Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

November 2022

Physics

Standard level

Paper 2

11 pages

Subject Details: Physics SL Paper 2 Markscheme

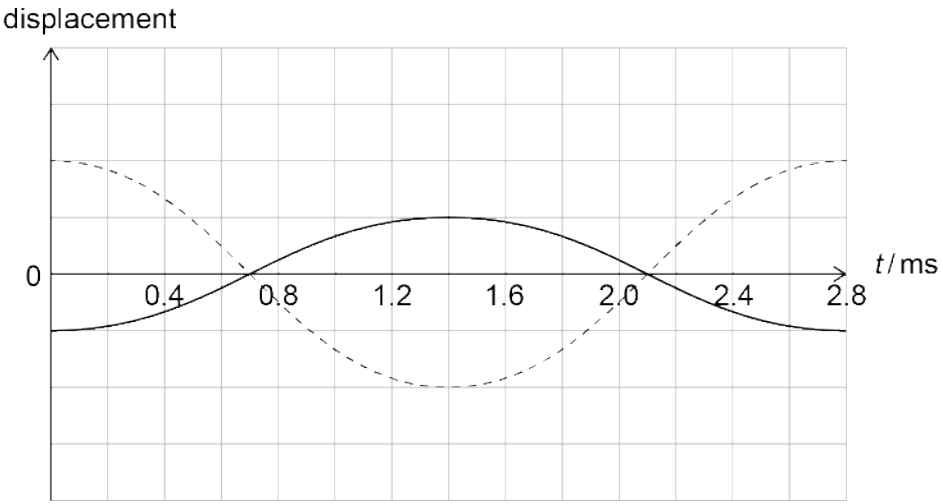
Mark Allocation

Candidates are required to answer ALL questions. Maximum total = [50 marks].

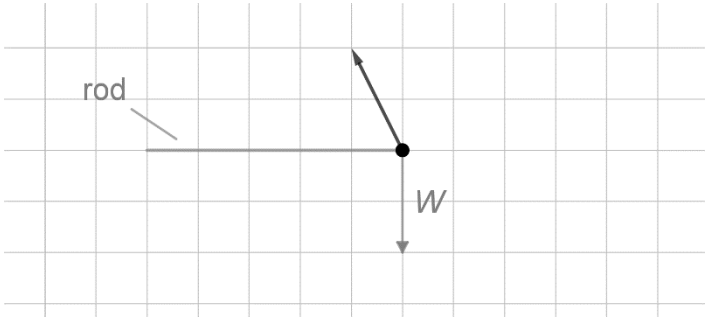
1. Each row in the "Question" column relates to the smallest subpart of the question.
2. The maximum mark for each question subpart is indicated in the "Total" column.
3. Each marking point in the "Answers" column is shown by means of a tick (✓) at the end of the marking point.
4. A question subpart 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. 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		*g* ***OR*** 9.81 «m s^{-2}» ***OR*** acceleration of gravity/due to free fall ✓	*Accept 10 «*m s^{-2}*».* *Ignore sign.* *Do* ***not*** *accept bald "gravity".* *Accept answer that indicates tangent of the graph at time t=0.*	1
1	b		Identification of air resistance/drag force «acting upwards» ✓ «that» increases with speed ✓ «until» weight and air resistance cancel out ***OR*** net force/acceleration becomes zero ✓	*A statement as "air resistance increases with speed" scores* ***MP1*** *and* ***MP2****.*	3
1	c	i	«loss in» GPE $=3.4\times10^{-5}\times9.81\times21$ «$=7.0\times10^{-3}$» «J» ***OR*** «gain in» KE $=0.5\times3.4\times10^{-5}\times9.0^2$ «$=1.4\times10^{-3}$» «J» ✓ energy transferred to air «$=7.0\times10^{-3}-1.4\times10^{-3}$» $=5.6\times10^{-3}$ «J» ✓ any calculated answer to 2 sf ✓	*Allow* ***[1]*** *through the use of kinematics assuming constant acceleration.* *Allow* ***ECF*** *from* ***MP1***	3
1	c	ii	«gravitational» potential energy «of the raindrop» into thermal/internal energy «of the air» ✓	*Accept heat for thermal energy* *Accept into kinetic energy of air particles* *Ignore sound energy*	1

