



Delegate Booklet

Course Title: A Level Physics: Preparing for AO3 Questions

Course Code: 9PH0-25O1/01

Agenda

Item	Time
Introduction	5 min
Understanding AO3 Skills	10 min
Detailed Analysis of Questions	25 min
Common mistakes (and how to avoid them)	3 min
Strategies for Teaching AO3 Skills	5 min
Conclusion	2 min
Resources and Support	2 min
Q & A	8 min

By the end of the training, you will have:

- Identified the key components of AO3 skills as outlined in the Pearson GCE A Level Physics specification.
- Gained a better understanding of how marks are awarded for AO3 questions.
- Explored different teaching and learning strategies to help students develop AO3 skills



Balance of AOs across the Assessment

		% in AS	% in AL
AO1	Demonstrate knowledge and understanding of science	35 – 37	31 – 33
AO2	Application of knowledge and understanding of science in familiar and unfamiliar contexts	41 – 43	41 – 43
AO3	Analysis and evaluation of scientific information to make judgements and reach conclusions Experimental skills in science, including analysis and evaluation of data and methods	20 – 23	25 – 27

AO3

- The focus of questions that target AO3 is to assess the student's ability to analyse, interpret and evaluate different forms of physics information, ideas and evidence.
- AO3 questions may require students to make a conclusion, make a choice, or to justify a statement.
 - These questions usually require students to carry out calculations to come to a conclusion.
 - They don't tell the students exactly what to calculate.
 - These questions are found in all question papers.
- AO3 questions may require students to develop and refine practical design and procedures.
 - These questions assess skills developed when students carry out the core practicals.
 - This type of question is found in both AS papers, but only in Paper 3 of the A Level assessment.



Examples of AO3 Questions

- 12 A wire-wound resistor consists of a long length of wire wound around an insulating core. A technician finds a wire-wound constantan resistor labelled $80\ \Omega$.
- (b) A potential difference of $9.8\ \text{V}$ is applied across the resistor and the current in the resistor is $0.12\ \text{A}$.

Deduce whether the value labelled on the resistor is supported by these data.

uncertainty in the potential difference = $\pm 0.1\ \text{V}$

uncertainty in the current = $\pm 0.01\ \text{A}$

- 4 A student carried out an experiment to determine the focal length of a converging lens. In his lab report he wrote:

"I made an initial determination of the focal length of the lens and concluded that it was about $15\ \text{cm}$. When I plotted a graph it confirmed my initial determination of the lens focal length."

Comment on whether the student's data is consistent with his initial determination of the focal length of the lens.

- 13 A 'tennis trainer' consists of a tennis ball suspended by a string from the top of a vertical pole. When the ball is hit it travels in a horizontal circle around the pole, as shown in both the photograph and the diagram.

The radius of the path of the ball is $1.2\ \text{m}$ and the speed of the ball is $3.8\ \text{m s}^{-1}$.

Deduce whether these values are consistent with the angle between the string and the vertical pole shown in the photograph.

(5)



- 15** Aluminium is one of the most widely recycled metals. Aluminium cans are heated from room temperature until all the aluminium has melted. The molten aluminium is then used to make new cans. This process uses only 5% of the energy needed to extract aluminium from raw materials.

On a website it is claimed that recycling one aluminium can of mass 14 g saves enough energy to listen to music on a mobile phone continuously for 7 days.

Assess the validity of this claim.

- 13** A manufacturer gives the following information about a spring.

1. Follows Hooke's law up to loads of 5 N
2. Maximum extension without permanent deformation 0.4 m
3. Stiffness $21 \text{ N m}^{-1} \pm 5\%$
4. Stores up to 1.6 J

A student carried out an investigation on the spring to test this information.

She applied a range of forces from 0 N to 5 N to the spring. She measured the length of the spring and recorded the extension for each force.

She plotted a graph of force against extension.

- (b) Discuss the extent to which the student's results are consistent with the information given by the manufacturer.



Common Challenges

- AO3 'calculation' questions do not necessarily have an explicit route, so students may not know how to start their solution.
- Students may not be able to extract salient detail from the question.
- Students may be distracted by the context.
- Students may not understand the role that context plays in the question.
- Students may not state a conclusion.
- Students may omit a comparison with a value given in the question in giving their conclusion.



Analysis of Questions

Q12 9PH01 (2024)

Electrical power is transmitted from Norway to Britain using a cable laid under the North Sea.

The following information is published on a website.

The cable has a diameter of 15 cm and a length of 720 km.

It is made of copper of resistivity $1.7 \times 10^{-8} \Omega \text{m}$.

The electrical power transmitted from Norway is 1400 MW and the transmission potential difference is 1100 kV.

The efficiency of this process is almost 100%.

Deduce, by calculation, whether the claim for efficiency is correct.

