Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

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Physics

Higher level

Paper 2

17 pages

International Baccalaureate
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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**		**ALTERNATIVE 1** there is a force «by the fan» on the air / air is accelerated «to the rear» ✓ by Newton 3 ✓ there is an «equal and» opposite force on the boat ✓ **ALTERNATIVE 2** air gains momentum «backward» ✓ by conservation of momentum / force is rate of change in momentum ✓ boat gains momentum in the opposite direction ✓	*Accept a reference to Newton's third law, e.g. N'3, or any correct statement of it for **MP2** in **ALT 1**.* *Allow any reasonable choice of object where the force of the air is acting on, e.g., fan or blades.*	**3**
1.	**b**	**i**	πR^2 **OR** «mass of air through system per unit time =» $Av\rho$ seen ✓ 244 «kg s^{-1}» ✓	*Accept use of Energy of air per second = 0.5 ρAv^3 = 0.5 mv^2 for **MP1**.*	**2**
1.	**b**	**ii**	«force = Momentum change per sec = $Av^2\rho$ = » 244 x 20 **OR** 4.9 «kN» ✓	*Allow use of 240*	**1**

	Question		Answers	Notes	Total
1.	**c**	**i**	resistive forces increase with speed **OR** resistive forces/drag equal forward thrust ✓ acceleration/net force becomes zero/speed remains constant ✓		**2**
1.	**c**	**ii**	recognition that area under the graph is distance covered ✓ «Distance =» 480 - 560 «m» ✓	*Accept graphical evidence or calculation of correct geometric areas for **MP1.*** ***MP2** is numerical value within range.*	**2**
1.	**c**	**iii**	calculation of acceleration as gradient at t = 0 «= 1 m s^{-2}» ✓ use of $F=ma$ **OR** $\frac{4900}{1}$ seen ✓ 4900 «kg» ✓	***MP1** can be shown on the graph.* *Allow an acceleration in the range 1 – 1.1 for **MP2** and consistent answer for **MP3*** *Allow **ECF** from **MP1.*** *Allow use of average acceleration $=\frac{18}{40}$* *or assumption of constant force to obtain 11000 «kg» for **[2]*** *Allow use of 4800 or 5000 for **MP2***	**3**

Question			Answers	Notes	Total
2.	**a**		Correct conversion of T «T = 310 K» seen ✓ « use of $N = \dfrac{pV}{kT}$ to get » 2.3×10^{23} ✓	*Allow **ECF** from **MP1** i.e., T in Celsius (Result is 2.7 x 10^{24})* *Allow use of n, R and N$_A$*	**2**
2.	**b**	**i**	density decreases ✓ volume is increased **AND** mass/number of particles remains constant ✓		**2**
2.	**b**	**ii**	internal energy is constant ✓ internal energy depends on kinetic energy/temperature «only» **OR** since temperature/kinetic energy is constant ✓	*Do not award **MP2** for stating that "temperature is constant" unless linked to the correct conclusion, as that is mentioned in the stem.* *Award **MP2** for stating that kinetic energy remains constant.*	**2**

	Question		Answers	Notes	Total
3.	a	i	«incident and reflected» waves superpose/interfere/combine ✓ «that leads to» standing waves formed **OR** nodes and antinodes present ✓ at antinodes / maxima there is maximum intensity / constructive interference / «displacement» addition / louder sound ✓ at nodes / minima there is minimum intensity / destructive interference / «displacement» cancellation / quieter sound ✓	*OWTTE* *Allow a sketch of a standing wave for* ***MP2*** *Allow a correct reference to path or phase differences to identify constructive / destructive interference*	**3 max**
3.	a	ii	wavelength = 0.24 «m» ✓ f = « $\dfrac{340}{0.24}$ =» 1.4 «kHz» **OR** 1400 «Hz» ✓	*Allow **ECF** from **MP1***	**2**
3.	b		relates intensity to amplitude ✓ antinodes / maximum intensity will be decreased / quieter ✓ nodes / minimum will be increased / louder ✓ difference in intensities will be less ✓ maxima and minima are at the same positions ✓	*OWTTE*	**3 max**

Question			Answers	Notes	Total
4.	**a**		« conservation of » charge ✓ « conservation of » energy ✓	*Allow **[1]** max if they explicitly refer to Kirchhoff' laws linking them to the conservation laws incorrectly.*	**2**
4.	**b**	**i**	12 V ✓		**1**
4.	**b**	**ii**	I = 2.0 A **OR** 12 = I (r +4) **OR** 4 = Ir **OR** 8 = 4I ✓ «Correct working to get » r = 2.0 «Ω» ✓	*Allow any valid method.* *Allow **ECF** from (**b**)(**i**)*	**2**
4.	**c**	**i**	Loop equation showing **EITHER** correct voltages, i.e., 10 – 4 on one side or both emf's positive on different sides of the equation **OR** correct resistances, i.e. I (1 + 2) ✓ 10−4 = I (1 + 2) **OR** I = 2.0 «A» seen ✓ V = 8.0 «V» ✓	*Allow any valid method*	**3**
4.	**c**	**ii**	Charge is being driven through the 4.0 V cell **OR** it is being (re-)charged ✓		**1**

