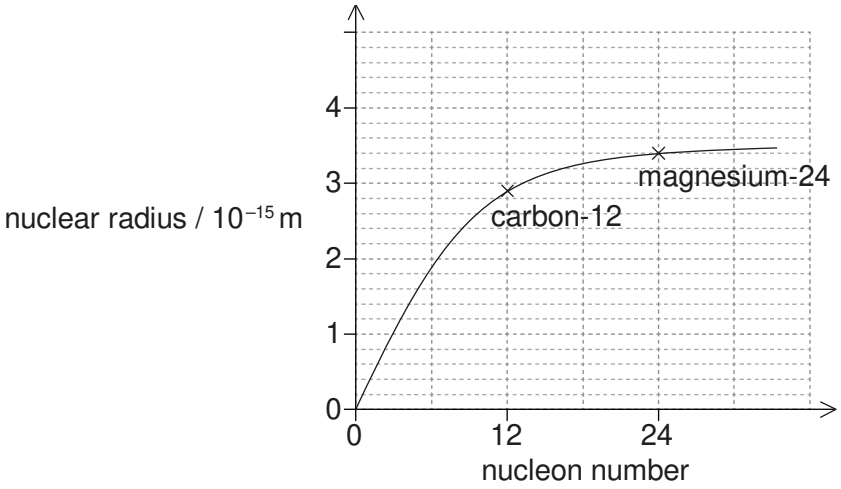
(continued…)

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

Question			Answers	Notes	Total
4.	a	i	« $l = \frac{RA}{\rho} = \frac{82 \times 8 \times 10^{-3} \times 2 \times 10^{-6}}{4.1 \times 10^{-5}}$ » 0.032 «m» ✓		1
4.	a	ii	power $= 1500 \times 8 \times 10^{-3} \times 0.032$ « $= 0.384$ » ✓ «current $\leq \sqrt{\frac{\text{power}}{\text{resistance}}} = \sqrt{\frac{0.384}{82}}$ » 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	« $v = c\frac{\sin i}{\sin r} =$ » $\frac{3 \times 10^8 \times \sin(33)}{\sin(46)}$ ✓ 2.3×10^8 «m s^{-1}» ✓		2

(continued…)

(Question 5 continued)

Question			Answers	Notes	Total
5.	**a**	**ii**	light strikes AB at an angle of 57° ✓ critical angle is $\text{«}\sin^{-1}\left(\frac{2.3}{3}\right)\text{=»}\ 50.1^\circ$ ✓ 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 $= 388 \times 2100 \times 20$ «$= 1.63 \times 10^7$ J» ✓ energy required to melt $= 388 \times 330 \times 10^3$ «$= 1.28 \times 10^8\,\text{J}$» ✓ 1.4×10^8 «J» ***OR*** 1.4×10^5 «kJ» ✓	*Accept any consistent units* *Award **[3 max]** for answer which uses density as 1000 kg^{-3} (1.5×10^8 «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	the diagram shows the combined effect of «single slit» diffraction and «double slit» interference ✓ recognition that there is a minimum of the single slit pattern ***OR*** a missing maximum of the double slit pattern at A ✓ waves «from the single slit» are in antiphase/cancel/have a path difference of $(n+\frac{1}{2})\lambda$ /destructive interference at A ✓		**2 max**
6.	a	ii	$\theta = \frac{4.1\times10^{-2}}{7.0}$ ***OR*** $b = \frac{\lambda}{\theta}$ «$= \frac{7.0\times5.9\times10^{-7}}{4.1\times10^{-2}}$» ✓ 1.0×10^{-4} «m» ✓	*Award **[0]** for use of double slit formula (which gives the correct answer so do not award BCA)* *Allow use of sin or tan for small angles*	**2**
6.	a	iii	use of $s = \frac{\lambda D}{d}$ with 3 fringes «$\frac{590\times10^{-9}\times7.0}{4.1\times10^{-2}}$» ✓ 3.0×10^{-4} «m» ✓	*Allow ECF.*	**2**

(continued…)

(Question 6 continued)

Question			Answers	Notes	Total
6.	b	i	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 the fringes are narrower/sharper because the region/area of constructive interference is smaller/there are more slits intensity of peaks has increased because more light can pass through	*Award **[1 max]** for stating one or more differences with no explanation* *Award **[2 max]** for stating one difference with its explanation* *Award **[MP3]** for a second difference with its explanation* *Allow "peaks" for "fringes"*	**3**
6.	b	ii	$\Delta\lambda = 589.592 - 588.995$ ***OR*** $\Delta\lambda = 0.597$ «nm» ✓ $N = «\frac{\lambda}{m\Delta\lambda} =» \frac{589}{2 \times 0.597}$ «493» ✓ beam width $= «\frac{493}{600} =» 8.2 \times 10^{-4}$ «m» ***or*** 0.82 «mm» ✓		**3**

Question			Answers	Notes	Total
7.	a	i	$T = \text{«}\frac{2.90\times10^{-3}}{\lambda_{max}}\text{=»}\frac{2.90\times10^{-3}}{10.1\times10^{-6}}$ ✓ $=$ 287 «K» ***or*** 14 « °C» ✓	*Award **[0]** for any use of wavelength from Sun* *Do not accept 287 °C*	**2**
7.	a	ii	wavelength of radiation from the Sun is shorter than that emitted from Earth «and is not absorbed by the atmosphere» ✓ infrared radiation emitted from Earth is absorbed by greenhouse gases in the atmosphere ✓ this radiation is re-emitted in all directions «including back to Earth» ✓		**3**
7.	b		peer review ✓ international collaboration ✓ full details of experiments published so that experiments can repeated ✓		**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 ✓	*Arrow does not need to touch X*	**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» ✓	*Allow ECF from (b)* *Accept converse argument for electron*	**4 max**