Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2019

Physics

Higher level

Paper 2

19 pages

Subject Details: Physics HL Paper 2 Markscheme

Mark Allocation

Candidates are required to answer ALL questions. Maximum total = [90 marks].

1. Each row in the "Question" column relates to the smallest subpart of the question.

2. The maximum mark for each question subpart is indicated in the "Total" column.

3. Each marking point in the "Answers" column is shown by means of a tick (✓) at the end of the marking point.

4. A question subpart may have more marking points than the total allows. This will be indicated by "max" written after the mark in the "Total" column. The related rubric, if necessary, will be outlined in the "Notes" column.

5. An alternative wording is indicated in the "Answers" column by a slash (/). Either wording can be accepted.

6. An alternative answer is indicated in the "Answers" column by "***OR***" between the alternatives. Either answer can be accepted.

7. Words in angled brackets **« »** in the "Answers" column are not necessary to gain the mark.

8. Words that are underlined are essential for the mark.

9. The order of marking points does not have to be as in the "Answers" column, unless stated otherwise in the "Notes" column.

10. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the "Answers" column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by ***OWTTE*** (or words to that effect) in the "Notes" column.

11. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

12. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script. "Allow ECF" will be displayed in the "Notes" column.

13. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the "Notes" column.

14. Allow reasonable substitutions where in common usage, *eg* ^{c} for rad.

Question			Answers	Notes	Total
1.	a	i	$F = \frac{\Delta mv}{\Delta t}$ / $m\frac{\Delta v}{\Delta t}$ / $\frac{0.058 \times 64.0}{25 \times 10^{-3}}$ ✓ $F = 148$ «N» ≈ 150 «N» ✓		2
1.	a	ii	***ALTERNATIVE 1*** $P = \frac{\frac{1}{2}mv^2}{t}$ / $\frac{\frac{1}{2} \times 0.058 \times 64.0^2}{25 \times 10^{-3}}$ ✓ $P = 4700 / 4800$ «W» ✓ ***ALTERNATIVE 2*** $P =$ average Fv / $148 \times \frac{64.0}{2}$ ✓ $P = 4700 / 4800$ «W» ✓		2

(continued…)

(Question 1 continued)

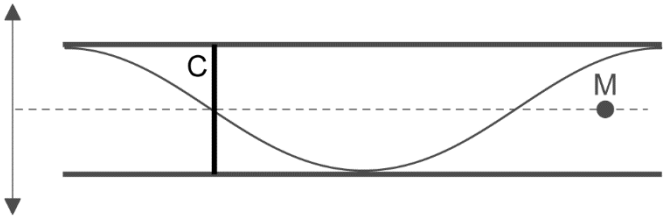
Question			Answers	Notes	Total
1.	b	i	horizontal component of velocity is $64.0 \times \cos 7^\circ = 63.52$ «m s^{-1}» ✓ $t = «\frac{11.9}{63.52} =»$ 0.187 / 0.19 «s» ✓		2
1.	b	ii	***ALTERNATIVE 1*** $u_y = 64 \sin 7 / 7.80$ «m s^{-1}» ✓ decrease in height $= 7.80 \times 0.187 + \frac{1}{2} \times 9.81 \times 0.187^2 / 1.63$ «m» ✓ final height = «2.80 – 1.63» = 1.1 / 1.2 «m» ✓ «higher than net so goes over» ***ALTERNATIVE 2*** vertical distance to fall to net «= 2.80 – 0.91» = 1.89 «m» ✓ time to fall this distance found using «$1.89 = 7.8t + \frac{1}{2} \times 9.81 \times t^2$» $t = 0.21$«s» ✓ 0.21 «s» > 0.187 «s» ✓ «reaches the net before it has fallen far enough so goes over»		3

(continued…)

(Question 1 continued)