Question			Answers	Notes	Total
4.	d	i	is generated from primary/other sources ✓		1
4.	d	ii	«a fuel » that can be replenished/replaced within a reasonable time span **OR** «a fuel» that can be replaced faster than the rate at which it is consumed **OR** renewables are limitless/never run out **OR** «a fuel» produced from renewable sources **OR** gives an example of a renewable (biofuel, hydrogen, wood, wind, solar, tidal, hydro etc..) ✓	*OWTTE*	1

Question			Answers	Notes	Total
4.	e	i	**ALTERNATIVE 1** «energy output of the panel =» Vlt **OR** 6 x 5 x 0.25 x 3600 **OR** 27000 «J» ✓ «available power =» 380 x 0.4 x 0.15 x 0.18 **OR** 4.1 «W» ✓ $t = $ « $\dfrac{27000}{4.1} = $» 6600 «s» ✓ **ALTERNATIVE 2** «energy needed from Sun =» $\dfrac{Vlt}{eff}$ **OR** $\dfrac{6 \text{ x } 5 \text{ x } 0.25 \text{ x } 3600}{0.18}$ **OR** 150000 «J» ✓ « incident power=» 380 x 0.4 x 0.15 **OR** 22.8 «W» ✓ $t = $ « $\dfrac{150000}{22.8} = $» 6600 «s» ✓	*Allow **ECF** for **MP3*** *Accept final answer in minutes (110) or hours (1.8).*	**3**
4.	e	ii	coherent reason ✓ *e.g.,* to improve efficiency, is non-polluting, is renewable, does not produce greenhouse gases, reduce use of fossil fuels,	*Do **not** allow economic reasons*	**1**

Question			Answers	Notes	Total
5.	**a**		background count rate is subtracted «from each reading» ✓	*OWTTE*	**1**
5.	**b**		thickness is 0.25 «mm» ✓ 380 «count min^{-1}» ✓	*MP1 and MP2 can be shown on the graph* *Allow a range of 0.23 to 0.27 mm for MP1* *Allow ECF from MP1.* *Accept a final answer in the range 350 – 420*	**2**

	Question		Answers	Notes	Total
5.	**c**		lead better absorber than copper ✓ not alpha ✓ as it does not go through the foil / it is easily stopped / it is stopped by paper ✓ there is gamma ✓ as it goes through lead ✓ ***ALTERNATIVE 1*** can be beta ✓ as it is attenuated by «thin» metal / can go through «thin» metal ✓ ***ALTERNATIVE 2*** not beta ✓ it is stopped by «thin» metal ✓		**4 max**
5.	**d**		$^{137}_{55}\text{Cs} \rightarrow\, ^{137}_{56}\text{Ba} +\, ^{0}_{-1}\beta$ 　　　　　　　　　✓ $+\, \bar{\upsilon}_e$ ✓	*Accept β or e in **MP1**.* *Do **not** penalize if proton / nucleon numbers or electron subscript in antineutrino are missing.*	**2**

	Question		Answers	Notes	Total
6.	**a**	**i**	1.3 «Hz» ✓		**1**
6.	**a**	**ii**	$k \propto m$ **OR** $\dfrac{m_1}{k_1} = \dfrac{m_2}{k_2}$ ✓ 0.25 **OR** $\dfrac{1}{4}$ ✓		**2**
6.	**a**	**iii**	$v_{max} = 4.8$ «m s^{-1}» ✓ $x_0 = $ « $\dfrac{v}{\omega} = \dfrac{vT}{2\pi} = \dfrac{4.8 \times 0.80}{2\pi}$ » $= 0.61$ «m» ✓	*Allow a range of 4.7 to 4.9 for **MP1*** *Allow a range of 0.58 to 0.62 for **MP2*** *Allow **ECF** from (**a**)(**i**)* *Allow **ECF** from **MP1**.*	**2**
6.	**a**	**iv**	all energy shown positive ✓ curve starting and finishing at $E = 0$ with two peaks with at least one at 44 J **OR** curve starting and finishing at $E = 0$ with one peak at 44 J ✓	*Do **not** accept straight lines or discontinuous curves for **MP2***	**2**
6.	**b**		read off of 9.4 «m s^{-1}» ✓ use of $f' = f(\dfrac{v}{v \pm u_s})$ **OR** $f' = f(\dfrac{v \pm u_o}{v})$ ✓ $f = 36$ «kHz» **OR** 34 «kHz» ✓ «recognition that there are two shifts so» change in f = 2 «kHz» **OR** f = 37 «kHz» **OR** 33 «kHz» ✓	*Allow a range of 9.3 to 9.5 for **MP1*** *Allow **ECF** from **MP1**.* ***MP4** can also be found by applying the Doppler effect twice.*	**4**