Question Number	Acceptable answers	Additional guidance	Mark
12	<ul style="list-style-type: none"> Use of $P = VI$ Use of $A = \pi r^2$ Use of $R = \rho l / A$ Use of $P = I^2 R$ Use of efficiency = power out/power in Accept for MP5 power loss/power in 100% and consistent conclusion (MP6 dependent on fully correct method) 	<p>(1) <u>Example of calculation</u></p> <p>$1400 \times 10^6 \text{ W} = 1100 \times 10^3 \text{ V} \times I$</p> <p>$I = 1273 \text{ A}$</p> <p>radius = $0.15 \text{ m} / 2 = 0.075 \text{ m}$</p> <p>$A = \pi(0.075)^2 = 0.0177 \text{ m}^2$</p> <p>$R = 1.7 \times 10^{-8} \Omega \text{ m} \times 720\,000 \text{ m} / \pi (0.075 \text{ m})^2$</p> <p>$R = 0.693 \Omega$</p> <p>$P_{\text{lost}} = (1273 \text{ A})^2 \times 0.693 \Omega = 1.12 \text{ MW}$</p> <p>Efficiency calculation $(1400 - 1.12) \text{ MW} / 1400 \text{ MW}$ or $1.12 \text{ MW} / 1400 \text{ W}$</p> <p>Efficiency = 99.9 % OR $1 - 0.0008 = 99.9 \%$</p>	6

Example 1

$$P = IV$$

$$V = \frac{1400 \times 10^6}{1100 \times 10^3} = 1272.727273 \text{ A}$$

$$I = \frac{1400 \times 10^6}{1100 \times 10^3} = 1272.727273 \text{ A}$$

$$R = \frac{\rho l}{A} \quad R = \frac{1.7 \times 10^{-8} \times 720 \times 10^3}{\pi \times (0.075)^2} = 0.69264$$

$$P = I^2 R = 1272^2 \times 0.69264 = 1.12 \times 10^6 \text{ W} \rightarrow \text{power losses}$$

$$1400 \text{ MW} - 1.12 \text{ MW} = 1398.88$$

$$\text{efficiency} = \frac{1398.88}{1400} = 99.9\%$$

so yes efficiency is close to 100%



Example 2

$$R = \frac{\rho l}{A} = \frac{(1.7 \times 10^{-8})(720 \times 10^3)}{(0.075)^2 \pi} = 0.693 \Omega$$

$$\text{Power dissipated} = \frac{V^2}{R} = \frac{(1100 \times 10^3)^2}{0.693}$$

$$= 1.75 \times 10^{12} \text{ W}$$

$$= \text{1750 TW}$$

$$\text{Power Dissipated} = \frac{1100^2}{0.693}$$

$$= 1.75 \times 10^6 \text{ W}$$

$$\frac{1400 - 1.75}{1400} \times 100 = 99.88\%$$

$$= 99.9\%$$

(Total for Question 12 = 6 marks)

This is almost 100% efficient
So the claim is correct

Q14(c) 8PH02 (2024)

The work functions of some minerals that have been found on the surface of the Moon are shown.

Mineral	Work function / eV
ilmenite	4.3
olivine	7.9
pyroxene	5.1

Ultraviolet radiation with a frequency of $2.0 \times 10^{15} \text{ Hz}$ is incident on a sample of one of these minerals and electrons are emitted by means of the photoelectric effect.

The released electrons have a maximum kinetic energy of 4.0 eV.

Deduce the mineral from which the photoelectron is released.

14(c)	<ul style="list-style-type: none"> Conversion between eV and J Use of $hf = \phi + \frac{1}{2}mv_{\text{max}}^2$ $\phi = 4.3 \text{ (eV)}$ therefore the mineral is Ilmenite 	<p>(1) <u>Example of calculation</u></p> <p>(1) $\phi = \frac{6.63 \times 10^{-34} \text{ J s} \times 2.0 \times 10^{15} \text{ Hz}}{1.6 \times 10^{-19} \text{ C}} - 4.0$</p> <p>(1) $\phi = 4.3 \text{ eV}$</p>	3
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Example 1

Deduce the mineral from which the photoelectron is released.

(3)

$$E = \frac{hc}{\lambda}$$

$$hf = \phi + \frac{1}{2}mv^2_{max}$$

$$(6.63 \times 10^{-34}) \times (2 \times 10^{15}) - (4 \times 1.6 \times 10^{-19}) = \phi$$

$$6.86 \times 10^{-19} J = \phi$$

$$\frac{6.86 \times 10^{-19}}{1.6 \times 10^{-19}} = 4.2875 = 4.3$$

ilmenite was released

Example 2

Deduce the mineral from which the photoelectron is released.

