OXFORD AQA
INTERNATIONAL QUALIFICATIONS

INTERNATIONAL A-LEVEL
PHYSICS
PH05
Unit 5 Physics in practice

Mark scheme

June 2024

Version: 1.0 Final

246XPH05/MS

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from www.oxfordaqa.com

Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

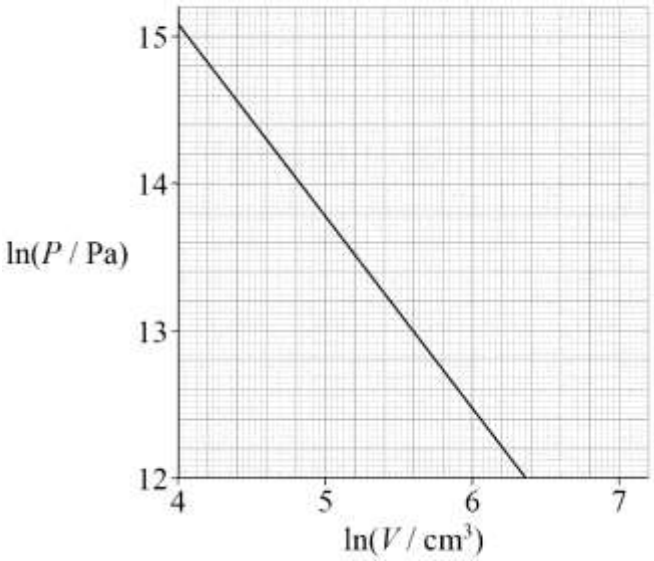
Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr><td>01.1</td><td>Sensible scales chosen ✓

Plotting correct at least 3 points within $\frac{1}{2}$ square ✓

Plotting all correct within $\frac{1}{2}$ square ✓

Best-fit line for their plots ✓</td><td>

At least half grid scale.

Do not award mp1, mp2, mp3 for awkward or non-linear scales.

<table>
<tr><th>ln (P/Pa)</th><th>ln(V / cm^3)</th></tr>
<tr><td>14.6</td><td>4.38</td></tr>
<tr><td>13.7</td><td>5.08</td></tr>
<tr><td>13.1</td><td>5.48</td></tr>
<tr><td>12.8</td><td>5.77</td></tr>
<tr><td>12.3</td><td>6.17</td></tr>
</table>
</td><td>4</td><td>AO3</td></tr>
</table>

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Correct data extraction with a large triangle ✓ (−)1.3 ✓	Look for (4.00, 15.1) and (6.37, 12.0) Allow answers that round to between 1.25 → 1.3 If data points used they must lie on line	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	Takes natural logs of both sides to give $\ln P = -\gamma \ln V + \ln k$ ✓ 1.3 ecf from **01.2** ✓	mp2 – appreciate that the magnitude of the gradient = $+\gamma$ must be a positive value	2	AO3
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Heating the apparatus (until T_1 and T_2 are steady) is done before timing starts / before measurements are taken ✓	Accept • apparatus is in thermal equilibrium / steady state • temperature of apparatus remains constant • it is included in energy transfer to surroundings	1	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	The (rate of) heat / energy transfer (to the surroundings) / Q is the same since the (change in) temperature(s) is the same ✓ … so the total heat transfer is the same as t is the same ✓	Use of thermal conductivity equation with symbols defined with a constant t is enough for mp2.	2	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	$V_2 I_2 t = m_2 c(T_2 - T_1) + Q$ seen ✓ Subtracts the two equations / equates Q **and** rearranges ✓	Subscripts all correct for MP2 MP2 depends on MP1	2	1× AO1 1× AO2

