2225 – 6712M

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

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Physics

Standard level

Paper 2

14 pages

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Subject Details: Physics SL Paper 2 Markscheme

Mark Allocation

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. For numerical answers, a correct answer with no working is awarded full marks UNLESS stated otherwise in the “Notes”. For correct numerical answers with working the working must be checked. If the working contains minor omissions or errors full marks are awarded. If the working contains wrong Physics or wrong method the correct answer obtained will be the result of numerical coincidence. In that case the answer is penalized.
6. An alternative wording is indicated in the “Answers” column by a slash (/). Either wording can be accepted.
7. An alternative answer is indicated in the “Answers” column by “OR” between the alternatives. Either answer can be accepted.
8. Words in angled brackets « » in the “Answers” column are not necessary to gain 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.
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 a marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then error carried forward (ECF) marks should be awarded. When marking, indicate this by adding ECF on the script. When ECF is not to be applied “Do not 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 alternative formats such as c for rad or use of E for scientific notation.

Question			Answers	Notes	Total
1	a	i	Work <<done on the car by *F*>> ***OR*** Kinetic energy <<of the car>> ✓		1
	a	ii	Area $=2.4\times10^5$ J ✓ «$2.4\times10^5=\frac{1}{2}\times1.6\times10^3\times v^2\Rightarrow$» $v=17$ m s^{-1} ✓	*Ignore units, they are not required for the answer. They have been included for clarity.* *Allow ECF from incorrect area.*	2
	b		$cv^2=\frac{P}{v}$ ***OR*** $c=\frac{P}{v^3}$ ✓ $c=1.5$ ✓ kg m^{-1} ✓	*Do not award ECF from part a) as this is about a different car.*	3

Question			Answers	Notes	Total
2	**a**		The use of Kepler's 3rd law, e.g. $\left(\frac{r_V}{r_E}\right)^3 = \left(\frac{225}{365}\right)^2$ ✓ $\frac{r_V}{r_E} = 0.724$ ✓		**2**
	b		Any 2 from: Identifies gravitational force «of the Sun» as causing circular/orbital motion ✓ Identifies orbital radius and orbital period of a planet about the Sun as observable/known quantities ✓ The mass of the Sun/central body is a constant in the equation that relates *r* and *T* ***OR*** Suggests an equation that combines r, T and M, e.g. $\frac{4\pi^2 rm}{T^2} = \frac{GMm}{r^2}$ or $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$✓	*Do not allow a bald statement of Newton's Law of Gravitation.* *Do not allow mention of gravitational force unless it is linked to orbital motion.*	**Max 2**

Question			Answers	Notes	Total
3	a		«$\frac{10}{0.20}$=»50 Ω ✓	*Unit is not required.* *If the unit is missing, assume Ω.* *If any other unit is given, the power of ten and the prefix must match, e.g. accept 0.050 kΩ.*	1
	b		Increases ✓	*Ignore details e.g. whether R increases at an increasing or decreasing rate.* *Award [0] when the answer suggests that R becomes constant after an initial increase.*	1
	c		120 mA ✓	*Unit is not required.*	1
	d		***ALTERNATIVE 1*** p.d. across P is 6.0 V ***or*** 0.12×50 ✓ emf $=$«$6.0+3.0=$»9.0 V ✓ ***ALTERNATIVE 2*** resistance of Q $= \frac{3.0}{0.12}$ ***or*** 25 Ω ✓ emf «$= 0.12(25+50)$» $= 9.0$ V ✓	*P.d. across P can be read off the graph or calculated.*	2

Question			Answers	Notes	Total
4	**a**		Sound waves are mechanical / require a medium «to propagate» ***OR*** EM waves don't require a medium / can propagate in vacuum ✓ Sound waves are «described in terms of» variation of pressure/vibrations of particles ***OR*** EM waves are «described in terms of» electric and magnetic fields ✓ The speed of sound is much lower than the speed of EM waves ✓		**1 max**
	b	**i**	«$\frac{340}{1700}$=»0.20 m ✓	*Unit is not required.*	**1**
	b	**ii**	Path difference =«2×0.50 – 0.70 =»0.30 m ✓ This is 1.5λ ***or*** $phase\ difference = 3\pi$ «hence destructive interference» ✓	*Allow statement that* $\Delta l = \left(n + \frac{1}{2}\right)\lambda\ AND\ n = 1$ *Accept π phase difference.* *Only award ECF from incorrect* ***wavelength*** *or* ***path difference*** *if it correctly leads to destructive interference.*	**2**

	c		Angle of incidence at P $= \sin^{-1}\left(\frac{0.35}{0.50}\right) = 44^o$ ✓ ***ALTERNATIVE 1*** Critical angle $= \sin^{-1}\left(\frac{340}{1500}\right) = 13°$ ✓ $\theta > \theta_{crit}$ hence the sound can't enter water at P ✓ ***ALTERNATIVE 2*** $\frac{\sin\theta_2}{\sin 44} = \frac{1500}{340}$ ***or*** $\sin\theta_2 = 3.1$ ✓ $\sin\theta_2 > 1$ ***or*** θ_2 *is undefined* hence the sound can't enter water at P ✓	*MP2 and 3 can only be awarded from one Alternative* *Award ECF from an incorrect angle of incidence*	**3**

