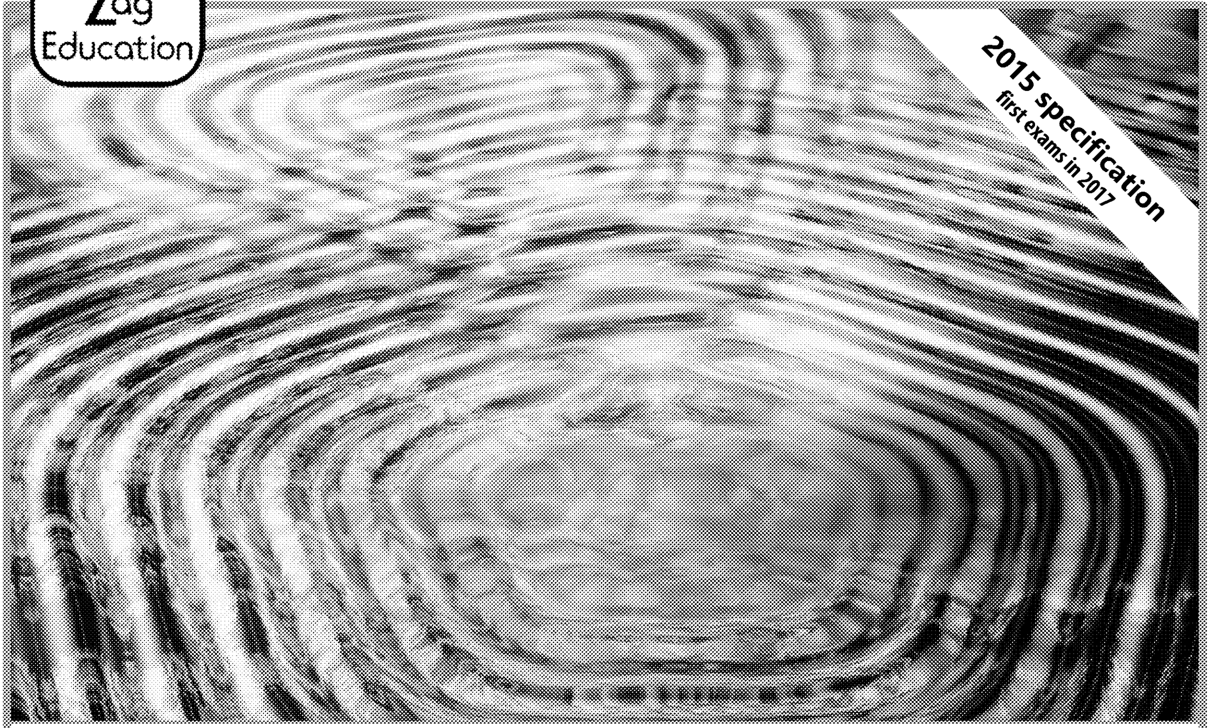
Physics

A Level | AQA | 7408



Practice Exams for A Level AQA Physics

Paper 3B Option D: Turning Points in Physics

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POD 7638

Contents

Teacher's Introduction

> **Remember!**
> Always check the exam board website for new information, including changes to the specification and sample assessment material.

This collection of four practice papers has been written to support the AQA A Level physics specification 7408 (first examination 2016). The pack consists of four sets of Paper 3B Option D: Turning Points in Physics.

Each paper consists of 35 marks covering the content in the Turning Points in Physics optional unit, including a 6 mark question testing communication skills. Paper 3 section A (Paper 3A) and Paper 3 section B (Paper 3B) are sat in the same session. Students are given 2 hours to complete both papers 3A and 3B, for a combined total of 80 marks.

Each paper follows a similar format to the AQA papers. Every item listed in the specification is covered, with most aspects visited several times in the pack. Each set of papers matches the weightings of assessment objectives, maths skills and practical skills set out by the exam board.

The mark schemes are written in a similar format to those written by AQA. The individual marking points are on separate lines with additional guidance to clarify points and indicate alternative acceptable answers.

