Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

November 2023

Physics

Standard level

Paper 2

11 pages

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Subject Details: Physics SL Paper 2 Markscheme

Candidates are required to answer **all** questions. Maximum total = **50 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***". Either answer can be accepted.

7. An alternative markscheme is indicated in the "Answers" column under heading ***ALTERNATIVE 1*** *etc*. Either alternative can be accepted.

8. Words inside chevrons **« »** in the "Answers" column are not necessary to gain the mark.

9. Words that are <u>underlined</u> are essential for the mark.

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

11. 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.

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

13. 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. "ECF acceptable" will be displayed in the "Notes" column.

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

Question			Answers	Notes	Total
1.	a		$M = \text{«}\frac{gr^2}{G} = \text{»}\frac{2.7\times10^{-3}\times(2.3\times10^{5})^2}{6.67\times10^{-11}}$ ✓ 2.1×10^{18} «kg» ✓		2
1.	b		0.25 - 0.26 «N» ✓		1
1.	c	i	***ALTERNATIVE 1*** the engine exerts an upward/opposing force <<on the probe>> ✓ <<upward>> force is greater than weight/grav force ***OR*** there is an upward resultant/net force ✓ « by NII » this causes deceleration/reduction in speed ✓ ***ALTERNATIVE 2*** the engine/probe exerts a force on the fuel molecules/gas ✓ <<by NIII>> an equal and opposite force acts on the engine/probe ✓ « by NII » this causes deceleration/reduction in speed ✓ « by NII » this causes deceleration/reduction in speed ✓ ***ALTERNATIVE 3*** engine causes change in momentum to fuel molecules/gas ✓ « by conservation of momentum » the probe has an equal and opposite change in momentum ✓ this results in deceleration/reduction in speed ✓	*Marks may only be awarded from one alternative.* *Examiners should determine which alternative provides the most marks.* ***MP3*** *must have a reduction in speed not just a change in speed*	3

Question			Answers	Notes	Total
1.	c	ii	***ALTERNATIVE 1*** net force on probe = 12 – 0.26 = « 11.7 » «N» ✓ change in momentum = 0.64 x 95 = « 60.8 Ns » ✓ time = « 60.8/11.7 » = 5.2 to 5.3 « s » ✓ any answer to 2 s.f. ✓ ***ALTERNATIVE 2*** net force on probe = 12 – 0.26 = « 11.7 » «N» ✓ acceleration « =F/m » = 11.7/95 « =0.12 » ✓ time = « 0.64/0.12 » = 5.2 to 5.3 « s » ✓ any answer to 2 s.f. ✓	*Allow ECF from 1b*	**4**
1.	d		time to reach surface $= \text{«}\sqrt{\frac{2\times 1.9}{2.7\times 10^{-3}}} = \text{»} 37.5$ «s» ✓ distance travelled horizontally = « 34×37.5 » = 1300 «m» ✓	*Award [2] for BCA* *(Allow unrounded correct answers e.g. 1275)* *Check units match power of ten e.g. 1.3 km scores both marks* *Award [1 max} for 21 <<m>> (g taken as 9.81* *Watch for ECF from incorrect t.*	**2**

Question			Answers	Notes	Total
2.	**a**	**i**	the angle of refraction ought to be greater than the angle of incidence ***OR*** the ray should refract away from the normal ✓ because ray goes from high refractive index/<<optically>> more dense/slower medium to low refractive index/optically less dense/faster medium✓	*Do not allow use of e.g n_1 unless medium one is described e.g. n_{air}*	**2**
2.	**a**	**ii**	there should be a <<transmitted>> ray in the oil ***OR*** total internal reflection is not possible ✓ because ray goes from low refractive index/<<optically>> less dense/faster medium to high refractive index/<<optically>> more dense/slower medium✓		**2**
2.	**b**		Use of Snell's Law **«** $\frac{\sin i}{\sin r} = \frac{1.60}{1}$ **»** ✓ $i = \sin^{-1}$ **«**$1.60 \times \sin 32^\circ$**»** $= 58$ **«** $^\circ$ **»** ✓	*'Use of' requires a substitution NOT just a statement of a formula* *Accept 1.0 rad (unit must be included to show a deliberate attempt to use rad rather than a calculator mistake)*	**2**
2.	**c**		$\frac{\sin i}{\sin r} = \frac{1.33}{1.60}$ and $\sin r = 1$ ✓ $i =$ **«**$\sin^{-1} 0.831$**»** $= 56$**«** $^\circ$ **»** ✓	*Accept 0.98 rad (unit required)*	**2**