1.	**b**	**iii**	***ALTERNATIVE 1*** Initial KE + PE = final KE / $\frac{1}{2}\times 0.058\times 64^2 + 0.058\times 9.81\times 2.80 = \frac{1}{2}\times 0.058\times v^2$ ✓ $v = 64.4$ «$\mathrm{m\,s^{-1}}$» ✓ ***ALTERNATIVE 2*** $v_v = \text{«}\sqrt{7.8^2 + 2\times 9.81\times 2.8}\text{»} = 10.8$ «$\mathrm{m\,s^{-1}}$» ✓ «$v = \sqrt{63.5^2 + 10.8^2}$» $v = 64.4$ «$\mathrm{m\,s^{-1}}$» ✓		**2**
1.	**c**		so horizontal velocity component at lift off for clay is smaller ✓ normal force is the same so vertical component of velocity is the same ✓ so bounce angle on clay is greater ✓		**3**

Question			Answers	Notes	Total
2.	a		$\frac{1}{2}mv^2 = \frac{3}{2}kT$ / $v = \sqrt{\frac{3kT}{m}}$ / $\sqrt{\frac{3\times1.38\times10^{-23}\times320}{6.6\times10^{-27}}}$ ✓ $v = 1.4\times10^3$ «ms^{-1}» ✓		2
2.	b		$N = \frac{pV}{kT}$ / $\frac{5.1\times10^5\times3.2\times10^{-6}}{1.38\times10^{-23}\times320}$ ***OR*** $N = \frac{pVN_A}{RT}$ / $\frac{5.1\times10^5\times3.2\times10^{-6}\times6.02\times10^{23}}{8.31\times320}$ ✓ $N = 3.7\times10^{20}$ ✓		2
2.	c	i	«$\frac{4\times10^{20}\times4.9\times10^{-31}}{3.2\times10^{-6}}$ =» 6×10^{-5} ✓		1
2.	c	ii	«For an ideal gas» the size of the particles is small compared to the distance between them/size of the container/gas ***OR*** «For an ideal gas» the volume of the particles is negligible/the volume of the particles is small compared to the volume of the container/gas ***OR*** «For an ideal gas» particles are assumed to be point objects ✓ calculation/ratio/result in (c)(i) shows that volume of helium atoms is negligible compared to/much smaller than volume of helium gas/container «hence assumption is justified» ✓		2

Question			Answers	Notes	Total
3.	a		Expression or statement showing acceleration is proportional to displacement ✓ so «$7.9 \times \frac{2.3}{3.2}$» $= 5.7$ «m s^{-2}» ✓		2
3.	b		$\sin\theta = \frac{340}{6010} \times \sin 54^0$ ✓ $\theta = 2.6^0$ ✓		2
3.	c		$\lambda =$ «$\frac{340}{250}$ =» $1.36 \approx 1.4$ «m» ✓		1
3.	d	i	horizontal arrow «at M» pointing left ✓		1
3.	d	ii	any point labelled C on the vertical line shown below ✓ *eg:* displacement to the right  displacement to the left		1

(continued…)

(Question 3 continued)

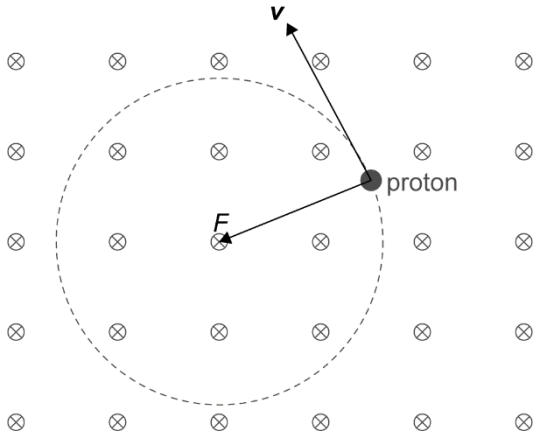
Question			Answers	Notes	Total
3.	**e**	**i**	$f' = 2500 \times \frac{340}{340 + 280}$ ✓ $f' = 1371 \approx 1400$ **«Hz»** ✓		**2**
3.	**e**	**ii**	$\lambda' = \frac{340}{1371} \approx 0.24 / 0.25$ **«m»** ✓		**1**

