AQA

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A-level PHYSICS

Paper 3
Section B Turning points in physics

Monday 3 June 2019 Afternoon

Time allowed: The total time for both sections of this paper is 2 hours. You are advised to spend approximately 50 minutes on this section.

Materials
For this paper you must have:
- a pencil and a ruler
- a scientific calculator
- a Data and Formulae Booklet.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
TOTAL	

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 35.
- You are expected to use a scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

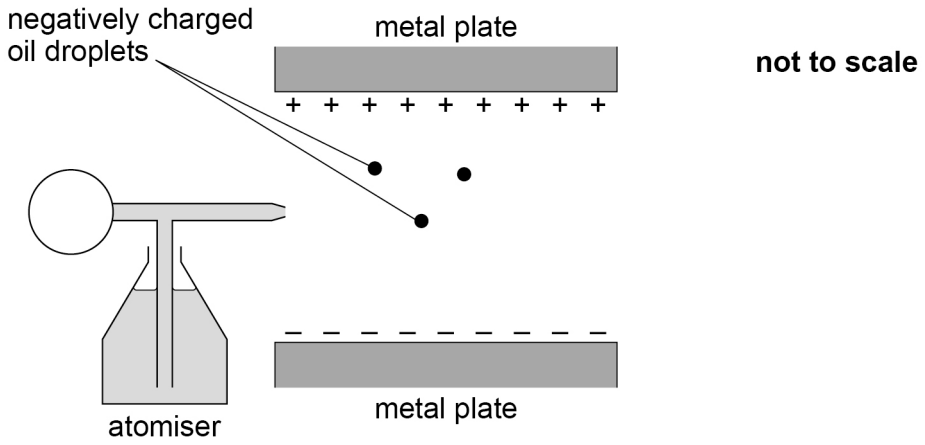
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Section B

Answer **all** questions in this section.

0 1 **Figure 1** shows an experiment to measure the charge of the electron.

Figure 1



Negatively charged oil droplets are sprayed from the atomiser into the gap between the two horizontal metal plates. A potential difference is applied between the metal plates.

One of the droplets remains stationary.

0 1 . 1 Identify the forces acting on the stationary droplet.
In your answer you should state the relationship between the forces.

The upthrust on the droplet due to the air it displaces is negligible.

[2 marks]

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0 1 . 2 The potential difference between the plates is changed to zero and the droplet falls at a terminal velocity of 1.0×10^{-4} m s^{-1}.

The density of the oil is 880 kg m^{-3}
The viscosity of air is 1.8×10^{-5} N s m^{-2}

Show that the radius of the droplet is about 1×10^{-6} m.

Assume that the droplet is spherical.

[3 marks]

Question 1 continues on the next page

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0 1 . 3 The potential difference between the plates is restored to its initial value and the droplet becomes stationary.

The charge on the droplet is -4.8×10^{-19} C.

A student suggests that, if the droplet splits into two spheres of equal size, both spheres would remain stationary.

Deduce whether this suggestion is correct.

[3 marks]

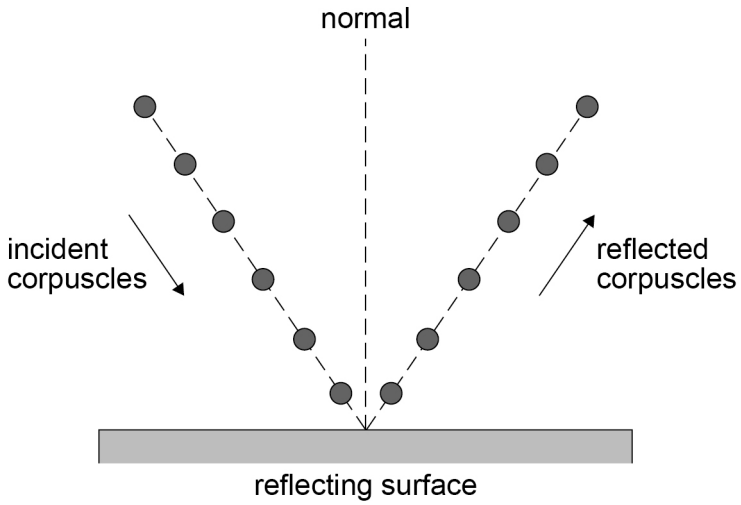
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0 2 Newton used a corpuscular theory of light to explain reflection.

Figure 2 shows how corpuscles would reflect from a horizontal surface.

Figure 2



0 2 . 1 What happens to the horizontal and vertical components of the velocity of the corpuscles, according to the theory, when they are reflected?

Tick (✓) **one** box.

[1 mark]

Horizontal component of velocity	Vertical component of velocity	Tick the correct box
Unchanged	Changed	
Changed	Unchanged	
Unchanged	Unchanged	
Changed	Changed	

Question 2 continues on the next page

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0 2 . 2 Newton used the corpuscular theory to explain the refraction of light at an interface between air and water.