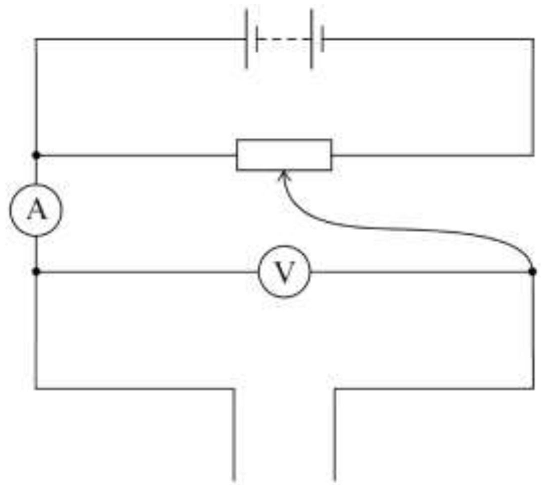
Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	absolute uncertainty in $(T_2 - T_1)$ = 0.2 K absolute uncertainty in $(m_1 - m_2)$ = 2 g ✓	Value and unit correct Do not allow °K or k Condone °C	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.5	percentage uncertainty in $(T_2 - T_1) = 3.6\%$ or 4% percentage uncertainty in $(m_1 - m_2) = 1.2\%$ or 1% ecf for candidate's **02.4** ✓	look for $\frac{\text{candidate's } 0.2\times100}{5.6}$ and $\frac{\text{candidate's } 2\times100}{163}$ Accept 1 or 2 SF only	1	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
02.6	$2.46\ (\mathrm{J\ g^{-1}\ K^{-1}})$ ✓	Accept $2.5\ (\mathrm{J\ g^{-1}\ K^{-1}})$	1	AO2

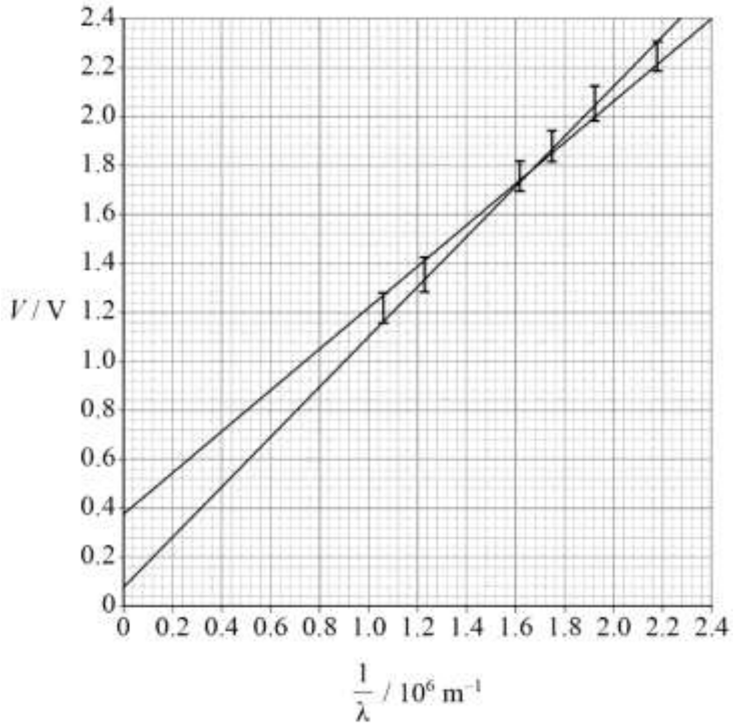
Question	Answers	Additional comments/Guidelines	Mark	AO
02.7	Adds 4% + candidate's 4% (from **02.5**) + candidate's 1% (from **02.5**) + 1% for t ✓ $0.24\ \mathrm{J\ g^{-1}\ K^{-1}}$ to $0.3\ \mathrm{J\ g^{-1}\ K^{-1}}$ ecf from **02.5** ✓	Allow ecf for **02.6** Condone lack of % uncertainty for t in mp1 Expect 9.8% to 2sf or 10% to 1 sf Allow $0.2\ \mathrm{J\ g^{-1}\ K^{-1}}$ Accept 1 or 2 SF only	2	1× AO1 1× AO2

