**Markscheme**

**May 2022**

**Physics**

**Standard level**

**Paper 2**

**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**<br>there is a force «by the fan» on the air / air is accelerated «to the rear» ✓<br>by Newton 3 ✓<br>there is an «equal and» opposite force on the boat ✓<br><br>**ALTERNATIVE 2**<br>air gains momentum «backward» ✓<br>by conservation of momentum / force is rate of change in momentum ✓<br>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**.*<br><br>*Allow any reasonable choice of object where the force of the air is acting on, e.g., fan or blades.* | **3** |
| **1.** | **b** | **i** | $\pi R^2$ **OR** «mass of air through system per unit time =» $Av\rho$ seen ✓<br><br>244 «kg s$^{-1}$» ✓ | *Accept use of Energy of air per second = 0.5 $\rho Av^3$ = 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 ✓<br><br>«Distance =» 480 - 560 «m» ✓ | *Accept graphical evidence or calculation of correct geometric areas for* **MP1.**<br><br>**MP2** *is numerical value within range.* | **2** |
| **1.** | **c** | **ii** | calculation of acceleration as gradient at $t$ = 0 «= 1 m s$^{-2}$» ✓<br><br>use of $F=ma$ **OR** $\dfrac{4900}{1}$ seen ✓<br><br>4900 «kg» ✓ | **MP1** *can be shown on the graph.*<br>*Allow an acceleration in the range 1 – 1.1 for* **MP2** *and consistent answer for* **MP3**<br>*Allow* **ECF** *from* **MP1.**<br>*Allow use of average acceleration =* $\dfrac{18}{40}$<br>*or assumption of constant force to obtain 11000 «kg» for* **[2]**<br><br>*Allow use of 4800 or 5000 for* **MP2** | **3** |
| **1.** | **d** | | **ALTERNATE 1**<br>« $\omega$ = » $4\pi$ rad s$^{-1}$ ✓<br>« $a = r\,\omega^2$= » 280 « m s$^{-2}$ » ✓<br><br>**ALTERNATE 2**<br>« $v = \dfrac{2\pi\,r}{T}$ » = 22.6 m s$^{-1}$ ✓<br><br>« $a = \dfrac{v^2}{r}$ »= 280 « m s$^{-2}$ » ✓ | *Allow* **ECF** *from* **MP1** *for wrong $\omega$ (120 gives 2.6 x 10$^4$« m s$^{-2}$ »)*<br><br>*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 ✓ <br><br> « use of $N = \dfrac{pV}{kT}$ to get » $2.3 \times 10^{23}$ ✓ | *Allow **ECF** from **MP1** i.e., T in Celsius (Result is 2.7 x 10²⁴)* <br><br> *Allow use of n, R and N$_A$* | **2** |
| **2.** | **b** | **i** | density decreases ✓ <br> volume is increased **AND** mass/number of particles remains constant ✓ | | **2** |
| **2.** | **b** | **ii** | internal energy is constant ✓ <br> internal energy depends on kinetic energy/temperature «only» <br> **OR** <br> 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.* <br><br> *Award **MP2** for stating that kinetic energy remains constant.* | **2** |

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

| | Question | | Answers | Notes | Total |
|---|---|---|---|---|---|
| 4. | a | | « conservation of » charge ✓ <br> « 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 = 4$I$ ✓ <br><br> «Correct working to get » $r$ = 2.0 «Ω» ✓ | *Allow **ECF** from **(b)(i)*** | 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) ✓ <br><br> 10−4 = $I$ (1 + 2) **OR** $I$ = 2.0 «A» seen✓ <br><br> $V$ = 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<br><br>**OR**<br><br>«a fuel» that can be replaced faster than the rate at which it is consumed<br><br>**OR**<br><br>renewables are limitless/never run out<br><br>**OR**<br><br>«a fuel» produced from renewable sources<br><br>**OR**<br><br>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**<br><br>«energy output of the panel =» $Vlt$ **OR** 6 x 5 x 0.25 x 3600 **OR** 27000 «J» ✓<br><br>«available power =» 380 x 0.4 x 0.15 x 0.18 **OR** 4.1 «W» ✓<br><br>$t = $ « $\dfrac{27000}{4.1}$ =» 6600 «s» ✓<br><br><br>**ALTERNATIVE 2**<br><br>«energy needed from Sun =» $\dfrac{Vlt}{eff}$ **OR** $\dfrac{6 \times 5 \times 0.25 \times 3600}{0.18}$ **OR** 150000 «J» ✓<br><br>« incident power=» 380 x 0.4 x 0.15 **OR** 22.8 «W» ✓<br><br>$t = $ « $\dfrac{150000}{22.8}$ =» 6600 «s» ✓ | *Allow **ECF** for **MP3***<br><br>*Accept final answer in minutes (110) or hours (1.8).* | **3** |
| **4.** | **e** | **ii** | coherent reason ✓<br><br>*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» ✓ <br><br> 380 «count min$^{-1}$» ✓ | ***MP1*** *and* ***MP2*** *can be shown on the graph* <br><br> *Allow a range of 0.23 to 0.27 mm for* ***MP1*** <br><br> *Allow* ***ECF*** *from* ***MP1***. <br><br> *Accept a final answer in the range 350 – 420* | **2** |
| **5.** | **c** | | lead better absorber than copper ✓ <br> not alpha ✓ <br> as it does not go through the foil / it is easily stopped / it is stopped by paper ✓ <br> there is gamma ✓ <br> as it goes through lead ✓ <br><br> ***ALTERNATIVE 1*** <br> can be beta ✓ <br> as it is attenuated by «thin» metal / can go through «thin» metal ✓ <br><br> ***ALTERNATIVE 2*** <br> not beta ✓ <br> it is stopped by «thin» metal ✓ | | **4 max** |

| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| **5.** | **d** | | $^{137}_{55}\text{Cs} \rightarrow {}^{137}_{56}\text{Ba} + {}^{0}_{-1}\beta$ <br><br> $\checkmark$ <br><br> $+ \bar{\upsilon}_e$ $\checkmark$ | *Accept β or e in* **MP1**. <br><br> *Do* **not** *penalize if proton / nucleon numbers or electron subscript in antineutrino are missing.* | **2** |