Question			Answers	Notes	Total
2.	**d**	**i**	Oscillations « of electric field vector » in one/same plane ✓	*Do not allow oscillations in one direction*	**1**
2.	**d**	**ii**	Rotation/change of alignment of polarizing filter ✓ changes intensity ✓		**2**

Question			Answers	Notes	Total
3.	a	i	Resistance « $= \frac{12^2}{150} =$»0.96«Ω» ✓		1
3.	a	ii	Use of $\rho = \frac{RA}{l}$ ✓ area = « $\frac{\rho l}{R} =$» 7.8×10^{-6} «m^2» ✓ radius « $= \sqrt{7.8x10^{-6} / \pi =}$ » 1.6 x 10^{-3} «m» ✓	*Check for ECF from (a)(i)*	3
3.	b		mass of ice = 900 x 0.6 x 0.21 x 0.5 x 10^{-3} ***OR*** 0.0567 <<kg>> ✓ energy required = 0.336 x 10^6 x 0.0567 ***OR*** 1.91 x 10^4 <<J>>✓ time = « $\frac{1.91 \times 10^4}{150} =$» 130 «s» ✓	*Be careful to check for ECF from **MP1** and **MP2**.*	3

Question			Answers	Notes	Total
3.	c		***ALTERNATIVE 1*** emf of almost discharged cell is lower than nominal value ✓ I/power decreases, so longer time ✓ ***ALTERNATIVE 2*** internal R of battery increased ✓ so I decreases, so longer time ✓ ***ALTERNATIVE 3*** power of the battery/heater is lower ✓ so energy is provided at a slower rate, so time is longer ✓	***MP1*** *and* ***MP2*** *must be taken from the same alternative.*	**2**
3.	d		advantage of batteries argument ✓ cost reduction argument ✓ improved storage argument ✓ environmental argument ✓	*e.g. allows energy from renewables to be stored for later use, easy transportation of energy,* *e.g. to make batteries for cars affordable* *e.g. so electric cars can have a longer range* *e.g. so they last longer before disposal, to reduce impact of mining for lithium* *Do not allow vague statements e.g., "more environmentally friendly", "more sustainable", "to reduce pollution", "to reduce the use of fossil fuels" etc.*	**2 max**

Question			Answers	Notes	Total
4.	**a**		Electron/atom loses energy ***OR*** electron/atom moves to a lower energy state ✓ by emitting a/one photon ✓		**2**
4.	**b**		Use of $E = \frac{hc}{\lambda}$ ***OR*** energy change $= «\frac{hc}{\lambda} =» 3.0 \times 10^{-19}$ **«**J**»** ✓ conversion to eV giving 1.88 *OR* 1.89 **«** eV **»** ✓ transition is from 2 to 3 ✓	*'Use of' requires a substitution NOT just a statement of a formula* *A bald statement of 1.88 OR 1.89 <<eV>> scores **MP1** and **MP2**.*	**3**

Question			Answers	Notes	Total
5.	**a**	**i**	average intensity at Ceres orbit $=\left(\frac{3.8\times10^{26}}{4\times\pi\times(4.4\times10^{11})^2}\right)$ **«**$=156\ \text{W m}^{-2}$**»** ✓ average incident intensity $=\frac{156}{4}$ = <<39>> ✓ temperature **«**$=\left(\frac{39}{5.67\times10^{-8}}\right)^{\frac{1}{4}}$**»** $=160$ <<K>> ✓	*Allow ECF from **MP1** and **MP2***	**3**
5.	**a**	**ii**	**«**kinetic**»** energy of decay products is converted to/transferred as thermal energy ✓ **«**primarily**»** by conduction ✓		**2**
5.	**b**	**i**	gases have no/weaker intermolecular forces/bonds <<than for solids>> ✓ gases larger intermolecular distances <<than for solids>> ✓ molecules in gases move freely <<but in solids do not>> ✓ <<same temperature so>> same *Ek* ✓	*Accept reverse arguments*	**3 max**
5.	**b**	**ii**	235 K used ✓ $\frac{160\times8.31\times235}{8.9}$ seen ✓ 3.5×10^4 <<m^3>> ✓	*Award [3] for BCA* *Award [2] for 5.7×10^3 <<m^3>> (for use of T in Celsius)*	**3**