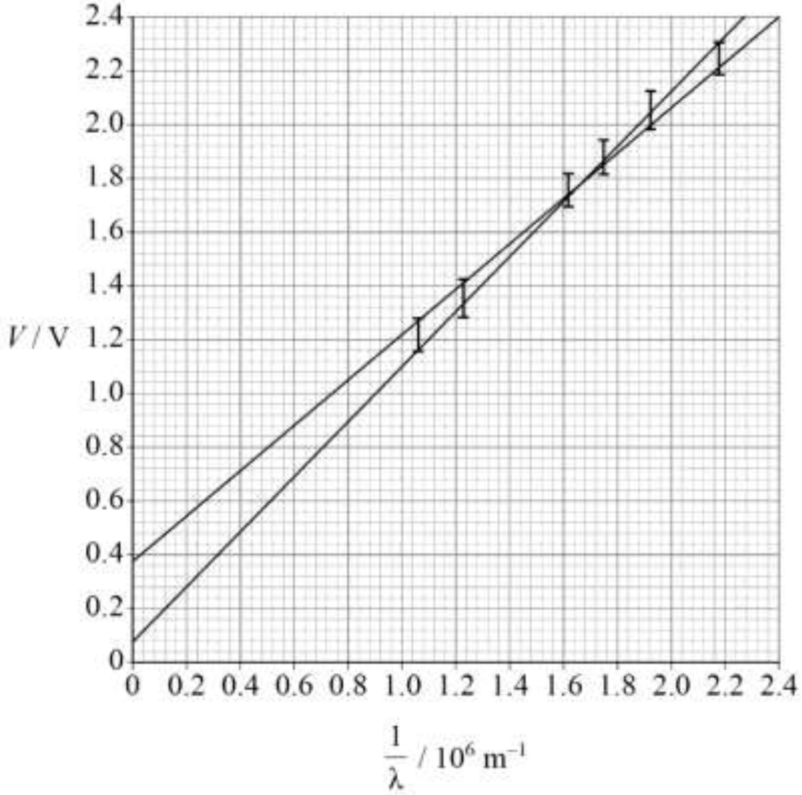
Question	Answers	Additional comments/Guidelines	Mark	AO
02.8	No effect since the leaked material is neither heated nor weighed ✓	Condone either not heated or not weighed on its own Allow “mass is measured at the end / outlet only” Condone “no change to $m_2 - m_1$ as the leak is present in both determinations.”	1	AO4
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Appropriate use of a potentiometer connected correctly ✓ Voltmeter in parallel and ammeter in series with thermistor with a correct use of either a potentiometer or a variable resistor ✓	 Accept re-drawn diagram condone extraneous details that do not affect the operation of the circuit correct potentiometer method scores mp1 and mp2 correct variable resistor method only scores mp2	2	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	(Convert to (absolute) temperature and) plot $\frac{1}{R}$ against (absolute) temperature ✓ If relationship is true the graph will be a straight line through the origin ✓	Condone lack of conversion to absolute temperature for MP1 Accept R against $\frac{1}{\text{absolute temperature}}$ do not condone missing absolute for mp1 in this method. MP2 awarded only for graphical method using <u>absolute</u> temperature Condone MP2 if temperature in $°C$ is plotted against $\frac{1}{R}$ and the graph is a straight line with temperature intercept of $-273\ °C$. **Alternative method** Allow $R \times$ (absolute) temperature = constant ✓ $\theta = \frac{k}{R}$ or $R = \frac{k}{\theta}$ is insufficient for mp1. Constant for all sets of data using <u>absolute</u> temperature ✓	2	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Any **two** from: ✓✓ • More data sets • Take measurements with smaller intervals • Greater range of data (as it only covers 293 K to 353 K) • Repeats AND averages • Repeats AND removes anomalies	Ignore references to insulation, reading at eye level etc.	2	AO4
Total			**6**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Correct plot within half a square ✓		1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Correct best-fit lines ✓ **ecf from 04.1** provided that the best-fit lines go through all error bars	doesn't have to go to the axis Look for *V* intercepts of around 0.4 (V) and 0.08 (V) OR Max through bottom of 1st bar and top of last; min through top of 2nd and bottom of 5th Allow plus or minus 1 square each 	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Correct data extraction for one gradient (with large triangle shown) ✓ At least one gradient correct for their line ✓ Uses their gradient = $\frac{hc}{e}$ ✓ Both values of Planck constant correct max = $(4.3 - 4.5) \times 10^{-34}$ (J s) and min = $(5.4 - 5.7) \times 10^{-34}$ (J s)✓	Ignore PoT in mp1, mp2 and mp3 Look for 1.0×10^{-6} and 8.2×10^{-7} Do not penalise sf	4	1× AO2 3× AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	MAX 3 ✓✓✓ Accepted value of the Planck constant is not within the range calculated / neither value is close to the accepted value. (Very) large (percentage) uncertainty in the value of the Planck constant OR calculated percentage uncertainty Equation suggests that the graph should go through the origin There is a systematic error in the data		3	2× AO3 1× AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
