2225 – 6718M

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

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Physics

Standard level

Paper 2

13 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.

The following are the annotations available to use when marking responses.

Annotation	Explanation	Shortcut	Annotation	Explanation	Shortcut
✔	Correct point – 1 mark will be added to the score for each tick placed up to the maximum for the question part. Please make sure that the number of ticks = the number of marks		NAQ	Does not answer question	
?	Unclear		OK	Answer acceptable	
λ	Omission mark		POT	Power of 10 error	
AEr	Arithmetic error		SEEN	Indicates that the point has been noted, but no credit has been given **or** to confirm that an examiner has checked a sub-part of a question that has not been answered.	
ALT	Alternative solution		T	Text box for comments – used for additional marking comments, it can be used in conjunction with a specific tick if that is appropriate. You might like to have a word document of regularly used comments that can be copied and pasted into the text box.	
BOD	Benefit of the doubt			Dynamic; can be sized to highlight area	
CON	Contradiction			Dynamic; horizontal line that can be expanded	
ECF	Error carried forward		0	Award 0 marks. 0 marks will be added to the marks panel when this annotation is stamped on the script.	

You **must** make sure you have looked at all pages. Please put the SEEN annotation on any blank page, to indicate that you have seen it.

Question			Answers	Notes	Total
1.	a		***ALT 1*** KE before is $\frac{1}{2}\times 3.0\times 6.0^2 = 54$ J ✓ KE after is $\frac{1}{2}\times 3.0\times 2.0^2 + \frac{1}{2}\times 6.0\times 4.0^2 = 54$ J ✓ ***ALT 2*** In elastic collisions relative velocity remains constant in magnitude ✓ |6 – 0| = |-2 – 4| ✓	*Ignore references to conservation of momentum*	[2]
	b	i	$F = \frac{6.0\times 4.0}{40\times 10^{-3}}$ ***OR*** $F = \frac{3.0\times(6.0-(-2.0))}{40\times 10^{-3}}$ ✓ $F = 6.0\times 10^2$ N ✓	*Allow ECF from a wrong time interval.* *If the final answer is incorrect, award MP1 for [1max] for any attempt to use rate of change of momentum or mass x acceleration with wrong data values for masses and velocities.*	[2]
	b	ii	***Alternative 1*** $\Delta E_K = \frac{1}{2}6.0\cdot 4.0^2$ ***OR*** $48J$ ✓ $P = « \frac{\Delta E_K}{\Delta t} = » \frac{48}{40\times 10^{-3}} = 1200\ W$ ✓ ***Alternative 2*** $\bar{P} = \bar{F}\frac{u+v}{2}$ ✓ $\bar{P} = 600\times\frac{0+4.0}{2} = 1200$ W ✓	*Award [2] if 1200 <<W>> is seen as the answer without working* *Award [1] for 2400 W.* *Allow ECF from bi) in ALT 2.*	[2]

	b	iii	KE is $\frac{1}{2}\times(3.0+6.0)\times 2.0^2 = 18$ J ✓ PE is $54-18=36$ J ✓	*Allow ECF from MP1*	[2]

Question			Answers	Notes	Total
2.	a		***ALT 1*** (in solids) reference to particle/atomic vibrations ***OR*** kinetic energy transferred ✓ via collisions ***OR*** between adjacent particles/atoms ✓ ***ALT 2*** (in metallic conductors) reference to motion of electrons ✓ that collide with atoms/ions ✓		[2]
	b		«$\frac{\Delta Q}{\Delta t} = kA\frac{\Delta T}{\Delta x} = \frac{1.3\times18\times(22-13)}{0.25}$» 8.4×10^2 ✓ Unit is W / Js^{-1} / $kgm^2\ s^{-3}$ ✓	Ignore the sign in MP1	[2]
	c	i	Identifies gradient as rate of thermal energy transfer ***OR*** temperature difference is decreasing ✓		[1]

