Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

Specimen paper

Physics

Higher level

Paper 2

16 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		static friction force «between blocks» **AND** directed to the right✓		1
1.	b		$F = 60a$ ✓ $F_f = 0.6 \times 15 \times 9.8$ «$= 88.2$N» ✓ $88.2 = 15 \times \frac{F}{60} \Rightarrow F = 350$«N» ✓	*Allow use of* $a = 0.6g$ *leading to 353 N.*	3

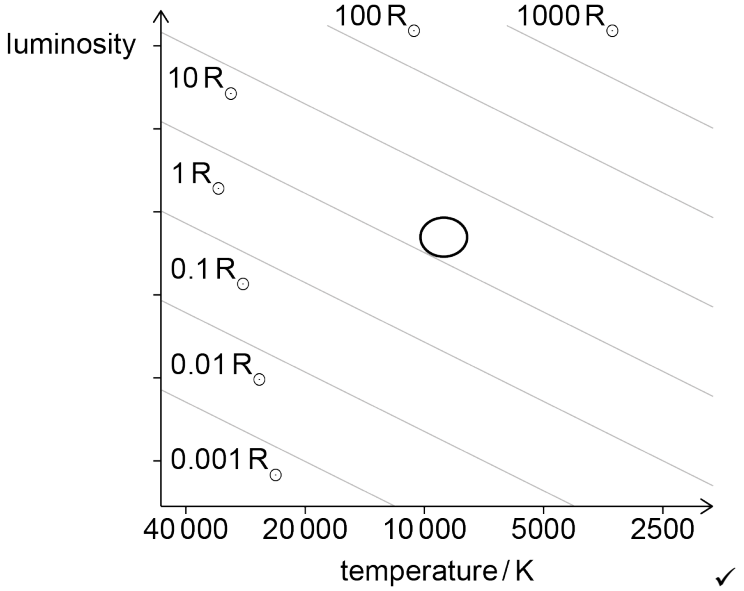
Question			Answers	Notes	Total
2.	**a**		$\gamma = \frac{1}{\sqrt{1-0.80^2}} = \frac{5}{3} = 1.67$ ✓		**1**
2.	**b**	**i**	«$\Delta x' = \gamma(\Delta x - v\Delta t) =$» $\frac{5}{3} \times 1200 = 2000$ «m» ✓	*Allow ecf from 1a.* *Allow use of* $L = \frac{L_0}{\gamma}$.	**1**
2.	**b**	**ii**	«$\Delta t' = \gamma(\Delta t - \frac{v}{c^2}\Delta x) =$» $\frac{5}{3}(0 - \frac{0.80}{3 \times 10^8} \times 1200)$ ✓ $\Delta t' =$ «–»5.3 «μs» ✓	*Allow use of* $\Delta t = \gamma \Delta t_0$.	**2**
2.	**c**		Because $\Delta t' < 0$ ✓ F occurred first ✓	*2nd MP only awarded if correct interpretation of 1st MP.*	**2**

Question			Answers	Notes	Total
3.	**a**		standing waves form «in the oven» by superposition / constructive interference✓ energy transfer is greatest at the antinodes «of the standing wave pattern»✓		**2**
3.	**b**		$\lambda = 12.2$«cm» ✓ f«$= \frac{c}{\lambda}$» $= \frac{3.0 \times 10^{8}}{1.22 \times 10^{-1}}$ ✓ $f = 2.46\,\text{GHz}$ ✓ correct answer only including power of ten	*Allow* $\lambda \pm 2$ *mm.* *Condone power of ten error in MP2 only.*	**3**

Question			Answers	Notes	Total
4.	a		arrow normal to the orbit towards the Earth ✓		1
4.	b	i	use of $v_{\text{orbital}} = \frac{2\pi r}{T}$ AND either $v_{\text{orbital}} = \sqrt{\frac{GM}{r}}$ or $\frac{mv_{\text{orbital}}^2}{r} = \frac{GMm}{r^2}$ correctly manipulated✓ «to yield $T^2 = \left(\frac{4\pi^2}{GM}\right) r^3$ »	*Allow use of* ω.	1
4.	b	ii	$r = \sqrt[3]{\frac{GMT^2}{4\pi^2}} = \sqrt[3]{\frac{6.67\times10^{-11}\times5.97\times10^{24}\times(5620)^2}{4\pi^2}}$ ✓ $= 6.83\times10^6$ «m» height $= «6.83\times10^6 - 6.37\times10^6 =» \ 4.6\times10^5$ «m» ✓		2
4.	c		Total energy is reduced ✓ hence decrease in orbital radius leads to increase in kinetic energy ✓ decrease in potential energy must be larger than increase in kinetic energy for total energy to decrease✓	*Allow ECF from b ii.*	3