Suggested Uses

1. Set as a mock examination under exam conditions, marked by the teacher. This provides the most reliable summative assessment.
2. Set as a complete paper under exam conditions which is then marked by the student. This provides a good formative assessment as the student gets a good understanding of how the mark schemes work and what they need to do to score. Such a session could be reinforced by a lesson on exam technique.
3. Set as a complete paper under exam conditions which is then peer marked. This could be by the teacher assigning scripts to students to mark or by students swapping amongst themselves. Group marking can be particularly helpful as the students get the chance to develop their ideas by discussing why things do and don't score.
4. Go through a question at a time in a lesson. Get students to discuss their answers before revealing the mark scheme for that question.
5. Set a paper as a homework for the student to answer and mark. This would be an ideal activity for study leave, when the student could come to a tutorial to go through their script. They should be briefed to list questions that need addressing as a result of their marking of their script.

Toby Brown & Samir Khonji, May 2017

Specification Cross-reference: Turning Points in Physics

Turning Points in Physics:	*3B (A)*	*3B (B)*	*3B (C)*	*3B (D)*
12 Turning points				
12.1 The discovery of the electron				
12.1.1 Cathode rays			1	
12.1.2 Thermionic emission of electrons			1	1
12.1.3 Specific charge of the electron	1, 2		1	
12.1.4 Principle of Millikan's determination of the electronic charge		1		
12.2 Wave–particle duality				
12.2.1 Newton's corpuscular theory		2		3
12.2.2 Significance of Young's double-slit experiment		2	3	3
12.2.3 Electromagnetic waves			2	3, 4
12.2.4 The discovery of photoelectricity				4
12.2.5 Wave–particle duality	2, 3		3	4
12.2.6 Electron microscopes	3			
12.3 Cosmology				
12.3.1 The Michelson–Morley experiment		3		4
12.3.2 Einstein's theory of special relativity		3	4	3, 4
12.3.3 Time dilation		4	4	
12.3.4 Length contraction		4	4	
12.3.5 Mass and energy	4	4	4	3

ZigZag Practice Exam Papers

Supporting A Level AQA Physics

Practice Exam Paper 3B

Option D: Turning Points in Physics

Name	

Time allowed

2 hours (for 3A and 3B)

Instructions

Answer **all** of the questions and use the space provided.

Information

The total marks available for this paper is **35**. The number of marks available for each question is shown on the right.

For this paper, you will need:

- Data and formulae booklet

Additional materials required

- Pencil
- Electronic calculator
- Ruler (cm/mm)

1. In 1909, Robert Millikan performed an experiment in which charged dro field generated by parallel charged plates, as seen in **Figure 1**.

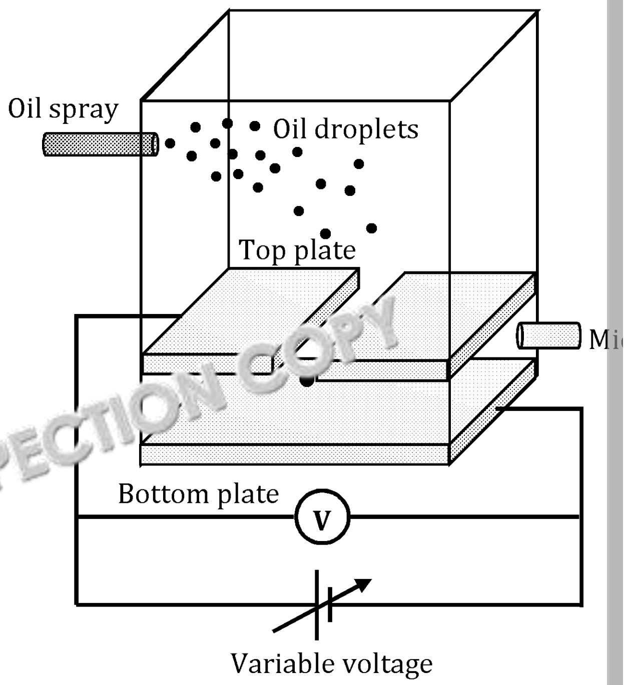

Figure 1

1.1 The variable voltage is first switched off and the oil drop falls with te

Show that the radius of the drop is given by

$$r = \left(\frac{9\eta v}{2\rho g}\right)^{\frac{1}{2}}$$

1.2 E. ow the radius and density of the oil drop can be used to deter

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1.3 The radius of an oil drop is measured to be 1.51×10^{-6} m, and the de
$1.26\ g\ cm^{-3}$.

The potential difference between the plates is 1120 V and the distance

Show that the charge on the oil drop is 4.76×10^{-19} C

1.4 The error on the value found in 1.3 is $\pm\ 0.05 \times 10^{-19}$ C. Discuss the a

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2. In the late seventeenth century, the scientific community was locked in a
of light – whether light is a particle or a wave.