	c	ii	***ALT 1*** $N_0 = \frac{PV}{kT_0}$ *and* $N = \frac{PV}{kT}$ ***OR*** 295 *and* 279 *seen* ✓ $\frac{\Delta N}{N_0} = \frac{\frac{PV}{k\times279} - \frac{PV}{k\times295}}{\frac{PV}{k\times295}}$ ✓ « $\frac{\Delta N}{N_0} = \frac{16}{279} =$ » 0.057 *OR* 5.7 % ✓ ***ALT 2*** N*T* = constant ***OR*** n*T* = constant ***OR*** 295 ***AND*** 279 seen ✓ « $\frac{N_2}{N_1}$ ***OR*** $\frac{n_2}{n_1}$ = » $\frac{295}{279}$ *seen* ✓ 5.7 % ✓	*Award only MP1, [1] max, if work shown in Celsius*	[3]

Question			Answers	Notes	Total
3.	a		$E = «\frac{120}{8.0\times10^{-2}} = »1.5\times10^{3} NC^{-1}$ ***OR*** Vm^{-1} ✓		[1]
	b	i	$F = «eE = »3.2\times10^{-19}\times1.5\times10^{3}$ ***OR*** $4.8\times10^{-16}N$ ✓ $a = «\frac{F}{m} = »\frac{4.8\times10^{-16}}{4\times1.67\times10^{-27}}$ ***OR*** $7.2\times10^{10} ms^{-2}$ ✓	*Allow ECF from a).* *Award [1] if they use a charge of e and a mass of 2u obtaining the right result.*	[2]
	b	ii	***ALT 1*** $t = \sqrt{\frac{2s}{a}}$ ✓ $t = «\sqrt{\frac{2\times8.0\times10^{-2}}{7.2\times10^{10}}} = »1.5\times10^{-6}\ s$ ✓ ***ALT 2*** $v = \sqrt{2\,a\,s}$ «$= 1.06\times10^{5}\ ms^{-1}$» ✓ $t = «\frac{v}{a} =»\ 1.5\times10^{-6}\ s$ ✓	*Award [2] if 1.5x10^{-6}«s» is seen as the answer without working.*	[2]
	b	iii	240 eV ✓	*Accept 3.8 x10^{-17} J*	[1]
	c		$F_m = F_e$ ***OR*** $qvB = qE$ ***OR*** $B = F_e / qv$ ✓ $B = «\frac{E}{v} = \frac{1.5\times10^{3}}{5.0\times10^{5}} = »\ 3.0\times10^{-3}T$ ✓	*Award [2] if 3.0 x10^{-3}«T» is seen as the answer without working.* *Allow ECF from a) and b) i)*	[2]

	d		Horizontal / undeflected path ✓		[1]

Question			Answers	Notes	Total
4.	a		Light comes from a single source ✓ Waves need to have a constant phase difference / in phase ✓ «To produce» a fixed/stable/clear/constant pattern «over time» ***OR*** Only coherent light has this property/produces this pattern ✓		[2 max]
	b	i	***Alternative 1*** $s = \frac{\lambda D}{d} \Rightarrow \phi = \frac{s}{D} = \frac{\lambda}{d}$ ✓ $\phi = \frac{720 \times 10^{-9}}{0.12 \times 10^{-3}} = 6.0 \times 10^{-3}$ rad ✓ ***Alternative 2*** $d \sin\frac{\phi}{2} = \frac{\lambda}{2} \Rightarrow \phi = 2\sin^{-1}\frac{\lambda}{2d}$ ✓ $\phi = 2\sin^{-1}\frac{720 \times 10^{-9}}{2 \times 0.12 \times 10^{-3}} = 6.0 \times 10^{-3}$ rad ✓ ***Alternative 3*** <<With small angle approximation>> $d\frac{\phi}{2} = \frac{\lambda}{2} \Rightarrow \phi = \frac{\lambda}{d}$ ✓ $\phi = \frac{720 \times 10^{-9}}{0.12 \times 10^{-3}} = 6.0 \times 10^{-3}$ rad ✓	*Award [2] if 6.0 x10^{-3}* «rad» *is seen as the answer without working* *Do not penalize if answer in degrees (0.34º)* *Award [1] for an answer of 0.012 or 0.003* «rad»	[2]
	b	ii	The energy missing at P_1 and P_2 is found at the maxima ✓		[1]

