Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2023

Physics

Higher level

Paper 2

15 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		***ALTERNATIVE 1*** Attempt to count squares ✓ Area of one square found ✓ 7.2 «m» (accept 6.4 – 7.4 m) ✓ ***ALTERNATIVE 2*** Uses area equation for either triangle ✓ Correct read offs for estimate of area of triangle ✓ 7.2 «m» (accept 6.4 – 7.4) ✓		**3**
1.	b		Attempt to calculate gradient of line at $t = 1.2$ s ✓ «–» 9.8 «m s^{-2}» (accept 9.6 - 10.0)✓		**2**
1.	c	i	Attempt to evaluate KE ratio as $\left(\frac{v_{final}}{v_{initial}}\right)^2$ ✓ «$\left(\frac{4.5}{10}\right)^2$ =» 0.20 ***OR*** 20 % ***OR*** $\frac{1}{5}$ ✓	*Accept ± 0.5 velocity values from graph*	**2**
1.	c	ii	Attempt to use force = momentum change ÷ time ✓ «= $\frac{(4.5+10)\times 0.027}{85\times 10^{-3}}$ = 4.6» Force = «4.6 + 0.3» 4.9 «N» ✓ Any answer to 2sf ✓	*Accept ± 0.5 velocity values from graph*	**3**
1.	d		Mass «leaving the bottle per second» will be larger for air–water ✓ the momentum change/force is greater ✓	*Allow opposite argument for air only*	**2**

Question			Answers	Notes	Total
2.	a		kg m^2 s^{-2} ✓		1
2.	b		***ALTERNATIVE* 1** Graph shown is a straight line/linear ***OR*** expected graph should be a straight line/linear ✓ If ideal then T intercept must be at T = -273 °C ✓ Use of $y = mx+c$ to show that x = -273°C when y = 0 ✓ (hence ideal) ***ALTERNATIVE* 2** Calculates $\frac{pV}{T}$ for two different points ✓ Obtains 1.50 «J K^{-1}» for both ✓ States that for ideal gas $\frac{pV}{T} = nR$ which is constant and concludes that gas is ideal ✓		3
2.	c		Use of $n = \frac{pV}{RT}$ ***OR*** $N = \frac{pV}{kT}$ ✓ Mass of gas = n x N_A x mass of molecule ***OR*** Mass of gas = N x mass of molecule ✓ 5.1 «g» ✓		3

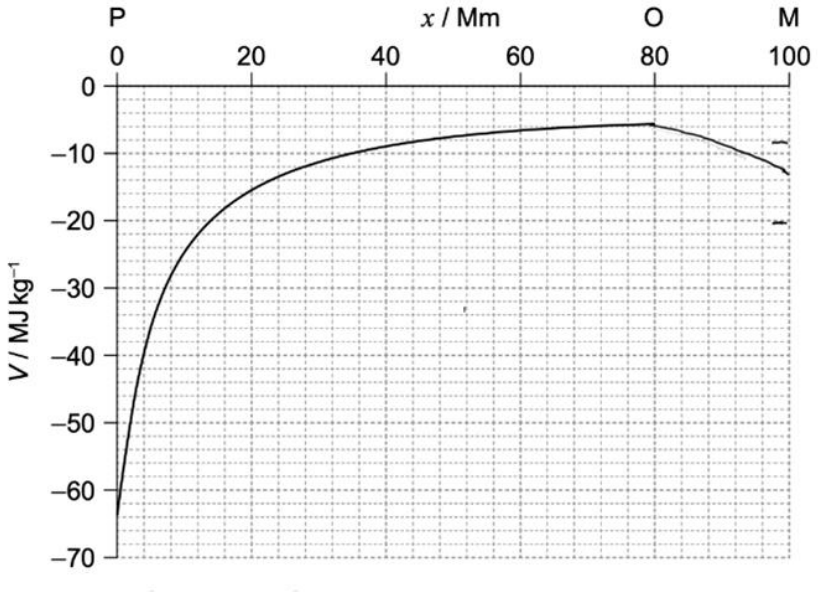
Question			Answers	Notes	Total
3.	a		Mention of interference / superposition ✓ Bright fringe occurs when light from the slits arrives in phase ✓ Dark fringe occurs when light from the slits arrives 180°/ π out of phase ✓		3
3.	b	i	$s = \frac{0.15}{8}$ ***OR*** $= 0.0188$ «m» ✓ use of $\lambda = \frac{ds}{D}$ ✓ 450 «nm» ✓		3
3.	b	ii	«As the measurements decrease» the fractional uncertainty in D/s increases. ✓ «Fractional uncertainties are additive here» so fractional uncertainty in λ increases ✓	*Answers can be described in symbols e.g. Δs/s*	2
3.	c		Blue fringe is unchanged ✓ Red fringes are farther apart than blue ✓ By a factor of 1.5 ✓ At some point/s the fringes coincide/are purple ✓		3 max