Question			Answers	Notes	Total
4.	a		total resistance of circuit is 8.0 «Ω» ✓ $P = \frac{12^2}{8.0} = 18$ «W» ✓		2
4.	b	i	«a resistor is now connected in parallel» reducing the total resistance ***OR*** current through YZ unchanged and additional current flows through X ✓		1
4.	b	ii	evidence in calculation or statement that pd across Y/current in Y is the same as before ✓ so ratio is 1 ✓		2
4.	c		$E = «\frac{1}{2}CV^2 = \frac{1}{2} \times 6 \times 10^{-6} \times 12^2 =» \ 4.3 \times 10^{-4}$ «J» ✓		1

(continued…)

(Question 4 continued)

Question			Answers	Notes	Total
4.	d	i	***ALTERNATIVE 1*** capacitance doubles and voltage halves ✓ since $E = \frac{1}{2}CV^2$ energy halves ✓ so change is «–»2.2×10^{-4} «J» ✓ ***ALTERNATIVE 2*** $E = \frac{1}{2}CV^2$ and $Q = CV$ so $E = \frac{Q^2}{2C}$ ✓ capacitance doubles and charge unchanged so energy halves ✓ so change is «–»2.2×10^{-4} «J» ✓		3
4.	d	ii	it is the work done when inserting the dielectric into the capacitor ✓		1

Question			Answers	Notes	Total
5.	a	i	F towards centre ✓		1
5.	a	ii	v tangent to circle and in the direction shown in the diagram ✓		1
5.	b	i	«$qvB = \frac{mv^2}{R} \Rightarrow$» $R = \frac{mv}{qB}$ / $\frac{1.673\times10^{-27}\times2.16\times10^{6}}{1.60\times10^{-19}\times0.042}$ ✓ $R = 0.538$ «m» ✓ $R = 0.54$ «m» ✓		3
5.	b	ii	$T = \frac{2\pi R}{v}$ / $\frac{2\pi\times0.54}{2.16\times10^{6}}$ ✓ $T = 1.6\times10^{-6}$ «s» ✓		2

Question			Answers	Notes	Total
6.	a		proton / ${}^{1}_{1}\mathrm{H}$ / p ✓		1
6.	b	i	«$3 \times 2.78 - 2 \times 2 \times 1.12$» See $3 \times 2.78 / 8.34$ ***OR*** $2 \times 2 \times 1.12 / 4.48$ ✓ 3.86 «MeV» ✓		2
6.	b	ii	the deuterium nuclei are positively charged/repel ✓ high KE/energy is required to overcome «Coulomb/electrostatic» repulsion /potential barrier ***OR*** high KE/energy is required to bring the nuclei within range of the strong nuclear force ✓ high temperatures are required to give high KEs/energies ✓		2 max
6.	c	i	-1 / -e ✓		1
6.	c	ii	-3 ✓		1

Question			Answers	Notes	Total
7.	a		$5.67 \times 10^{-8} \times 289^4$ ***OR*** $= 396$ «$\mathrm{W\,m^{-2}}$» ✓ «$\approx 400\,\mathrm{W\,m^{-2}}$»		1
7.	b		«most of the radiation emitted by the oceans is in the» infrared ✓ «this radiation is» absorbed by greenhouse gases/named greenhouse gas in the atmosphere ✓ «the gases» reradiate/re-emit ✓ partly back towards oceans/in all directions/awareness that radiation in other directions is also present ✓		3 max
7.	c	i	water loses $396 - 330 / 66$ «$\mathrm{W\,m^{-2}}$» ✓ extra intensity that must be lost is «$170 - 66$» $= 104 \approx 100\,\mathrm{W\,m^{-2}}$» ✓ ***OR*** absorbed by water $330 + 170 / 500$ «$\mathrm{W\,m^{-2}}$» ✓ extra intensity that must be lost is «$500 - 396$» $= 104 \approx 100\,\mathrm{W\,m^{-2}}$» ✓		2

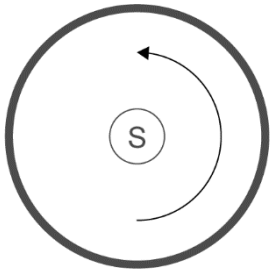
(continued…)

(Question 7 continued)

Question			Answers	Notes	Total
7.	**c**	**ii**	conduction to the air above ***OR*** **«**mainly**»** evaporation ***OR*** melting ice at the poles ***OR*** reflection of sunlight off the surface of the ocean ✓	*Do not accept convection or radiation.*	**1**