Question			Answers	Notes	Total
2.	a	i	energy required $= 250 \times 4200 \times (30 - 15)$ ✓ energy available $= 0.30 \times 680 \times t \times A$ ✓ $A = \text{«}\frac{250 \times 4200 \times 15}{0.30 \times 680 \times 60 \times 60}\text{»} =$» 21 «$m^2$» ***OR*** 22 «$m^2$» ✓	*Allow **ECF** from **MP1** and **MP2**.* *Accept the correct use of 0.30 in either **MP1** or **MP2**.*	**3**
2	a	ii	absorbed intensity $= (1 - 0.2) \times 680$ «$= 544$» «W m^{-2}» **OR** emitted intensity = $0.97 \times 5.67 \times 10^{-8} \times T^4$ ✓ $T = \sqrt[4]{\frac{544}{0.97 \times 5.67 \times 10^{-8}}} = 315$ «K» ✓ 42 «°C» ✓	*Allow **ECF** from **MP1** and **MP2.*** *Allow **MP1** if absorbed or emitted intensity is multiplied by area.*	**3**
2	b	i	can be liquefied ✓ has intermolecular forces / potential energy ✓ has atoms/molecules that are not point objects / take up volume ✓ does not follow the ideal gas law «for all T and p» ✓ collisions between particles are non-elastic ✓	*Accept the converse argument.*	**1 max**
2	b	ii	***ALTERNATIVE 1*** «constant p and V imply» $nT = \text{const}$ ✓ T increases hence n decreases ✓ ***ALTERNATIVE 2*** «constant p and n imply» V is proportional to T / air expands as it is heated ✓ «original» air occupies a greater volume **OR** some air leaves through opening ✓	***MP2** in **ALT 2** must come from expansion of air, not from expansion of water.* *Award **[0]** for an answer based on expansion of water.* *Award **[1] max** for an answer based on convection currents.*	**2**
2	c		solar «energy» to electrical in a photovoltaic cell ***AND*** solar to thermal in a heating panel ✓		**1**

Question			Answers	Notes	Total
3.	a	i	oscillation in antiphase ✓ smaller amplitude than P ✓ 		2
3	a	ii	wavelength $= \frac{2}{3} \times 0.80 = 0.53$ «m» ✓ speed $= \frac{0.53}{2.8 \times 10^{-3}} = 190$ «m s^{-1}» ✓	*Allow **ECF** from incorrect wavelength*	2

Question			Answers	Notes	Total
3	b	i	kg m s^{-2} ***OR*** m^2 s^{-2} seen ✓ kg m^{-1} ✓	*Award **[2]** for a **BCA***	**2**
3	b	ii	speed increases hence frequency increases ✓ by factor $\sqrt{2}$ ✓		**2**
3	c		travelling waves transfer energy ***OR*** standing waves don't ✓ amplitude of oscillation varies along a standing wave ***OR*** is constant along a travelling wave ✓ standing waves have nodes and antinodes ***OR*** travelling waves don't ✓ points in an internodal region have same phase in standing waves ***OR*** different phase in travelling waves ✓		**2 max**

Question			Answers	Notes	Total
4.	**a**		horizontal component of any length to the left ✓ vertical component two squares long upwards ✓ E.g.  	*Ignore point of application.* *Award **[1] max** if arrowhead not present.*	**2**
4	**b**		***ALTERNATIVE 1*** the net/centripetal force has constant magnitude ✓ the direction of the net/centripetal force constantly changes ✓ this is achieved by vector-adding weight and the force from the rod ***OR*** the force from the rod is vector difference of the centripetal force and weight ✓ ***ALTERNATIVE 2*** at the top $F_{rod} = F_c - W$ ✓ at the bottom, $F_{rod} = F_c + W$ ✓ net F/F_c is constant so the force from the rod is different «hence is changing» ✓	*Accept reference to centripetal or net force indistinctly.* *Allow reference to centripetal acceleration.*	**3**

