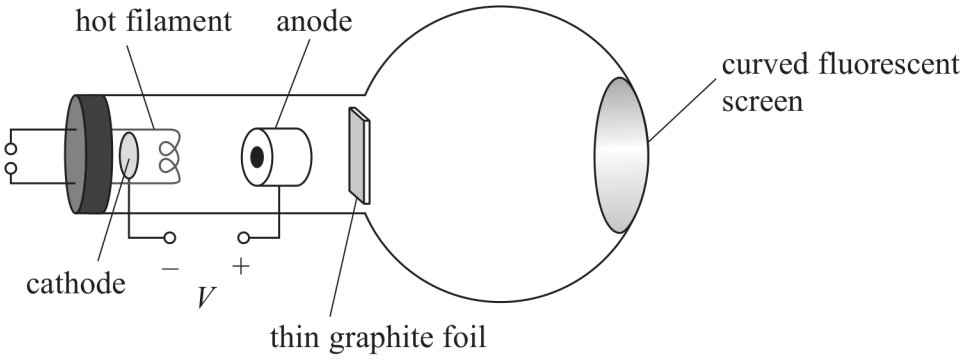
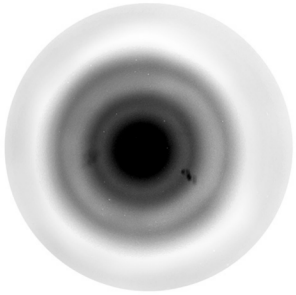
3 A student investigated the diffraction of electrons using an electron beam tube as shown.



The potential difference, V, accelerates electrons from the hot filament towards the thin graphite foil.

The electrons diffract as they pass through the foil, producing a ring pattern on the curved fluorescent screen as shown below.



(Source: © ANDREW LAMBERT PHOTOGRAPHY/SCIENCE PHOTO LIBRARY)

(a) The student used vernier calipers to measure the diameters of the rings on the curved screen.

(i) Give **two** reasons why vernier calipers are more appropriate for these measurements than a transparent ruler.

(2)

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(ii) Describe how the student should measure the diameter of a ring as accurately as possible.

(2)

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(b) The student used the diameter of the rings to determine the wavelength λ of the electrons.

He repeated this for two more values of V.

The student also determined the value of a constant a using the formula

$$a = V\lambda^2$$

The results are shown in the table below.

V / kV	λ / 10^{-12} m	a / 10^{-18} m^2 V
200	2.67	1.23
250	2.44	1.11
300	2.14	1.32

(i) Determine the mean value of a in m^2 V.

(2)

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Mean value of a = ... m^2 V

(ii) Determine the percentage uncertainty in the mean value of a.

(2)

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Percentage uncertainty in the mean value of a = ...

(iii) A different student repeated the investigation using six values of V. She plotted a graph of V against $\frac{1}{\lambda^2}$ and determined the constant a from the gradient.

Give **two** reasons why this is a better method to determine a value for a.

(2)

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(c) The value of a can also be calculated using the formula

$$a = \frac{h^2}{2em_e}$$

where
h is the Planck constant
e is the electron charge
m_e is the electron mass.

(i) Calculate the value of h, in J s, when a is $1.46 \times 10^{-18}\,\text{m}^2\,\text{V}$.

(2)

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$h =$ ..... J s

(ii) The percentage uncertainty in the calculated value of h is 6%.

Comment on the accuracy of your calculated value of h.

(2)

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(Total for Question 3 = 14 marks)