Isaac Newton preferred the corpuscular theory of light, in which light is c
while Christiaan Huygens adopted the theory that light is a wave.

2.1 Discuss the evidence for both the corpuscular theory of light and Hu
including the factors that led to the initial acceptance of the corpuscu
eventual wider acceptance of light as a wave.

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2.2 While there are [illegible] of evidence of light acting as wave, in 19
for[illegible] the [illegible] theory of light, for which he later won the 1921 N

Ex[illegible] why light acting as a particle in the way theorised by Einstei

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3. The Michelson–Morley experiment was used to determine the velocity of theorised *aether*, the medium through which light was supposed to propa

3.1 Describe the Michelson–Morley experiment, stating the result expect

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3.2 Why is it significant that the Michelson–Morley did **not** detect the pr with respect to Earth?

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3.3 Describe how Einstein's theory of special relativity resolved the issu Michelson–Morley experiment.

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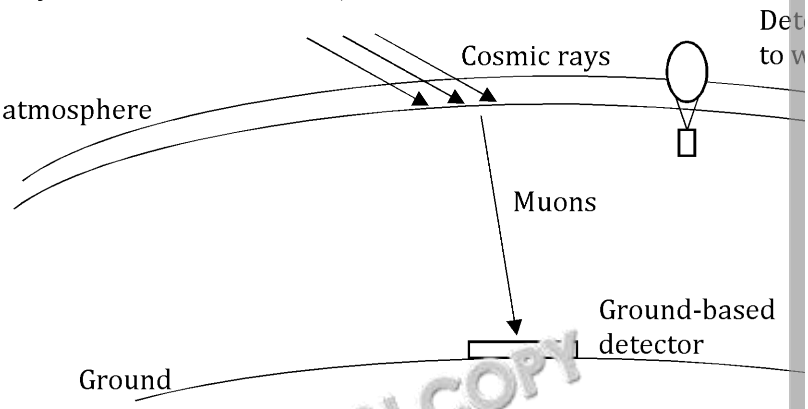
4. Muons are unstable particles created when cosmic rays bombard particle
Muons decay with a half-life of 1.56 μs.



4.1 Muons are detected in the upper atmosphere travelling at a velocity
Show that ab × 10 % of the muons would be expected at grou
A th all muons are emitted directly downwards.

4.2 The actual amount of muons detected at ground level is significantly
Explain why this is the case.

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4.3 Show that the percentage of the muons actually detected is 8.69 %.

4.4 C e t total energy of a muon travelling at 2.96×10^8 m s^{-1}.

ZigZag Practice Exam Papers

Supporting A Level AQA Physics

Practice Exam Paper 3B

Option D: Turning Points in Phys

Name	

Time allowed

2 hours (for 3A and 3B)

Instructions

Answer **all** of the questions.

Information

The total marks available for this paper is **35**. The number of marks available for each question is shown on the right.

For this paper, you will need:

- Data and formulae booklet

Additional materials required

- Pencil
- Electronic calculator
- Ruler (cm/mm)
- Graph paper

1. Cathode rays produced in low-pressure discharge tubes were used to ide

 1.1 Describe the structure of a discharge tube, and how cathode rays we

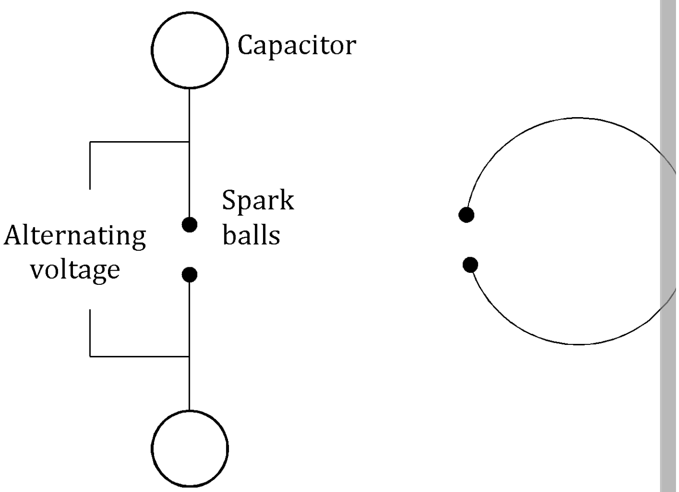
 1.2 Discharge tubes were later developed into cathode ray tubes, as used Cathode ray tubes accelerated electrons through a ring-shaped anode screen, producing an image.

