Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2022

Physics

Standard level

Paper 2

15 pages

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			Does not answer question	
	Unclear			Answer acceptable	
	Omission mark			Power of 10 error	
	Arithmetic error			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.	
	Alternative solution			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.	
	Benefit of the doubt			Dynamic; can be sized to highlight area	
	Contradiction			Dynamic; horizontal line that can be expanded	
	Error carried forward			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  annotation on any blank page, to indicate that you have seen it.

General Marking Instructions

Assistant Examiners (AEs) will be contacted by their team leader (TL) through RM™ Assessor, by e-mail or telephone – if through RM™ Assessor or by e-mail, please reply to confirm that you have downloaded the markscheme from IBIS. The purpose of this initial contact is to allow AEs to raise any queries they have regarding the markscheme and its interpretation. AEs should contact their team leader through RM™ Assessor or by e-mail at any time if they have any problems/queries regarding marking. For any queries regarding the use of RM™ Assessor, please contact emarking@ibo.org.

1. Follow the markscheme provided, award only whole marks and mark only in **RED**.

2. Make sure that the question you are about to mark is highlighted in the mark panel on the right-hand side of the screen.

3. Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark. **One tick to be shown for each mark awarded.**

4. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases use RM™ Assessor annotations to support your decision. You are encouraged to write comments where it helps clarity, especially for re-marking purposes. Use a text box for these additional comments. It should be remembered that the script may be returned to the candidate. Please do not allow these annotations to obscure the written material. Try to keep these to the margin of the scan as far as possible**.** (Ticks should however be at the point of award, cf 4.)

5. Personal codes/notations are unacceptable.

6. Where an answer to a part question is worth no marks but the candidate has attempted the part question, use the “ZERO” annotation to award zero marks. Where a candidate has not attempted the part question, use the “SEEN” annotation to show you have looked at the question. RM™ Assessor will apply “NR” once you click complete.

7. Ensure that you have viewed every page including any additional sheets. Please ensure that you stamp “SEEN” on any additional pages that contain work not related to the QIG you are currently marking, or are blank or where the candidate has crossed out his/her work.

8. Mark positively. Give candidates credit for what they have achieved and for what they have got correct, rather than penalizing them for what they have got wrong. However, a mark should not be awarded where there is contradiction within an answer. Make a comment to this effect using a text box or the “CON” stamp.

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		***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	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	ii	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**
1.	d		***ALTERNATE 1*** « ω = » 4π rad s^{-1} ✓ « $a = r\omega^2$= » 280 « m s^{-2} » ✓ ***ALTERNATE 2*** « $v = \frac{2\pi r}{T}$ » = 22.6 m s^{-1} ✓ « $a = \frac{v^2}{r}$ »= 280 « m s^{-2} » ✓	*Allow **ECF** from **MP1** for wrong ω* (120 gives 2.6 x 10^4« m s^{-2} ») *Award **[2]** for bald correct answer.* *Allow **ECF** from **MP1** for wrong T (2 s gives 18 «* m s^{-2} **»)***	**2**

Question			Answers	Notes	Total
2.	a		Correct conversion of T «T = 310 K» seen ✓ « use of $N = \frac{pV}{kT}$ to get » 2.3×10^{23} ✓	*Allow **ECF** from **MP1** i.e., T in Celsius (Result is 2.7 x 10^{24})* 1.96*10^24 *Allow use of n, R and N_A* *Award **[2]** for a bald correct answer*	**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 = « $\frac{340}{0.24}$ =» 1.4 «kHz» ***OR*** 1400 «Hz» ✓	*Allow* ***ECF*** *from* ***MP1*** *Award* ***[2]*** *for a bald correct answer*	**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. Check carefully as there are incorrect alternatives leading to the expected answer.* *Allow **ECF** from (**b)(i)*** *Award **[2]** for a bald correct answer*	**2**
4.	**c**		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**

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 =» *VIt* ***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 = «$\frac{27000}{4.1}$ =» 6600 «s» ✓ ***ALTERNATIVE 2*** «energy needed from Sun =» $\frac{VIt}{eff}$ ***OR*** $\frac{6 \times 5 \times 0.25 \times 3600}{0.18}$ ***OR*** 150000 «J» ✓ « incident power=» 380 x 0.4 x 0.15 ***OR*** 22.8 «W» ✓ t = «$\frac{150000}{22.8}$ =» 6600 «s» ✓	*Award **[3]** for a bald correct answer* *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,	*Although the question focuses on the importance of research, accept answers referring to the advantages of solar energy.* *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****.* *Award* ***[2]*** *for a bald correct answer.* *Accept a final answer in the range 350 – 420*	**2**
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**

Question			Answers	Notes	Total
5.	**d**		$^{137}_{55}\text{Cs} \rightarrow {}^{137}_{56}\text{Ba} + {}^{0}_{-1}\beta$ ✓ $+ \overline{\upsilon}_{\text{e}}$ ✓	*Accept β or e in **MP1**.* *Only accept antineutrino for **MP2*** *Do **not** penalize if proton / nucleon numbers or electron subscript in antineutrino are missing.*	**2**