Question			Answers	Notes	Total
5.	**a**		ring B cuts an increasing number of magnetic field lines **OR** magnetic field from current in A increases at the position of B ✓		**1**
5.	**b**		counterclockwise ✓		**1**
5.	**c**		the rate of change of «magnetic» flux in B increases **OR** The gradient of the graph is increasing with time ✓ Faraday's law states that the induced emf in B will «therefore» increase ✓ so induced current will increase because resistance of ring is constant ✓		**3**
5.	**d**		the current induced in B gives rise to a magnetic field opposing that of A **OR** there will be a magnetic force opposing the motion ✓ work must be done to move B in the opposite direction to this force✓		**2**

Question			Answers	Notes	Total
6.	a		$^{241}_{95}\text{Am}$ ✓ $^{237}_{93}\text{Np} + {}^{4}_{2}\alpha$ ✓		2
6.	b		Alpha particles only travel a few cm in air / penetration of alpha particles is poor (and will not escape the chamber) ✓	*OWTTE*	1
6.	c		$\text{Half-life} = \frac{\ln 2}{5.08 \times 10^{-11}} \approx 10^{10}\ \text{s}$ ✓ Idea that this is much longer than lifetime of other components ✓ Reasoned comparison by conversion to reasonable unit eg ≈ 430 year ✓		3
6.	d		Each alpha gives rise to $\frac{5.5 \times 10^{6}}{15} = 3.67 \times 10^{5}$ ion pairs ✓ So $\frac{3.67 \times 10^{5} \times 42000}{3} = 5.13 \times 10^{9}$ ion pairs per second ✓ $\text{current} = 1.6 \times 10^{-19} \times 5.13 \times 10^{9} = 0.82 \times 10^{-9}$ «A» ✓		3

Question			Answers	Notes	Total
7.	a		correct substitution into $\lambda_{max} = \frac{2.9 \times 10^{-3}}{T}$ OR 9350 K ✓		1
7.	b		Attempted use of $L = 4\pi bd^2$ ✓ use of $r = \sqrt{\frac{L}{4\pi\sigma T^4}}$ ✓ $r = 1.4\,\text{Gm}$ ✓	*Accept a range of values between 1.3 to 1.5 Gm*	3
7.	c		Shows $r \approx 2R_\odot$ ✓ Correct position on diagram  ✓	*[use of 9000 K gives $2.2R_\odot$]*	2

Question			Answers	Notes	Total
8.	a		$(0.030\times0.7\times10^3\times5)+(0.030\times220\times10^3)+(0.030\times2.13\times10^3)(T-47)$ $=(0.150\times2.13\times10^3)(240-T)$ One heat capacity term correctly substituted ✓ latent heat correctly substituted $(0.030\times220\times10^3)$ ✓ $T=190$«°C» ✓		**3**
8.	b	i	Experimental temperature will be lower ✓ Heat loss to the environment ✓		**2**
8.	b	ii	Insulate the container **OR** Carry out experiment quicker **OR** Use larger volumes of substances ✓		**MAX 1**

Question			Answers	Notes	Total
9.	a	i	equally spaced arrows «by eye» all pointing down ✓ edge effects also shown with arrows ✓		2
9.	a	ii	$E = \frac{V}{d} = \frac{960}{8.0 \times 10^{-3}}$ ✓ $E = 1.2 \times 10^{5}$ «NC^{-1}» ✓		2
9.	b		friction transfers electron(s) to or from drop ***AND*** through collisions/ interaction with air molecules in the tube OR through collisions/interaction with wall of tube ✓		1
9.	c	i	weight of oil drop is $\rho_o gV$ ✓ $\frac{F_b}{W} = \frac{\rho_a gV}{\rho_o gV} = \frac{\rho_a}{\rho_o}$ ✓ «$\frac{F_b}{W} = \frac{1}{730}$ =»1.4×10^{-3} ***OR*** Ratio of F_b to W is much less than 1 ✓		3