Question			Answers	Notes	Total
8.	a		there is constructive interference at M ***OR*** the amplitude doubles at M ✓ intensity is «proportional to» amplitude^2 ✓ 88 « $\mathrm{W\,m^{-2}}$ » ✓		3
8.	b		« $s = \frac{\lambda D}{d} \Rightarrow$ » $\lambda = \frac{sd}{D}$ / $\frac{0.12\times10^{-3}\times7.0\times10^{-3}}{1.5}$ ✓ $\lambda = 560$ «nm» ✓		2
8.	c	i	«the interference pattern will be modulated by» single slit diffraction ✓ «envelope and so it will be less»		1
8.	c	ii	***ALTERNATIVE 1*** the angular position of this point is $\theta = \frac{28\times10^{-3}}{1.5} = 0.01867$ «rad» ✓ which coincides with the first minimum of the diffraction envelope $\theta = \frac{\lambda}{b} = \frac{560\times10^{-9}}{0.030\times10^{-3}} = 0.01867$ «rad» ✓ «so intensity will be zero» ***ALTERNATIVE 2*** the first minimum of the diffraction envelope is at $\theta = \frac{\lambda}{b} = \frac{560\times10^{-9}}{0.030\times10^{-3}} = 0.01867$ «rad» ✓ distance on screen is $y = 1.50\times0.01867 = 28$ «mm» ✓ «so intensity will be zero»		2

Question			Answers	Notes	Total
9.	a	i	$E = \frac{1}{2}m\frac{GM}{r} - \frac{GMm}{r} = -\frac{1}{2}\frac{GMm}{r}$ ✓ comparison with $V = -\frac{GM}{r}$ ✓ «to give answer»		2
9.	a	ii	***ALTERNATIVE 1*** «at the position of the planet» the potential depends only on the mass of the star /does not depend on the radius of the star ✓ the potential will not change and so the energy will not change ✓ ***ALTERNATIVE 2*** r / distance between the centres of the objects / orbital radius remains unchanged ✓ since $E_{Total} = -\frac{1}{2}\frac{GMm}{r}$, energy will not change ✓		2
9.	b		$\frac{kQ}{(0.600+0.820)^2} = \frac{kq}{0.820^2}$ ✓ $\frac{Q}{q} = «\frac{(0.600+0.820)^2}{0.820^2} = 2.9988 \approx» 3$ ✓		2

Question			Answers	Notes	Total
10.	**a**		the magnetic field at the position of the ring is increasing «because the magnet gets closer to the ring» ✓		**1**
10.	**b**		the current must be counterclockwise «in diagram 2» ✓ *eg:*  **Diagram 2: view from above**		**1**
10.	**c**		since the induced magnetic field is upwards ***OR*** by Lenz law the change «of magnetic field/flux» must be opposed ***OR*** by conservation of energy the movement of the magnet must be opposed ✓ therefore the force is repulsive/upwards ✓		**2**

Question			Answers	Notes	Total
11.	a		«de Broglie's hypothesis states that the» electron is represented by a wave ✓ therefore it cannot be localized/it is spread out/it does not have a definite position ✓	*Award MP1 for any mention of wavelike property of an electron.*	2
11.	b	i	«$d\sin\theta = \lambda \Rightarrow$» $d = \frac{1.6\times10^{-15}}{\sin17^{\circ}} / 5.47\times10^{-15}$ «m» ✓ $R = \frac{d}{2} \approx 2.7 / 2.8\times10^{-15}$ «m» ✓		2
11.	b	ii	this implies that the nucleons are very tightly packed/that there is very little space in between the nucleons ✓ because the nuclear force is stronger than the electrostatic force ✓		2
11.	c	i	number of nuclei is $\frac{28\times10^{-3}}{64}\times6.02\times10^{23} / 2.63\times10^{20}$ ✓ $A =$ «$\lambda N = 2.63\times10^{20}\times\frac{5.5\times10^{-2}}{3600}$» $= 4.0\times10^{15}$ «Bq» ✓		2
11.	c	ii	$\frac{1}{3} = e^{-\lambda t}$ ✓ $t = 20$ «hr» ✓		2