Huygens used the wave theory to explain the refraction of light at the interface.

Discuss the evidence that led to the rejection of Newton's corpuscular theory.

In your answer you should include
- how each theory explains refraction
- how experimental evidence led to the acceptance of the wave theory.

[6 marks]

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Question 2 continues on the next page

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0 2 . 3 Light is now known to behave as an electromagnetic wave.

Describe a plane-polarised electromagnetic wave travelling through a vacuum.
You may wish to draw a labelled diagram.

[3 marks]

10

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Turn over for the next question

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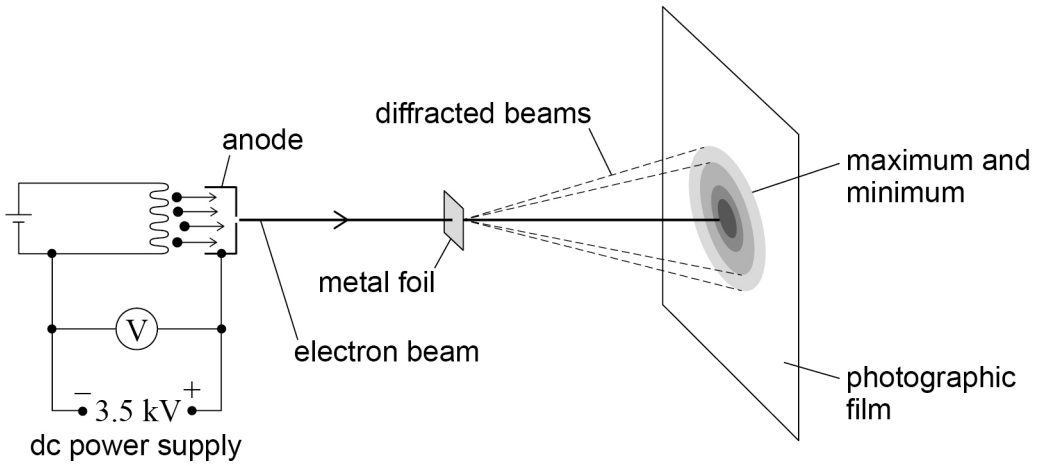
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0 3 **Figure 3** shows part of the apparatus used to investigate electron diffraction.

Electrons were accelerated through a potential difference to form a beam which was then incident on a thin metal foil.

Regions of maximum and minimum intensity formed on a photographic film behind the foil.

Figure 3



0 3 . 1 State de Broglie's hypothesis.

[2 marks]

0 3 . 2 The voltmeter in **Figure 3** shows a reading of $3.5\ \text{kV}$.

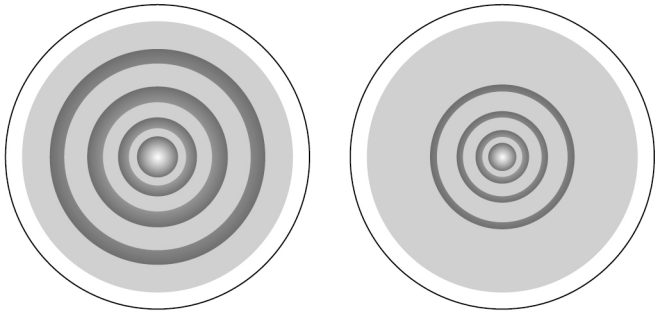
Determine whether this voltmeter reading is consistent with a de Broglie wavelength for the electrons in the beam of about $0.02\ \text{nm}$.

[2 marks]

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0 3 . 3 The experiment is repeated using a similar arrangement to that shown in **Figure 3**. **Figure 4** shows the diffraction patterns from the two experiments.

Figure 4



first experiment second experiment

State and explain **two** independent changes that could be made to the arrangement in **Figure 3** to produce the result shown for the second experiment in **Figure 4**.

[4 marks]

First change

Second change

8

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0 4 **Table 1** shows data of speed v and kinetic energy E_k for electrons from a modern version of the Bertozzi experiment.

Table 1

v / 10^8 m s^{-1}	E_k / MeV
2.60	0.5
2.73	0.7
2.88	1.3
2.96	2.6
2.99	5.8

0 4 . 1 Classical mechanics predicts that $E_k \propto v^2$.

Deduce whether the data in **Table 1** are consistent with this prediction.

[2 marks]

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0 4 . 2 Discuss how Einstein's theory of special relativity explains the data in **Table 1**.

[4 marks]

0 4 . 3 Calculate, in J, the kinetic energy of one electron travelling at a speed of $0.95c$.

[3 marks]

kinetic energy = _____ J

9

END OF QUESTIONS

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