

17 In 1905 Einstein published his equation for the photoelectric effect.

In 1916 Millikan demonstrated that the maximum kinetic energy of photoelectrons is consistent with Einstein's equation.

*(a) Discuss the extent to which our current understanding of observations of the photoelectric effect supports the idea that light behaves as photons rather than as waves.

(6)

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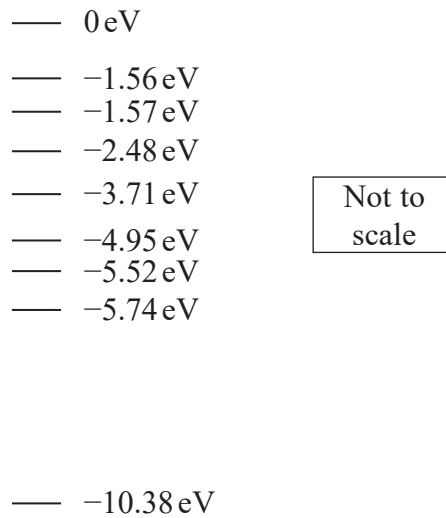
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- (c) Millikan's experiments involved using different frequencies of light. These were obtained using a mercury vapour lamp which produced an emission spectrum with a specific number of known frequencies.

The diagram shows some energy levels for a mercury atom.



Determine which transition from the -3.71 eV energy level would produce light of wavelength 6.1×10^{-7} m.

(4)

Transition from -3.71 eV to



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(d) Millikan used a device known as a monochromator to ensure that a single wavelength of light was used to illuminate the surface of the lithium. A monochromator separates wavelengths using a diffraction grating.

Calculate the angle at which a diffraction grating would produce the most intense line at a single wavelength of 6.1×10^{-7} m.

number of lines per mm for grating = 600 mm^{-1}

(3)

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Angle =

(Total for Question 17 = 16 marks)



- 6 When light is incident on the surface of a metal, electrons may be emitted by the photoelectric effect. Observations of the photoelectric effect helped to establish that light can exhibit particle behaviour.

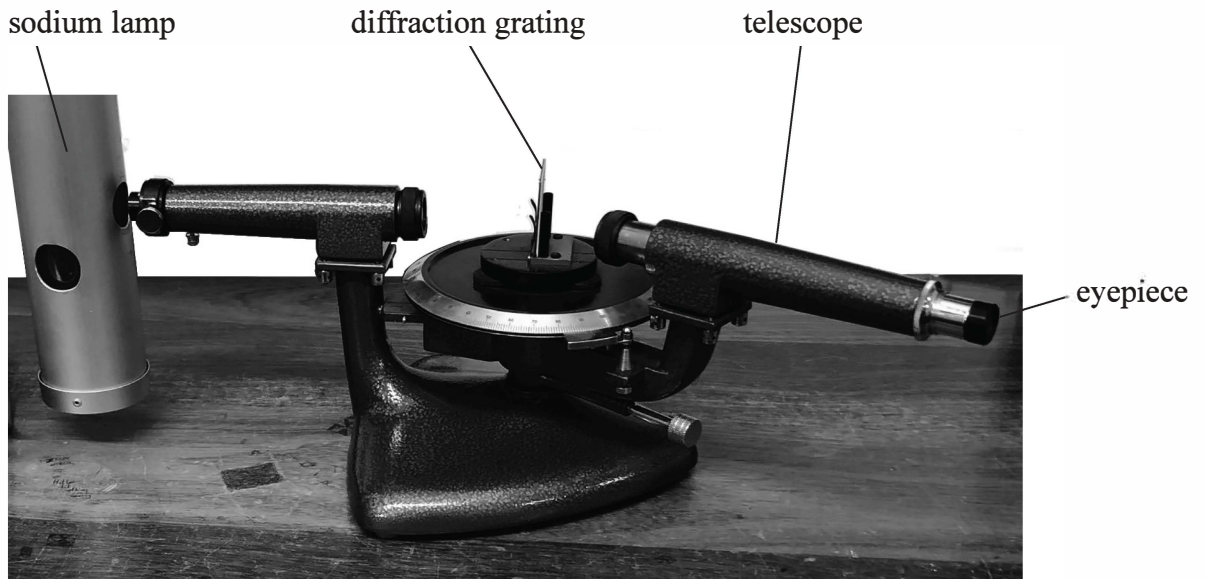
Which of the following observations of the photoelectric effect could also be explained by light behaving as a wave?

- A Emission of photoelectrons occurs immediately the surface is illuminated.
- B Photoelectrons are only emitted when the frequency of the light is more than a certain minimum value.
- C The maximum kinetic energy of the photoelectrons is independent of the intensity of the incident light.
- D When the intensity of the incident light increases, photoelectrons are emitted at a greater rate.

(Total for Question 6 = 1 mark)



17 The photograph shows a school spectrometer.



The spectrometer allows parallel rays of light to be passed through a diffraction grating and the resulting angles of diffraction to be measured.

- (a) In the telescope, light from the grating is focused to make a real image 16.7 mm in front of the eyepiece lens. The eyepiece lens then uses this real image as an object to produce a magnified virtual image for the observer.

Calculate the magnification produced by the eyepiece lens.

focal length of eyepiece lens = 17.9 mm

(3)

Magnification =



(ii) Diffraction gratings with the following spacings are available:

$d/10^{-6}$ m	1.0	1.7	2.0	3.3
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Explain which would be the best spacing to use to measure the diffraction angle for the third order maximum for yellow light of wavelength 589 nm.

(3)

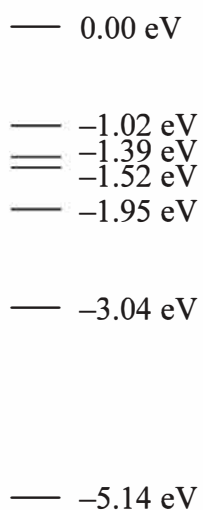
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(c) The diagram shows some of the energy levels in a sodium atom.



Add an arrow to the diagram to show the transition involved in the emission of yellow light of wavelength 589 nm.

Show your working below.

(4)

(Total for Question 17 = 16 marks)