9.	**c**	**ii**	Weight vertically down ***AND*** electric force vertically up ✓ Of equal length «by eye» ✓		**2**
9.	**c**	**iii**	Mass of drop is $\rho_0 V$ ✓ $qE = (\rho_0 V)g$ ✓ «hence answer»	*MP1 must be shown implicitly for credit.*	**2**
9.	**c**	**iv**	Negative ✓		**1**
9.	**d**	**i**	Net force is zero ✓ Acceleration of the oil drop is zero ✓ ***OR*** For terminal velocity drag must equal weight ✓ weight $= \rho_0 gV$ **and** drag $= 6\pi\eta rv$ ✓		**2**

9.	**d**	**ii**	$q = \frac{6\pi\eta r v}{E}$ ✓ $q = \frac{6\pi \times 1.60 \times 10^{-5} \times 1.36 \times 10^{-6} \times 1.40 \times 10^{-4}}{1.2 \times 10^{5}}$ ✓ $q = 4.79 \times 10^{-19}$ «C» ✓	*Answer must be shown to 3+ sf.*	**3**
9.	**d**	**iii**	charge is quantized ✓ so, the charges must be 1e and 2e ✓		**2**

Question			Answers	Notes	Total
10.	**a**		$h = A\cos(\frac{2\pi}{T}t)$ ***OR*** $h = A\sin(\frac{2\pi}{T}t + \frac{\pi}{2})$ ✓	*Do not accept use of* ω *or* x *or other symbols unless explained.*	**1**
10.	**b**		negative sin curve of period T ✓ labelled $\frac{2\pi A}{T}$ for the peak value ✓	*Accept* ωA *for the second mark.*	**2**
10.	**c**	**i**	Identifies mass of one crest $m = \rho V = \rho\frac{\lambda}{2}Aw$ ✓ Recognizes position of centre of mass of one crest at $\frac{A}{2}$ ✓ Correctly combined expressions for mass and height <<to obtain the answer>> ✓		**3**
10.	**c**	**ii**	gravitational potential energy per unit length of wavefront is transferred at a rate of $\frac{\rho g w \lambda A^2}{4wT} = \frac{\rho g v A^2}{4}$ ✓ kinetic energy is transferred at the same rate as gravitational potential energy so the total power is $\frac{2\rho g v A^2}{4}$ ✓		**2**

10.	**d**	**i**	Efficiency $= 1 - \frac{303}{823} = 0.63$ ✓ second law sets an upper limit on the maximum efficient transfer from thermal to mechanical energy ✓	*MP1 to 2sf or better for credit.*	**2**
10.	**d**	**ii**	e.g. ${}^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{87}_{36}\text{Kr} + {}^{147}_{56}\text{Ba} + 2{}^{1}_{0}\text{n}$ Kr identified✓ nuclear equation completely correct ✓	*Accept any example with 2 or 3 neutrons on the right hand side where mass numbers add up to 236.*	**2**
10.	**d**	**iii**	***ALTERNATIVE 1*** $200 \times 10^{6} \times 1.6 \times 10^{-19} \times 6.02 \times 10^{-23} = 1.9 \times 10^{13}\,\text{J}$ ✓ $\frac{1.9 \times 10^{13} \times 1000}{235} = 81\text{TJ}$ ✓ $\text{ratio} = \frac{81 \times 10^{12}}{25 \times 10^{6}} = 3.2 \times 10^{6}$ ✓ ***ALTERNATIVE 2*** $E = 200\text{MeV} \times e = 3.2 \times 10^{-11}\text{J}$ ✓ $\frac{E}{m} = \frac{3.2 \times 10^{-11}}{235 \times 1.67 \times 10^{-27}} = 8.2 \times 10^{13}\,\text{Jkg}^{-1}$ ✓	*Allow ecf from second m.p.*	**3**

			$\frac{8.2\times10^{13}}{25\times10^{6}}=3.3\times10^{6}$ ✓		
10.	**d**	**iv**	any suitable one e.g.: no radioactive fragments, readily available fusionable elements ✓ extreme initial temperatures to overcome electrical repulsion, containments at this temperature ✓		**2**
10.	**e**		3 Marks (✓✓✓): Compares correctly all three methods mentioned in question referring twice to some data described during the question with appropriate concepts referring to efficiency, environmental impact or availability of the resource. 2 marks (✓✓): Compares at least two of the three methods mentioned in the question correctly, referring at least once to some data from the question in terms of two appropriate concepts drawn from efficiency, environmental impact or availability of the resource. 1 mark (✓)**:** Refers correctly to one method making reference to at least one correct concept related to efficiency, environmental impact or availability of the resource. 0 marks: Generic concepts with no correct points specific to this question.		**3**