Question			Answers	Notes	Total
5.	**a**		infinite resistance ***OR*** no current is flowing through it ✓		**1**
5	**b**	**i**	current $= \frac{1.47}{50.0} = 2.94 \times 10^{-2}$ «A» ✓ $r = \frac{1.49}{2.94 \times 10^{-2}} - 50.0$ ***OR*** 0.68 «Ω» ✓	*For **MP2,** allow any other correctly substituted expression for r*	**2**
5	**b**	**ii**	$1.49 \times 2.94 \times 10^{-2}$ ***OR*** $\frac{1.49^2}{50.0 + 0.68}$ ***OR*** $\left(2.94 \times 10^{-2}\right)^2 \left(50.0 + 0.68\right)$ ✓ 0.0438 «W» ✓	*Accept use of 0.7 Ω in **MP1***	**2**
5	**c**	**i**	charge/carriers are moving in a magnetic field ✓ there is a magnetic force on them / quote *F = qvB* ***OR*** this creates a magnetic field that interacts with the external magnetic field ✓	*Accept electrons* *For **MP2**, the force must be identified as acting on charge / carriers*	**2**
5	**c**	**ii**	magnetic needle is deflected by nearby currents ***OR*** two «parallel» current-carrying wires exert a force on each other ***OR*** magnetic field due to a current can be measured directly with a probe ✓	*Only accept argument that refers to an observation or experiment*	**1**

Question			Answers	Notes	Total
6.	a		according to $\Delta E = \Delta mc^2$ / identifies mass energy equivalence ✓ energy is released when nucleons come together / a nucleus is formed «so nucleus has less mass than individual nucleons» ***OR*** energy is required to «completely» separate the nucleons / break apart a nucleus «so individual nucleons have more mass than nucleus» ✓	*Accept protons and neutrons*	**2**
6	b	i	$\left(m_{\text{polonium}} - m_{\text{lead}} - m_{\alpha}\right)c^2$ ***OR*** $\left(209.93676 - 205.92945 - 4.00151\right)$ ***OR*** mass difference = 5.8×10^{-3} ✓ conversion to MeV using 931.5 to give 5.4 «MeV» ✓	*Allow **ECF** from **MP1*** *Award **[2]** for a **BCA*** *Award **[1]** for 8.6×10^{-13} J*	**2**

Question			Answers	Notes	Total
6	b	ii	***ALTERNATIVE 1*** energy ratio expressed in terms of momentum, e.g. $\frac{E_\alpha}{E_{\text{lead}}} = \frac{p_\alpha^2 / 2m_\alpha}{p_{\text{lead}}^2 / 2m_{\text{lead}}}$ ✓ $p_\alpha = p_{\text{lead}}$ hence $\frac{E_\alpha}{E_{\text{lead}}} = \frac{m_{\text{lead}}}{m_\alpha}$ ✓ $\frac{m_{\text{lead}}}{m_\alpha} \simeq \frac{206}{4} = 51.5 \Rightarrow E_\alpha = 51.5E_{\text{lead}}$ «so α has a much greater KE» ***OR*** m_{lead} «much» greater than m_{alpha} «so α has a much greater KE» ✓ ***ALTERNATIVE 2*** alpha particle and lead particle have equal and opposite momenta ✓ so their velocities are inversely proportional to mass ✓ but KE ∝ v^2 «so α has a much greater KE» ✓		**3**
6	b	iii	alpha particle ✓ is electrically charged hence more likely to interact with electrons «in the surrounding material» ✓		**2**