Question			Answers	Notes	Total
5.	a	i	Mention of core temperature **and** density ✓ Core temperature implies high kinetic energy/high speed ***OR*** needed to overcome repulsion/e.m. force ✓ Density needed to increase frequency/number/probability of collisions ✓	*Ignore reference to mass.* *Do not award MP1 if radius and/or surface temperature are mentioned.*	[3]
	a	ii	<<Inwards>> gravitational force/pressure/ ✓ <<Outwards>> thermal/gas/radiation pressure/force ✓		[2]
	b		$\Delta m = 2M_{H1} - (M_{H2} + m_e) =$ $2 \times 1.007276 - 2.013550 - 0.000549$ ✓ $= 4.53 \times 10^{-4}$ u $Q = 4.53 \times 10^{-4} \times 931.5 = 0.422 \approx 0.42$ MeV ✓	*Accept* 6.8 x 10^{-14} J *as final answer.* *Award [1] for final answer of 0.93 MeV, if positron ignored.* *Award [1] for final answer of* 1.5 x10^{-13} *J if positron ignored.*	[2]
	c	i	Hydrogen mass to be lost 0.1 x 1.5 x 10^{30} ***OR*** 1.5 x 10^{29} kg ✓ Number of reactions per second $\frac{3.8\times10^{26}}{4.3\times10^{-12}}$ OR $8.8 \times 10^{37}\ s^{-1}$ ***OR*** Time for one reaction $\frac{4.3\times10^{-12}}{3.8\times10^{26}}$ OR $1.1 \times 10^{-38}\ s$ ***OR*** Total mass (4H or He-4) in each reaction is $4 \times 1.67 \times 10^{-27}\ kg$ ✓ $T = \frac{0.1\times1.5\times10^{30}}{8.8\times10^{37}\times4\times1.67\times10^{-27}}$ OR $2.5 \times 10^{17}\ s$ **OR** $8.1 \times 10^{9}\ a$ ✓	*Award MP1 if seen isolated or in a calculation.* *Award MP2 if 4 x mass of H seen isolated or in calculation.* *Allow ECF from MP2 if they use H instead of 4H as the mass in each reaction.*	[3]

	c	ii	The luminosity/power output has remained constant ✓	*Accept rate of fusion or similar.*	[1]
	c	iii	8.1 x10^9 years = 2.5 x10^{17} seconds ***OR*** Energy produced while on the main sequence =$L \times t$ ✓ Mass loss =$\frac{3.8\times10^{26}\times2.55\times10^{17}}{c^2}$ = 1.1 x 10^{27} kg ✓		[2]
	d		$\lambda = \frac{2.9\times10^{-3}}{T}$ ✓ $\lambda = 5.0 \times 10^{-7}$ m ✓		[2]
	e	i	P is approaching ✓ wavelength decrease ✓ mention of Doppler/blueshift ✓		[2 max]
	e	ii	$\frac{\Delta\lambda}{\lambda_0} = \frac{v}{c}$ ***AND*** $v = \frac{2\pi R}{T}$ ✓ $T = \lambda_0 \frac{2\pi R}{c\Delta\lambda}$ ✓ $T = 656.2797 \times \frac{2\pi \times 7.0\times10^8}{3\times10^8 \times 4.4\times10^{-3}} = 2.19\times10^6$ s ≈ 25 days ✓	*Do not penalize the use of observed wavelength.*	[3]