Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2021

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.

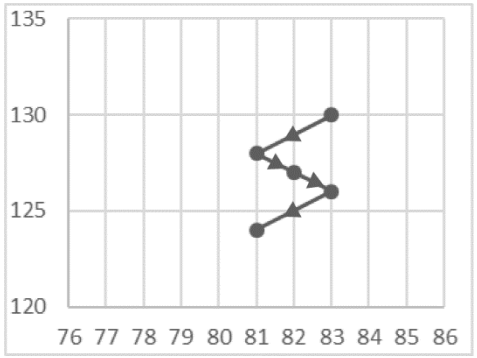
Question			Answers	Notes	Total
1.	a		$\Delta p = 0.45 \times 19$ ***OR*** $a = \frac{19}{0.055}$ ✓ «= $F = \frac{0.45 \times 19}{0.055}$ »160 «N» ✓	*Allow **[2]** marks for a bald correct answer.* *Allow **ECF** for **MP2** if* 19 sin22 ***OR*** 19 cos22 *used.*	**2**
1.	b	i	horizontal speed = 19 x cos 22 «= 17.6 m s^{-1}» ✓ time = « $\frac{\text{distance}}{\text{speed}} = \frac{11}{19\cos 22} =$ » 0.62 «s» ✓	*Allow **ECF** for **MP2***	**2**
1.	b	ii	initial vertical speed = 19 x sin 22 «= 7.1 m s^{-1} » ✓ «7.12 x 0.624 - 0.5 x 9.81 x 0.624^2 =» 2.5 «m» ✓ ball does not hit wall ***OR*** 2.5 **«**m**»** **>** 2.4 **«**m**»** ✓	*Allow **ECF** from (b)(i) and from **MP1*** *Allow g* = 10 m s^{-2}	**3**
1.	c		air resistance opposes «direction of» motion ***OR*** air resistance opposes velocity ✓ on the way up «vertical» acceleration is increased ***OR*** greater than g ✓ on the way down «vertical» acceleration is decreased ***OR*** smaller than g ✓	*Allow deceleration/acceleration but meaning must be clear*	**2 max**

Question			Answers	Notes	Total
2.	a		«He behaves as ideal gas if» $p \propto T$ «at constant V» ✓ uses two points to show that $p \propto T$ ✓	***MP1** can also be described as* $\frac{p}{T} = k$ ***OR*** $\frac{p}{T} = \frac{nR}{V}$	**2**
2.	b		$\frac{100 \times 10^3 \times 10^{-3}}{250 \times 8.31}$ = «0.048 mol» ✓ «0.048 x 4 =» 0.19 «g» ✓	*Allow any correct data point to be used.* *Allow **ECF** from **MP1***	**2**
2.	c		recognizes that pressure will double ✓ graph will be steeper ***OR*** gradient will be larger ✓ graph will still go through the origin ✓	***MP1** can be expressed as* *e.g.* "$p \propto n$" ***OR*** "$\frac{nR}{V}$ *will double".* *Accept* $pv = 2nRT$ *for **MP1**.*	**2 max**

Question			Answers	Notes	Total
3.	a		identifies units of σ as C m^{-2}✓ $\frac{C}{m^2} \times \frac{Nm^2}{C^2}$ seen and reduced to N C^{-1}✓	*Accept any analysis (eg dimensional) that yields answer correctly*	**2**
3.	b	i	horizontal force *F* on ball = *T* sin 30 ✓ $T = \frac{mg}{\cos 30}$ ✓ *F* «=*mg* tan 30 = 0.025 x 9.8 x tan 30» = 0.14 «N»✓	*Allow g*= 10 N kg^{-1} *Award **[3] marks** for a bald correct answer.* *Award **[1max]** for an answer of zero, interpreting that the horizontal force refers to the horizontal component of the net force.*	**3**
3.	b	ii	$E = \frac{0.14}{1.2 \times 10^{-6}}$ **«**$= 1.2 \times 10^5$**»** ✓ $\sigma =$ « $\frac{2 \times 8.85 \times 10^{-12} \times 0.14}{1.2 \times 10^{-6}}$ » = 2.1 x 10^{-6} «C m^{-2}»✓	*Allow **ECF** from the calculated F in (b)(i)* *Award **[2]** for a bald correct answer.*	**2**
3.	c		horizontal/repulsive force and vertical force/pull of gravity act on the ball ✓ so ball has constant acceleration/constant net force ✓ motion is in a straight line ✓ at 30° to vertical away from wall/along original line of thread✓		**3 max**
3.	d	i	$\frac{Q}{0.22^2} = \frac{1.2 \times 10^{-6}}{0.18^2}$ ✓ «+»1.8 x 10^{-6} «C» ✓ 2sf ✓	*Do not award **MP2** if charge is negative* *Any answer given to 2 sig figs scores **MP3***	**3**