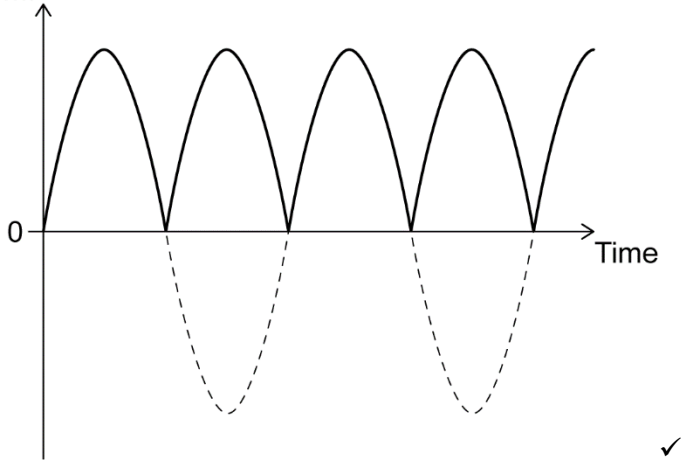
Question			Answers	Notes	Total
4.	a		$I = \sqrt{\frac{P}{R}}$ =» 1.9 «A» ✓		1
4.	b	i	***ALTERNATIVE* 1** (Calculation of length) Read off from graph [2.8 - 3.2 x10^{-5} Ω m]✓ Use of $I = \frac{RA}{\rho}$ ✓ I = 1.3 - 1.4 «m» ✓ ***ALTERNATIVE* 2** (Calculation of area) Read off from graph [2.8 - 3.2 x10^{-5} Ω m]✓ Use of $A = \rho\frac{I}{R}$ ✓ A = 8.3 - 9.5 x 10^{-6} «m^2» ✓ ***ALTERNATIVE* 3** (Calculation of resistance) Read off from graph [2.8 - 3.2 x10^{-5} Ω m]✓ Use of $R = \rho\frac{I}{A}$ ✓ R = 3.6 - 4.2 «Ω» ✓ ***ALTERNATIVE* 4** (Calculation of resistivity) Use of $\rho = \frac{RA}{I}$ ✓ ρ = 3.2 x 10^{-5} «Ωm» ✓ Read off from graph 260 – 280 K ✓		3

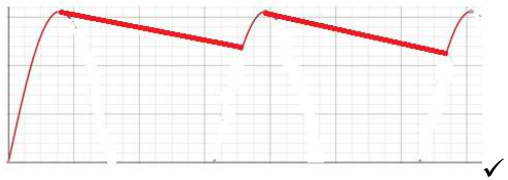
Question			Answers	Notes	Total
4.	**b**	**ii**	«Resistivity and hence» resistance will decrease ✓ «Pd across pad will not change because internal resistance is negligible» Current will increase ✓		**2**
4.	**c**	**i**	«The force is» away from PQ/repulsive/to the right ✓		**1**
4.	**c**	**ii**	The magnetic fields «due to currents in PQ and TU» are in opposite directions ***OR*** There are two «repulsive» forces in opposite directions ✓ Net force is zero ✓		**2**
4.	**d**		Air is a poor «thermal» conductor ✓ Lack of convection due to air not being able to move in material ✓ Appropriate statement about energy transfer between the pet, the resistor and surroundings ✓ The rate of thermal energy transfer to the top surface is greater than the bottom «due to thinner material» ✓	*Accept air is a good insulator*	**3 max**

Question			Answers	Notes	Total
5.	**a**		«An atom with» the same number of protons ***AND*** different numbers of neutrons ***OR*** Same chemical properties ***AND*** different physical properties ✓	*Do **not** allow just atomic number and mass number*	**1**
5.	**b**	**i**	3 ✓		**1**
5.	**b**	**ii**	2 ✓		**1**
5.	**c**		d→u ✓		**1**
5.	**d**		Strong force is short range & electromagnetic force is long range ✓ Strong force is attractive between nucleons/neutrons & protons ✓ electromagnetic force is repulsive between protons ✓ Overall, the strong force dominates ✓		**3 max**
5.	**e**		Alphas have double charge «and so are better ionisers »✓ alphas have more mass and therefore slower «for same energy» ✓ so longer time/more likely to interact with the «atomic» electrons/atoms «and therefore better ionisers» ✓	*Accept reverse argument in terms of betas travelling faster.*	**2 max**