Question			Answers	Notes	Total
5	**a**	**i**	Upwards «on the diagram»/ towards the positive plate ✓		**1**
	a	**ii**	Correct symbolic or substituted expression for the force, e.g. $\frac{qV}{d}$, $\frac{1.60\times10^{-19}\times30}{0.04}$, 1.2×10^{-16} N ✓ $a=\frac{1.2\times10^{-16}}{9.11\times10^{-31}}$ ***or*** 1.3×10^{14} m s^{-2} ✓	*Unit is not required.* *Ignore any negative sign in the answer.* *Check the steps in the calculation.* *Allow ECF from MP1 if 4 cm used. Leads to 1.3 x 10^{12}.* *Allow ECF from MP1 if 0.02 m or 2 cm is used.*	**2**
	b		The use of an appropriate kinematics equation for time, e.g. $0.02=\frac{1}{2}\times1.32\times10^{14}\times t^2$, $t=1.7\times10^{-8}$ s ✓ Recognizes constant horizontal velocity, e.g. $x=9.4\times10^{6}t$ ✓ 0.16 m ✓	*Ignore units as they are not required for the answer.* *Accept any valid rounding of acceleration, e.g.* $a=1.0\times10^{14}$ m s^{-2} *leads to* $t=2\times10^{-8}$ s *and* $x=0.19$ m *.* *Allow ECF from MP1.* *Watch for ECF from aii). Candidates may obtain an answer for acceleration which is incorrect but rounds to 10^{14}.*	**3**

	c		***ALTERNATIVE 1*** $evB = e\frac{V}{d} \Rightarrow B = \frac{V}{vd}$ ✓ $«\frac{30}{9.4\times10^{6}\times0.04}=»8.0\times10^{-5}$ T ✓ ***ALTERNATIVE 2*** *evB = Force from aii) MP1✓* $B = \ll \frac{1.2\times10^{-16}}{1.6\times10^{-19}\times9.4\times10^{6}} = \gg 8.0\times10^{-5}\ T$✓	*Marks can only be awarded from one Alternative* *Ignore units as they are not required for the answer.* *Allow ECF from aii).* *Accept use of F = ma for electric force with the acceleration calculated in aii). This leads to 6.1 x 10^{-5} <<T>>if rounded value used.*	**2**

Question			Answers	Notes	Total
6	**a**		The intensity <<of solar radiation>> received by the Earth ✓	*Accept 'power per unit area' for intensity.*	**1**
	b	**i**	<<Absorption by GHG molecules of>> radiation whose energy matches the energy difference between molecular levels ***OR*** <<Absorption of radiation that causes>> resonance of the GHG molecule ✓ Followed by emission «from GHG molecules» in random/all directions ✓	*For MP2 do not accept towards the surface as that is in the stem of the question.*	**2**
	b	**ii**	Average incoming intensity $= \frac{S}{4}$ « $= 340$ W m^{-2}» ✓ Absorbed intensity $= (1 - 0.30) \times 340$ ***or*** 238 W m^{-2} ✓	*The steps in the calculation must be shown.*	**2**

	b	**iii**	Emitted intensity $=$«$5.67\times10^{-8}\times0.90\times288^4$ =»351 W m^{-2} ✓ Intensity leaving Earth $=238$ W m^{-2} ✓ Re-radiated intensity $=$«$351-238=$»113 W m^{-2} ✓	*Ignore units as they are not required for the answer.* *The steps in the calculation must be checked.* *Accept outgoing intensity = 240 W m^{-2} for MP2.*	**3**
	c		Recognition that $r = 1.5 \times 10^{11} m$ ***AND*** $S = 1.36 \times 10^3 W\, m^{-2}$ ✓ $4\pi\left(1.5\times10^{11}\right)^2\times1.36\times10^3$ or 3.8×10^{26} W ✓	*Unit is not required.* *The values of r and S must be seen to award MP1.* *Allow ECF from use of* $S = 1.4 \times 10^3 W\, m^{-2}$	**2**

continue…

Question 6 continued.

	d	**i**	***ALTERNATIVE 1*** $\Delta m = 4 \times 1.007276 + 2 \times 0.000549 - 4.001506$«$= 0.028696$ u» ✓ «$0.028696 \times 931.5 =$»26.7 MeV ✓ ***ALTERNATIVE 2*** $\Delta m = 4 \times 938 + 2 \times 0.511 - 4.001506 \times 931.5$ «$= 25.6\ MeV\ c^{-2}$» ✓ 25.6 MeV ✓	*Marks can only be awarded from one Alternative* *Unit is not required.* *Particle masses in u and MeV c^{-2} lead to differently rounded answers, working must be checked.* *Award [1] max if electrons are omitted. This leads to ALT 1 25.7 <<MeV>>, ALT 2 24.6 <<MeV>>* *Award ECF if incorrect number of particles used e.g. 1 electron rather than 2.*	**2**
	d	**ii**	<<Photons emitted>> in fusion give rise to outward/ thermal/radiation pressure ✓ Which prevents the Sun from collapsing due to <<inward>> gravitational forces ✓	*For MP1, outward/thermal/ radiation pressure must be linked to fusion reactions*	**2**
	d	**iii**	Any mention of absorption or emission spectrum «of the Sun» ✓ Observed lines/wavelengths/frequencies match those of helium ***OR*** Helium lines/wavelengths/frequencies are present «in the spectrum» ✓	*Allow solar spectrum*	**2**
	e	**i**	«red» supergiant ✓	*Do not allow 'red giant'.*	**1**

	e	**ii**	The Sun only fuses hydrogen <<to helium>> ***OR*** Antares allows heavier elements «than hydrogen» to be fused ***OR*** Antares has fusion up to iron ✓ Fusion in Antares occurs at a greater rate «because of greater mass/later evolutionary stage» ***OR*** Fusion in Antares requires a higher «core» temperature/density «because of greater mass/later evolutionary stage» ✓ Antares has regions/shells where different elements are fused «due to its late evolutionary stage» ✓	*MP1 is about what is fusing to what* *Do not allow ECF from white dwarf for MP1* *MP2 is about fusion rate/conditions for fusion* *MP3 is about where fusion occurs*	**3**