Question			Answers	Notes	Total
3.	**d**	**ii**	work must be done to move a «positive» charge from infinity to P «as both charges are positive» ***OR*** reference to both potentials positive and added ***OR*** identifies field as gradient of potential and with zero value ✓ therefore, point P is at a positive / non-zero potential ✓	*Award **[0]** for bald answer that P has non-zero potential*	**2**

Question			Answers	Notes	Total
4.	a	i	$^{205}_{82}Pb$ ✓ $^{0}_{-1}e$ ***AND*** $^{0}_{0}\upsilon_e$ ✓		**2**
4.	a	ii	calculates $\lambda = \frac{\ln 2}{15 \times 10^6}$ «= 4.62 x 10^{-8} $year^{-1}$» ✓ calculates nuclei remaining = 0.50 x 10^{-6} x 6.0 x 10^{23} «= 3.0 x 10^{17}» ✓ activity = « λN = 1.4 x 10^{10} nuclei per year» = 440 «nuclei per second» ✓	*Accept conversion to seconds at any stage.* *Award **[3] marks** for a bald correct answer.* *Allow **ECF** from **MP1** and **MP2*** *Allow use of decay equation.*	**3**
4.	b		Reference to proton repulsion ***OR*** nucleon attraction ✓ strong force is short range ***OR*** electrostatic/electromagnetic force is long range ✓ more neutrons «than protons» needed «to hold nucleus together» ✓		**2 max**

Question			Answers	Notes	Total
4.	**c**		 any α change correct ✓ any β change correct ✓ diagram fully correct ✓	*Award **[2] max** for a correct diagram without arrows drawn.* *For **MP1** accept a (-2, -2) line with direction indicated, drawn at any position in the graph.* *For **MP2** accept a (1, -1) line with direction indicated, drawn at any position in the graph.* *Award **[1]** max for a correct diagram with all arrows in the opposite direction.*	**3**

Question			Answers	Notes	Total
5.	**a**		energy is not propagated by standing waves ✓ amplitude constant for travelling waves ***OR*** amplitude varies with position for standing waves ***OR*** standing waves have nodes / antinodes ✓ phase varies with position for travelling waves ***OR*** phase constant inter-node for standing waves ✓ travelling waves can have any wavelength ***OR*** standing waves have discrete wavelengths ✓	***OWTTE***	**2 max**
5.	**b**	**i**	«sound» wave «travels down tube and» is reflected ✓ incident and reflected wave superpose/combine/interfere ✓	***OWTTE*** *Do not award **MP1** if the reflection is quoted at the walls/container*	**2**
5.	**b**	**ii**	nodes shown at water surface ***AND*** $\frac{2}{3}$ way up tube (by eye) ✓	*Accept drawing of displacement diagram for correct harmonic without nodes specifically identified.* *Award **[0]** if waveform is shown below the water surface*	**1**
5.	**b**	**iii**	$\lambda = 0.74$ «m» ✓ $f = \left\langle\left\langle \frac{c}{\lambda} = \frac{320}{0.74} \right\rangle\right\rangle$ 430 «Hz» ✓	*Allow **ECF** from **MP1***	**2**

Question			Answers	Notes	Total
6.	a		there is a potential difference across the internal resistance ***OR*** there is energy/power dissipated in the internal resistance ✓ when there is current «in the cell»/as charge flows «through the cell» ✓	*Allow full credit for answer based on* $V = \varepsilon - Ir$	**2**
6.	b		***ALTERNATIVE 1*** pd dropped across cell = 6.5 «V» ✓ internal resistance = $\frac{6.5}{0.9}$ ✓ 7.2 «Ω» ✓ ***ALTERNATIVE 2*** $\varepsilon = I(R + r)$ so $\varepsilon = V + Ir$ ✓ 21.0 = 14.5 + 0.9 x r ✓ 7.2 «Ω» ✓	*Alternative solutions are possible* *Award **[3]** marks for a bald correct answer*	**3**
6.	c		power arriving at cell = 680 x 0.35 x 0.45 = «107 W» ✓ power in external circuit = 14.5 x 0.9 = «13.1 W» ✓ efficiency = 0.12 ***OR*** 12 % ✓	*Award **[3]** marks for a bald correct answer* *Allow **ECF** for **MP3***	**3**
6.	d		«energy from Sun/photovoltaic cells» is renewable ***OR*** non-renewable are running out ✓ non-polluting/clean ✓ no greenhouse gases ***OR*** does not contribute to global warming/climate change ✓	***OWTTE*** *Do not allow economic aspects (e.g. free energy)*	**2 max**