(3)

$$hf = \phi + K_{Emax}$$

$$(6.63 \times 10^{-34}) \times (2 \times 10^{15}) = \phi + 4$$

$$1.326 \times 10^{-18} = \phi + 4$$

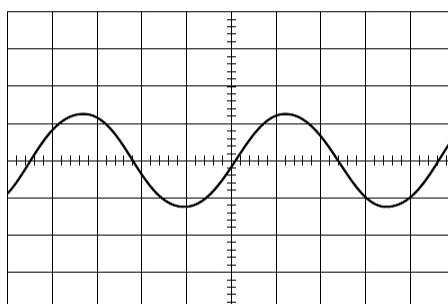
$$(1.326 \times 10^{-18}) \times (1.6 \times 10^{-19})$$

ilmenite

Q6(b) 9PH03 (2024)

The plate is set into movement by a vibration generator. The wavelength of the waves produced in the plate was estimated to be 0.32 m.

The signal applied to the vibration generator is shown on the oscilloscope trace below. The time base of the oscilloscope was set to 0.50 ms div⁻¹.



The waves produced in the plate travel at a speed much less than the speed of sound in air.

Evaluate whether the data supports a value for the speed of waves in the plate that is much less than the speed of sound in air.

speed of sound in air = 340 m s⁻¹

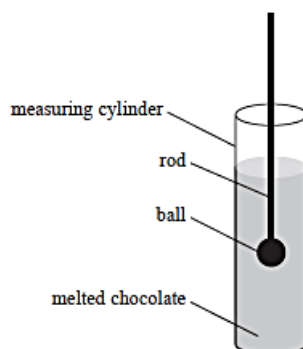
6(b)	<ul style="list-style-type: none"> 1 full cycle read from oscilloscope trace 4.5 → 4.7 div Converts from div to s Use of $f = 1/T$ Use of $v = f\lambda$ $v = 140 \text{ m s}^{-1}$, which is (much) less than 340 m s⁻¹ 	<p>(1) <u>Example of calculation</u></p> <p>(1) $T = 4.6 \text{ div} \times 0.5 \text{ ms div}^{-1} = 2.3 \text{ ms}$</p> <p>(1) $f = \frac{1}{2.3 \times 10^{-3} \text{ s}} = 435 \text{ Hz}$</p> <p>(1) $v = 435 \text{ s}^{-1} \times 0.32 \text{ m} = 139 \text{ m s}^{-1}$</p> <p>(1) Allow "the speed of sound in air" for 340 m s⁻¹</p>	5
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Q12(a) 9PH03 (2024)

12 Chocolate is a solid at room temperature, but melts just below body temperature.

- (a) A student investigated the viscosity of some melted chocolate using a falling-ball method. Since chocolate is opaque, a thin rod was attached to the ball so that the movement of the ball could be monitored. The apparatus is shown in the diagram.



The chocolate was maintained at a constant temperature during the investigation.

- (i) The student used a stopwatch to measure the time t for the ball to fall 22.5 cm whilst travelling at its terminal velocity v .

Her results are shown in the table.

t_1 / s	t_2 / s	t_3 / s
9.6	9.9	9.6

v is given by the formula

$$v = \frac{2r^2g(\rho_B - \rho_C)}{9\eta}$$

where

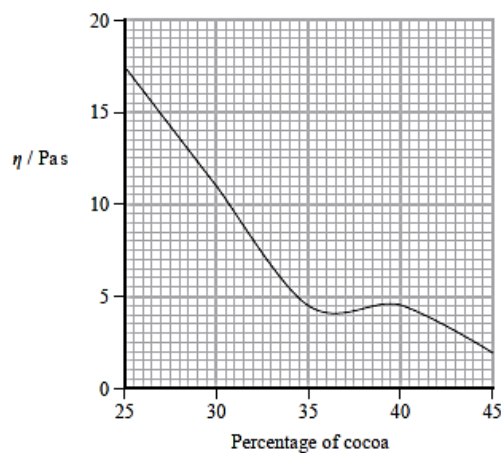
r is the radius of the ball

ρ_B is the density of the ball

ρ_C is the density of the chocolate

η is the viscosity of the chocolate.

The graph is taken from a commercial website. It shows how, at the temperature of the experiment, η depends on the percentage of cocoa in the chocolate.



The chocolate wrapper indicated that the chocolate had a 35% cocoa content.