04.5	Idea that the student is adjusting the variable voltage supply and overshoots on each occasion ✓	Allow idea of a time lag between adjusting the supply and the reaction of the LED Allow idea that the student does not see LED when lit up due to background light etc.	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.6	Suggests use of a darkened room or a cardboard tube (to exclude light) ✓		1	AO4
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Calculates mass flow rate OR $V = \frac{m}{\rho}$ ✓ Area = $\pi(8.8 \times 10^{-4})^2$ or deals with 24 jets ✓ 7.96 (m s^{-1}) to 3 sf ✓	$\frac{1680}{3600}$ seen - expect to see 0.4667 Expect to see 2.44×10^{-6} (m^2) or division by 24	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Uses $v_h = v \cos 43$ to attempt to find t ✓ Uses $v_v = v \sin 43$ ✓ Uses $s = ut + \frac{1}{2}at^2$ ✓ (−)0.26 (m) ✓	Expect range 0.18 to 0.26 Allow ecf from **05.1**	4	1× AO1 2× AO2 1× AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Deduces that faster water will land further from the jet or reverse argument ✓ Explains in terms of longer airborne time due to larger (vertical component of) velocity or reverse argument✓	For MP2 do not allow a larger horizontal component causes a longer time of flight. If no other marks, award 1 for stating that they have different times of flight.	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	Uses change in momentum = force = mass flow rate × v ✓ 0.027 (kg s^{-1}) seen ✓ 0.64 (kg s^{-1}) ✓	mp2 value or expression recognition of their value ×24	3	1× AO1 1× AO2 1× AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.5	Uses torque (from each jet) = $Fr \sin 60$ ✓ 0.13 N m ✓	Expect to see $5.40\text{x}10^{-3}$	2	AO2
Total			**14**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Use of $v = r\omega$ ✓ 2.6 (m s^{-1}) ✓	Ignore POT in mp1	2	1× AO2 1× AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Use of $s = vt$ to give 0.11 (m) **ecf** from **06.1** ✓	2.64×40 ms → 0.11 2.6×40 ms → 0.104 2.638937829×40 ms → 0.106 Penalise 1 sf	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Uses $V = \dfrac{Q}{4\pi\varepsilon_0 r}$ or $Q = CV$ and manipulates correctly ✓ Combines both equations and manipulates correctly ✓	**Alternative** Use of $C = \frac{\varepsilon_0 A}{r}$ or $A = 4\pi r^2$ and manipulates correctly✓	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	Uses $E = \frac{1}{2}CV^2$ OR $E = Pt$ ✓ Attempts to use efficiency = $\frac{\text{useful output power}}{\text{input power}}$ ✓ 0.058 (%) ✓	Expect to see energy values of 0.14 J and 240 J Or power values 0.028 W and 48 W Allow use of energy in efficiency equation. 1 or 2 sig fig answer only	3	1× AO1 1× AO2 1× AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.5	Attempt to use $E_k = \frac{1}{2}mv^2$ ✓ Attempts to calculate the (maximum) kinetic energy of the nucleus in J using $E_k = qV$ ✓ Uses specific charge = $\frac{q}{m}$ ✓ 3.4×10^6 (m s^{-1}) ✓	Condone confusing specific charge and charge for mp2. $\frac{1}{2}mv^2 = qV$ scores mp1 and mp2	4	1× AO1 2× AO2 1× AO3