Question			Answers	Notes	Total
7.	a	i	« $\frac{15}{110} \times 3300 =$ » 450 «turns» ✓		1
7.	a	ii	***ALTERNATIVE 1*** calculates total current = $\frac{35}{15} \times 8$ « = 18.7 A» ✓ resistance = « $\frac{15}{18.7}$ = » 0.80 «Ω» ✓ ***ALTERNATIVE 2*** calculates total power = 35x8 « = 280 W» ✓ resistance = « $\frac{15^2}{280}$ =» 0.80 «Ω» ✓ ***ALTERNATIVE 3*** calculates individual resistance = $\frac{15^2}{35}$ « = 6.43 Ω» ✓ resistance = « $\frac{6.43}{8}$ » = 0.80 «Ω» ✓		2
7.	a	iii	total power required = 280 «W» ***OR*** uses factor $\frac{3300}{450}$ ***OR*** total current = 18.7 « A» ✓ current = 2.5 OR 2.6 «A» ✓	*Award **[2]** marks for a bald correct answer.* *Allow **ECF** from (a)(ii).*	2

Question			Answers	Notes	Total
7.	a	iv	the secondary coil does not enclose all flux «lines from core» ✓ induced emf in secondary ***OR*** power transferred to the secondary ***OR*** efficiency is less than expected ✓	*Award **[0]** for references to eddy currents/heating of the core as the reason.* *Award **MP2** if no reason stated.*	**2**
7.	b		bob cuts mag field lines ***OR*** there is a change in flux linkage ✓ induced emf across bob ✓ leading to eddy/induced current in bob ✓ eddy/induced current produces a magnetic field that opposes «direction of» motion ✓ force due to the induced magnetic field decelerates bob ✓ damping of pendulum increases/there is additional «magnetic» damping ✓	***MP4** and **MP5** can be expressed in terms of energy transfer from kinetic energy of bob to electrical/thermal energy in bob*	**4 max**

Question			Answers	Notes	Total
8.	a	i	0 ***OR*** 2π ***OR*** 360° ✓		1
8.	a	ii	4λ ✓		1
8.	a	iii	$\sin\theta$ «$= \frac{XZ}{VX}$» $= \frac{4\lambda}{2d}$ ✓	*Do **not** award **ECF** from(a)(ii).*	1
8.	b		identifies gradient with $\frac{\lambda}{d}$ ***OR*** use of $d\sin\theta = n\lambda$ ✓ gradient = 0.08 ***OR*** correct replacement in equation with coordinates of a point ✓ $d = \frac{633\times10^{-9}}{0.080}$ = «7.91 x 10^{-6} m» ✓ 1.26 x 10^{2} ***OR*** 1.27 x 10^{2}«mm^{-1}» ✓	*Allow **ECF** from **MP3***	4
8.	c	i	gradient smaller ✓		1
8.	c	ii	no change ✓		1

Question			Answers	Notes	Total
9.	**a**	**i**	photon transfers «all» energy to electron ✓		**1**
9.	**a**	**ii**	photon energy is less than both work functions ***OR*** photon energy is insufficient «to remove an electron» ✓	*Answer must be in terms of photon energy.*	**1**
9.	**a**	**iii**	Identifies P work function lower than Q work function ✓		**1**
9.	**b**		changing/doubling intensity «changes/doubles number of photons arriving but» does not change energy of photon ✓		**1**
9.	**c**		$5.1 \times 10^{-19} = 1.1 \times 10^{-18} - \phi$ ✓ work function = « $\frac{(11.0-5.1)\times 10^{-19}}{1.6\times 10^{-19}} =$ » 3.7 «eV» ✓	*Award **[2]** marks for a bald correct answer.*	**2**

Question			Answers	Notes	Total
10.	**a**		$\text{«}\frac{GM}{r^2} = \frac{6.67\times10^{-11}\times8.9\times10^{22}}{\left(1.8\times10^{6}\right)^2}\text{=» } 1.8$ ✓ N kg^{-1} ***OR*** m s^{-2} ✓		**2**
10.	**b**	**i**	$\frac{1.9\times10^{27}}{4.9\times10^{8}}$ ***AND*** $\frac{8.9\times10^{22}}{1.8\times10^{6}}$ seen ✓ $\text{«}\frac{1.9\times10^{27}\times1.8\times10^{6}}{4.9\times10^{8}\times8.9\times10^{22}}\text{=»} 78$ ✓	*For **MP1**, potentials can be seen individually or as a ratio.*	**2**
10.	**b**	**ii**	«this is the escape speed for Io alone but» gravitational potential / field of Jupiter must be taken into account ✓	***OWTTE***	**1**
10.	**c**		$-GM_{\text{Jupiter}}\left(\frac{1}{1.88\times10^{9}}-\frac{1}{1.06\times10^{9}}\right)$ = «5.21 x 10^{7} J kg^{-1}» ✓ « multiplies by 3600 kg to get » 1.9 x 10^{11} «J» ✓	*Award **[2]** marks if factor of ½ used, taking into account orbital kinetic energies, leading to a final answer of 9.4x10^{10}* «J». *Allow **ECF** from MP1* *Award **[2]** marks for a bald correct answer-*	**2**