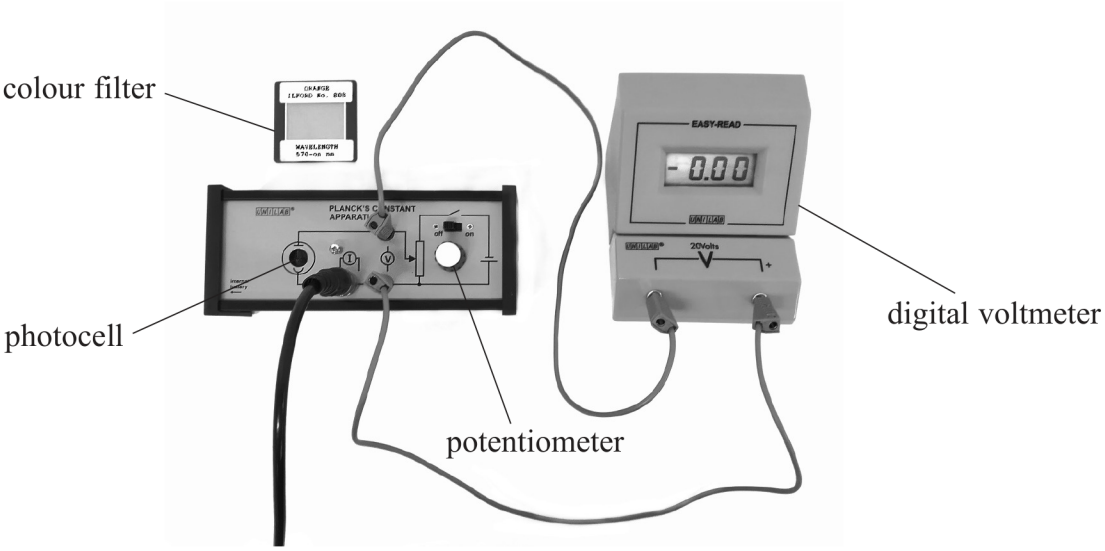
4 A student investigated the photoelectric effect using the apparatus shown.



He used a source of white light and colour filters to shine different wavelengths λ of light onto the photocell.

Photoelectrons were emitted with a range of kinetic energies, creating a small current in the photocell.

Using the potentiometer, the student varied the potential difference across the photocell. As the potential difference across the photocell increased, the current in the photocell decreased.

He measured the potential difference V_s when the current in the photocell was zero.

He calculated the maximum kinetic energy E_{max} of the photoelectrons for each wavelength of light.

(a) The table shows the student's data.

V_s / V	E_{max} / 10^{-20} J	λ / nm	
0.35	5.6	620	
0.43	6.9	577	
0.51	8.2	546	
0.75	12.0	470	
0.87	13.9	436	

(i) Plot a graph of E_{max} on the y-axis against $1/\lambda$ on the x-axis on the grid opposite.

Use the additional column of the table for your processed data.

(6)

(ii) The relationship between the maximum kinetic energy E_{max} of the emitted electrons and the wavelength λ of the incident photons is given by the equation

$$\frac{hc}{\lambda} = \phi + E_{max}$$

Show that the Planck constant h is equal to $\frac{\text{gradient of graph}}{c}$

(2)

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(iii) Determine a value of h.

(4)

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h = ...

(iv) Calculate the percentage difference between h and the accepted value for the Planck constant.

(2)

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Percentage difference = ...

(b) The student's investigation involves a small random error and a large systematic error.

For each of these, suggest a source of the error and a realistic modification to the procedure which would reduce it.

(4)

Random error:

Systematic error:

(Total for Question 4 = 18 marks)