Assess whether the student's timing data supports this percentage cocoa content.

$$r = 4.25 \times 10^{-3} \text{ m}$$

$$\rho_B = 7750 \text{ kg m}^{-3}$$

$$\rho_C = 1330 \text{ kg m}^{-3}$$

(5)



12(a)(i)	<p>EITHER</p> <ul style="list-style-type: none"> Calculation of mean t (1) Use of $s = ut$ (1) Use of $v = \frac{2r^2 g(\rho_B - \rho_C)}{9\eta}$ (1) Cocoa content = 30% Or viscosity at 35% = 4.5 (Pa s) (1) Conclusion consistent with their graph value (1) <p>OR</p> <ul style="list-style-type: none"> Viscosity at 35% = 4.5 (Pa s) (1) Use of $v = \frac{2r^2 g(\rho_B - \rho_C)}{9\eta}$ (1) Use of $s = ut$ to calculate time to fall T_{fall} (1) Calculation of mean t (1) Conclusion consistent with calculated value of T_{fall} (1) 	<p><u>Example of calculation</u></p> $t = \frac{(9.6 + 9.9 + 9.6) \text{ s}}{3} = 9.7 \text{ s}$ $v = \frac{0.225 \text{ m}}{9.7 \text{ s}} = 0.0232 \text{ m s}^{-1}$ $\eta = \frac{2 \times (4.25 \times 10^{-3} \text{ m})^2 \times 9.81 \text{ m s}^{-2} \times (7750 - 1330) \text{ kg m}^{-3}}{9 \times 0.0232 \text{ m s}^{-1}}$ $\eta = 10.9 \text{ Pa s, so cocoa content is 30% (from graph)}$ <p>Cocoa content is 30% so not consistent Or viscosity value is 4.5 Pa s so not consistent</p> <p>Time taken would be 4.0 s so not consistent with mean time</p>	5
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Example 1

Assess whether the student's timing data supports this percentage cocoa content.

$$r = 4.25 \times 10^{-3} \text{ m}$$

$$\rho_B = 7750 \text{ kg m}^{-3}$$

$$\rho_C = 1330 \text{ kg m}^{-3}$$

(5)

$$v = \frac{s}{t}$$

$$t = \frac{9.6 + 9.6 + 9.1}{3} = 9.1$$

$$\frac{22.5 \times 10^{-2}}{9.1} = 0.223 \text{ m s}^{-1}$$

$$0.023 \dots = \frac{2(4.25 \times 10^{-3})^2 (9.81)(7750 - 1330)}{9\eta}$$

$$\eta = 10.898 \dots$$

$$= 10.9 \text{ Pa s}$$

Timing data does not support 35% but supports 30% of cocoa.

Example 2

A
SID

$$v = \frac{2 \times (4.25 \times 10^{-3})^2 \times 9.81 \times (7750 - 1330)}{9 \times 4.5}$$

$$v = 0.0861 \times 22.5 \times 10^{-2}$$

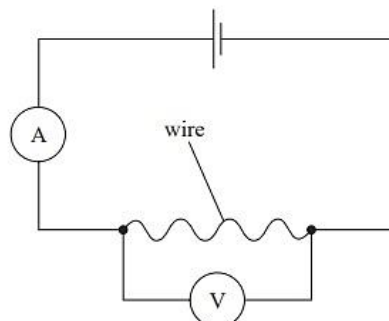
$$\frac{22.5 \times 10^{-2}}{0.0861} = 4.01 \text{ seconds}$$

The student's time does not support his cocoa content percentage.



Q12(c) 8PH01 (2024)

- 12 A student carried out an experiment to determine the resistivity of a metal alloy. The student used a wire made of the alloy and connected it in a circuit, as shown.



- (c) The student stated that the ammeter reading was the most significant source of uncertainty in the calculated value of resistivity.

The percentage uncertainty in the ammeter reading was 0.9%.
 The percentage uncertainty in the measurement of diameter was 0.8%.
 The percentage uncertainty in the measurement of length was 0.1%.
 The percentage uncertainty in the voltmeter reading was 0.3%.

Assess the validity of the student's statement.

12(c)	• The area is determined by d^2	(1)	<u>Example Calculation</u> $\%U(\text{diameter}^2) = 2 \times 0.8\% = 1.6\%$ MP3 dependent on MP1 and 2	3
	• Percentage uncertainty in diameter is doubled. $\%U = 2\%$	(1)		
	• The student's statement is incorrect as percentage uncertainty in diameter squared is the greatest percentage uncertainty	(1)		

Example 1

Assess the validity of the student's statement.

(3)

This statement would not be true as for calculating the cross-sectional area of the wire (πr^2) would cause the radius' uncertainty to double from 0.8% to 1.6% which is greater than the other quantities' uncertainties.

Example 2

Assess the validity of the student's statement.

(3)

The percentage uncertainty of the ammeter is ~~0.9%~~ ^{supporting the student} which is the largest at 0.9%, however the overall ^{percent} uncertainty in the diameter when it is divided by 2 and squared to work out the cross-sectional area ^{for P} is $2(0.8\% \times 2) = 3.2\%$ which equals $\pm 3.2\%$ therefore the diameter measurement is the largest source of uncertainty in the calculated resistivity thus the student's statement is invalid. (Total for Question 12 = 9 marks)