 Explain why cathode ray tubes were fully evacuated of all air, while t required the presence of gas at low pressure.

 1.3 J J Thomson later performed experiments on cathode rays, in which t was bent.

 Explain how J J Thomson's work showed the particle nature of electr

2. Heinrich Hertz used the set-up below to confirm the nature of light as an e



Sparks were created in the gap between spark balls, and an alternating cu wire loop.

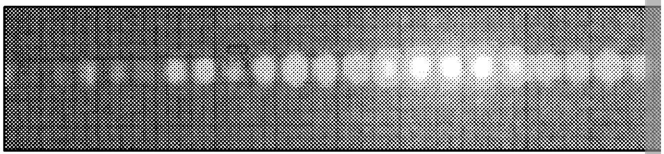
 2.1 Explain why the results of this experiment confirmed the nature of lig

 2.2 Describe how this effect is used in radio communications.

 2.3 Hertz later used a similar set-up to find the positions of nodes and an radio wave.

 Explain how this allowed Hertz to determine the speed of light.

3. In Young's double-slit experiment, light is passed through two narrow slit a distant screen, as seen below.



3.1 Explain how fringes are produced in Young's double-slit experiment.

3.2 Discuss the shortcomings of the wave theory of light to explain certai your discussion, you should write about:

- the problem with black-body radiation
- the problems with the photoelectric effect
- how the understanding of light changed to overcome these short

3.3 The particle theory of electrons cannot explain electron diffraction.

Explain why electron diffraction cannot be described by the particle t

4. A beam of protons moving at a relativistic speed passes between two dete

4.1 State the two postulates of Einstein's theory of special relativity.

4.2 The beam of protons moves at a speed of $0.859\ c$ in the frame of the d the second detector 1.55×10^{-7} s after it is detected by the first.

Calculate how long it takes the beam of protons to pass between the d the protons.

4.3 The positions of the detectors are changed so that they are separated the frame of the detectors. The distance between the detectors in the 54.1 m. Calculate the distance D.

4.4 Explain why the speed of the beam of protons may not exceed the sp energy may increase without limit.

Preview of Questions Ends Here

This is a limited inspection copy. Sample of questions ends here to avoid students previewing questions before they are set. See contents page for details of the rest of the resource.

Mark Scheme: Set A

Question	Answer	Mark
1.1	Electrons produced and accelerated towards anode ✓ Electrons deflected by electric field (upwards) ✓ Magnetic field varied until deflection of electron path decreases to zero ✓ Electric and magnetic forces equated and rearranged to find e/m ✓	1 1 1 1
1.2	$F_E = Ee$ $F_B = Bev$ $Ee = Bev$ (for forces to balance) $v = \frac{E}{B}$ ✓ $\frac{1}{2}mv^2 = eV$ $\frac{e}{m} = \frac{v^2}{2V}$ ✓ $\frac{e}{m} = \frac{(E/B)^2}{2V}$ ✓ $\left(\frac{e}{m} = \frac{E^2}{2VB^2}\right)$	 1 1 1
1.3	Factor $= \frac{\text{specific charge of electron}}{\text{specific charge of hydrogen ion}} = \left(\frac{e/m_e}{e/m_H}\right)$ Factor $\sim \frac{10^{11}}{10^8}$ ✓ Factor $\sim 10^3$ ✓	 1 1
2.1	$\lambda = \frac{h}{p}$ $E_k = \frac{p^2}{2m}$ E_k comes from the potential difference $E_k = eV$ $eV = \frac{p^2}{2m}$ ✓ $p = \sqrt{2mE_k}$ ✓ $\left(\lambda = \frac{h}{\sqrt{2meV}}\right)$	 1 1
2.2	The electron accelerated across a lower potential difference is slower ✓ and so has a larger de Broglie wavelength ✓ so the gaps between fringes will be larger / the electron will be diffracted more ✓	1 1 1
2.3	(Determination of $\frac{e}{m}$ for an electron suggests that) the electron has mass and so acts as a particle ✓ Diffraction is a property of waves and so electrons act as waves ✓ Shows wave–particle duality – all particles act as waves; all waves act as particles ✓	1 1 1