Total			**12**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	Uses $N = N_0e^{-\lambda t}$ ✓ Uses N_0 = 96.9 for uranium-238 AND N_0 = 3.1 for uranium-235 ✓ One correct calculation: U-238 reduced to 74.5 OR U-235 reduced to 0.58 ✓ Finds current ratio of approximately 0.8% for U-235 OR 99.2% for U-238 ✓ <u>Alternative</u> Uses $T_{1/2} = \frac{\ln 2}{\lambda}$ to work out $T_{1/2}$ ✓ works out number of half-lives for Uranium-235 AND uranium-238 ✓ One correct calculation: U-238 reduced to 74.5 OR U-235 reduced to 0.58 ✓ Finds current ratio of approximately 0.8% for U-235 OR 99.2% for U-238 ✓	Accept use of 96.9x etc for quantities Accept reverse argument. Accept use of $A = \lambda N$ and $A = A_0e^{-\lambda t}$ for mp1, mp2 and mp3 expect 7.044×10^8 for Uranium-235 and 4.47×10^9 for Uranium-238 Expect 2.41 for Uranium-235 And 0.38 for Uranium-238	4	1× AO1 2× AO2 1× AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Uranium-235 is fissile but uranium-238 is not (for thermal fission) ✓ Idea that a neutron is more likely to be absorbed (in a fission event) if there are more fissile nuclei present ✓	Condone ^{238}U not fissile Condone collided for absorbed	2	1× AO2 1× AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	Max 4 ✓✓✓✓ • Water is a moderator • Fast neutrons are produced from (thermal) fission • Fission only happens when a (fissile) nucleus absorbs a neutron • (Fast) neutrons need to be / are slowed (in order to be absorbed in a fission reaction) • Slowing down occurs when neutrons collide with (light) atoms (such as hydrogen in water)		4	1× AO1 2× AO2 1× AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	**One** from: (Specific) heat capacity Thermal conductivity Porosity Melting point Density Concentration of U-235 ✓	 Condone heat for thermal	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.5	**One** from: (Specific) heat capacity Specific latent heat (of vaporisation) Density Boiling point ✓	Condone mass or amount or volume.	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.6	Converts 211 MeV to amu by dividing by 931.5 ✓ Multiplies by 1.661×10^{-27} to get 3.76×10^{-28} ✓ (kg) **Alternative** Converts 211 MeV to J by multiplying by 1.6×10^{-13} ✓ Divides by c^2 to get 3.75×10^{-28} ✓ (kg)	Expect to see 0.2265 (u) Condone PoT in mp1 expect to see $3.376 \text{ x } 10^{-11}$	2	1× AO2 1× AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.7	Uses $\frac{4.6}{3.8\times10^{-28}}$ to find the number of fissions ✓ Divides by 6.02×10^{23} OR attempts to use relative molar mass ✓ Multiplies by 0.235 to get 4700 (kg) ✓	Candidates who use 4×10^{-28} will get 4500 (kg) Candidates who use 3.75×10^{-28} will get 4800 (kg)	3	1× AO1 1× AO2 1× AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.8	The build-up of fission products, some of which are neutron absorbers ✓	Accept the idea that (geological) conditions may have changed so that the water cannot return / is removed (to start another cycle) Allows neutrons produced per unit time decrease so chain reaction can't proceed	1	AO2
Total			**18**	