Question			Answers	Notes	Total
6.	a		Work using $g \propto \frac{m}{r^2}$ ✓ $\frac{g_M}{g_P} = \frac{m_M}{m_P}\left(\frac{r_P}{r_M}\right)^2 = 0.75$ ✓		2
6.	b	i	$g = 0$ ✓ As g «= $-\frac{\Delta V_g}{\Delta r}$ which» is the gradient of the graph ***OR*** As the force of attraction/field strength of P and M are equal ✓		2
6.	b	ii	The gravitational field is attractive so that energy is required «to move away from P» ✓ the gravitational potential is defined as 0 at ∞, (the potential must be negative) ✓		2
6.	b	iii	$V_P = -\frac{GM}{R_P}$ ***AND*** $g_P = \frac{GM}{R_P^2}$ (at surface) ✓ Suitable working and cancellation of G and M seen ✓ $V_P = -g_P R_P$	*Must see negative sign*	2
6.	b	iv	«$\frac{V_M}{V_P} = \frac{g_M R_M}{g_P R_P} = 0.75 \times 0.27$» $= 0.20$ ✓ V_M = «-6.4 x 10^7 x 0.2=» «-»1.3 x 10^7 «J kg^{-1}»✓		2

Question			Answers	Notes	Total
6.	b	v	Line always negative, of suitable shape and end point below −8 and above −20 unless awarding ***ECF*** from **b(iv)** ✓ 		1

Question			Answers	Notes	Total
7.	a	i	Use of $\sqrt{2} \times \frac{n_S}{n_P}$ ***OR*** correct conversion of rms to peak value at some point ✓ 16 «V» ✓		2
7.	a	ii	Output emf  ✓		1
7.	b		There is now a current in the secondary coils ✓ Energy loss due to heating in the coils ***OR*** «Lenz's law predicts that» this will oppose the original induced emf ✓ «and reduce the pd across the coils»		2

Question			Answers	Notes	Total
7.	c		 ✓		1
7.	d		Adding a capacitor in parallel will increase the capacitance / will increase RC ✓ idea that this makes the waveform smoother ✓		2

Question			Answers	Notes	Total
8.	**a**		There is «partial» reflection at the front surface of the layer and also at the glass-layer interface ✓ destructive interference «between these reflections occurs at the missing wavelength» ✓		**2**
8.	**b**		Use of $2dn = m\lambda$ ✓ Use of $n = 1.63$ ✓ 470 «nm» ✓		**3**
8.	**c**	**i**	There is relative motion between the girl and the automobile ✓ «Relative to the girl» the wavelength of the sound changes/increases ✓	*Just mention of 'Doppler effect' is insufficient.*	**2**
8.	**c**	**ii**	Use of $f = f'\left(\frac{c+u}{c}\right)$ ✓ $«f = 410\left(\frac{330+15}{330}\right) = »430$ «Hz» ✓		**2**

Question			Answers	Notes	Total
9.	**a**		(26.98434 - 26.98153) x 931.5 ***OR*** 2.6175 «MeV» seen ✓		**1**
9.	**b**	**i**	evidence for nuclear energy levels ✓		**1**
9.	**b**	**ii**	Difference = 2.6175 – (1.76656 +0.84376) = 2.6175 – 2.61032 = 0.007195 «MeV» ***OR*** Difference = 2.6175 – (1.59587 +1.01445) = 2.61032= 0.007195 «MeV» ✓		**1**
9.	**b**	**iii**	Another particle/«anti» neutrino is emitted «that accounts for this mass / energy» ✓		**1**
9.	**c**	**i**	So 1.1 x 10^{-8} kg ≡ $\frac{1.1}{0.027}\times 10^{-8}$ «mol» ***OR*** Mass of atom = 27 x 1.66 x 10^{-27} «kg» ✓ 2.4 - 2.5 x 10^{17} atoms ✓		**2**
9.	**c**	**ii**	$N_{10} = 9.50\times 10^{15}\times e^{-0.00122\times 600}$ seen ✓ $N_{10} = 4.57\times 10^{15}$ ✓ So number of aluminium-27 nuclei = (9.50 – 4.57) x 10^{15} = 4.9(3) x 10^{15} ✓		**3**
9.	**c**	**iii**	Total energy released = ans **(c)(ii)** x 2.62 x 10^{6} x 1.6 x 10^{-19} «= 2100 J» ✓ $\frac{2100}{600}$ =»3.4 – 3.5 «W» ✓		**2**