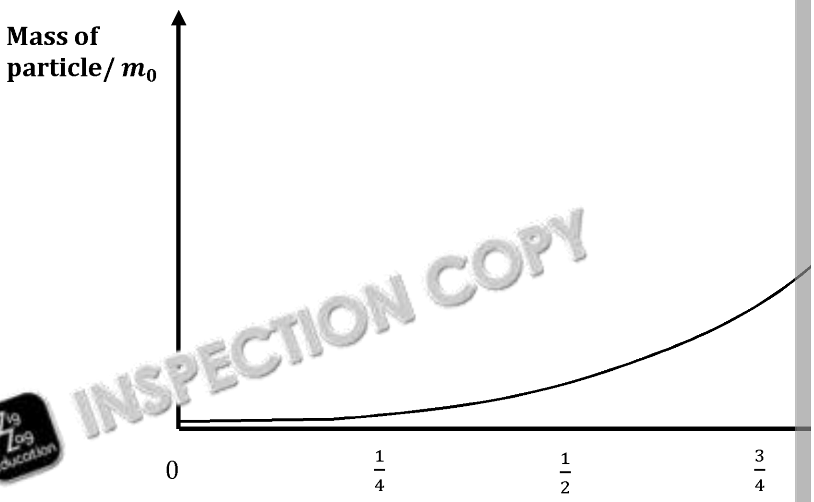
Question	Answer	Mark
3.1	Wavelength required = size of atom $\sim 10^{-10}$ m ✓	1
	$\lambda = \frac{h}{\sqrt{2meV}}$	
	$V = \frac{h^2}{\lambda^2 2me}$	
	$V = \frac{(6.63\times10^{-34})^2}{(10^{-10})^2\times2\times9.11\times10^{-31}\times1.60\times10^{-19}}$ ✓	1
	$V = 151$ V ✓	1
3.2	Lighter areas represent less dense areas which electrons can pass through ✓	1
	Darker areas show denser areas which block electrons ✓	1
3.3	The guidance below outlines the features [illegible] a 1-, 2-, 3-, 4-, 5- and 6-mark an	

Mark	Criteria	
[illegible]	A detailed discussion of the operation of an STM, including both modes of operation and the advantages of STMs over TEMs.	Relev coher and cl gramm handv
5	A detailed discussion of the operation of STMs, including both modes of operation and advantages, with very minor gaps in detail.	
4	A discussion that includes the majority of main points about the operation, including different modes and advantages	Inforn is suff Spelli and h
3	A discussion that includes the main points about the operation and at least one point for advantages. There are gaps in knowledge and missing details.	
2	Only a couple of points made correctly; significant knowledge is missing.	Some prese and g deriv
1	Only one correct point made about the operation, such as quantum tunnelling being utilised.	
0	No relevant information provided.	Prese seriou Under

Max 6 – The following statements are likely to be included:

Operation
- Tip of probe is short distance (1 nm) above sample
- Electrons cross gap from sample to probe via quantum tunnelling
- Quantum tunnelling because of the wave nature of electrons
- Small voltage between tip of probe and sample to ensure electrons only
- Mode 1: Height of probe kept constant: change in height of sample caus crossing gap
- Mode 2: Height of probe changes to keep the current constant
- Variation in current/height converted to map of heights of the sample

Advantages of STM over TEM
- Can be used in air and water
- Can be used over a range of temperatures, exceeding 500 K
- STM has resolution of 0.01 nm (depth) and 0.1 nm (laterally)
- Loss of speed in TEM reduces focusing power
- TEM much more affected by vibrations

Question	Answer	Mark
4.1	Correct shape of graph (mass increasing with speed with increasing gradient) ✓ Up to asymptote at c ✓  	1 1
4.2	$E = mc^2 = \frac{m_0c^2}{\sqrt{1-\frac{v^2}{c^2}}}$ $m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$ $2m_0 = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$ ✓ $\sqrt{1-\frac{v^2}{c^2}} = \frac{1}{2}$ $1-\frac{v^2}{c^2} = \frac{1}{4}$ $\frac{v^2}{c^2} = \frac{3}{4}$ $v^2 = \frac{3}{4}c^2$ ✓ $v = \frac{\sqrt{3}}{2}c$ ✓	1 1 1
4.3	Direct evidence of variation of kinetic energy with speed ✓ Speed of particles limited to below c ✓	1 1

Preview of Answers Ends Here

This is a limited inspection copy. Sample of answers ends here to stop students looking up answers to their assessments. See contents page for details of the rest of the resource.