	Question		Answers	Notes	Total
7.	**a**		the work done per unit charge ✓ In bringing a small/point/positive/test «charge» from infinity to the point ✓	*Allow use of energy per unit charge for* **MP1**	**2**
7.	**b**		use of Vr = constant ✓ 0.40 m ✓	*Allow* **[1]** *max if r + 2.8 used to get 0.47 m.* *Allow* **[2]** *marks if they calculate Q at one potential and use it to get the distance at the other potential.*	**2**
7.	**c**	**i**	90° / perpendicular ✓		**1**
7.	**c**	**ii**	$\frac{1}{2}$ x 0.14 x 10⁻³ x 3.1² **OR** 0.67 «mJ» seen ✓		**1**
7.	**c**	**iii**	«p.d. between point and sphere surface = » (53.9 kV – 7.71) «kV» **OR** 46.2 «kV» seen ✓ «energy required =» VQ « = 46 200 × 2.4 × 10⁻⁸» = 1.11 mJ ✓ this is greater than kinetic energy so will not reach sphere ✓	**MP3** *is for a conclusion consistent with the calculations shown.* *Allow* **ECF** *from* **MP1**	**3**

Question			Answers	Notes	Total
8.	a	i	«−» 5.0 «mV» **OR** 5.0 × 10 $^{-3}$ «V» ✓	*Accept 5.1*	1
8.	a	ii	kg m^2 A^{-1} s^{-3} ✓		1
8.	b	i	**ALTERNATIVE 1** Flux linkage is represented by magnetic field lines through the coil ✓ when magnet has passed through the coil / is moving away ✓ flux «linkage» is decreasing ✓ suitable comment that it is the opposite when above ✓ when the magnet goes through the midpoint the induced emf is zero ✓ **ALTERNATIVE 2** reference to / states Lenz's law ✓ when magnet has passed through the coil / is moving away ✓ «coil attracts outgoing S pole so» induced field is downwards ✓ before «coil repels incoming N pole so» induced field is upwards **OR** induced field has reversed ✓ when the magnet goes through the midpoint the induced emf is zero ✓	*OWTTE*	3 max

Question			Answers	Notes	Total
8.	b	ii	area represents the total change in flux «linkage» ✓ the change in flux is the same going in and out ✓ «when magnet is approaching» flux increases to a maximum ✓ «when magnet is receding» flux decreases to zero ✓ «so areas must be the same»		**2 max**
8.	c		magnet moves slower ✓ overall time «for interaction» will be longer ✓ peaks will be smaller ✓ areas will be the same as before ✓	*Allow a graphical interpretation for **MP2** as "graph more spread out"*	**3 max**

Question			Answers	Notes	Total
9.	**a**	**i**	wave properties ✓	*Accept reference to diffraction or interference.*	**1**
9.	**a**	**ii**	440 x 10⁶ x 1.6 x 10⁻¹⁹ **OR** 7.0 × 10⁻¹¹ «J» ✓		**1**
9.	**a**	**iii**	$\dfrac{6.63 x10^{-34} \, x \, 3 x10^{8}}{7 x10^{-11}}$ **OR** $\dfrac{1.24 x10^{-6}}{440 x10^{6}}$ **OR** 2.8 × 10⁻¹⁵ «m» seen ✓ read off graph as 46° ✓ «Use of $D = \dfrac{\lambda}{\sin\theta}$ =» 3.9 × 10⁻¹⁵ m ✓	*Accept an angle between 45 and 47 degrees.* *Allow **ECF** from **MP2***	**3**
9.	**b**		**ALTERNATIVE 1** use of $R \propto A^{\frac{1}{3}}$ **OR** $V \propto A$ ✓ volume of Sn = $\dfrac{4}{3}\pi\left(\dfrac{A_{Sn}}{A_{O}}\right)r_{O}^{3}$ or equivalent working ✓ 2.3 to 2.5 × 10⁻⁴³ «m³» ✓ answer to 1 or 2sf ✓ **ALTERNATIVE 2** use of $R = R_{o} \, x \, A^{\frac{1}{3}}$ ✓ volume of Sn = $\dfrac{4}{3}\pi R^{3}$ **OR** 5.9 x10⁻¹⁵ seen ✓ 8.5 × 10⁻⁴³ «m³» ✓ answer to 1 or 2sf ✓	*Although the question expects candidates to work from the oxygen radius found, allow **ALT 2** working from the Fermi radius.* ***MP4** is for any answer stated to 1 or 2 significant figures.*	**4**