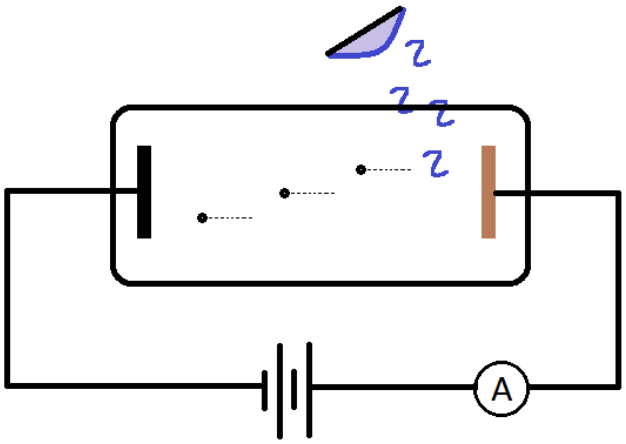
Question 19 **(14 marks)**

A photoelectric effect experiment using copper as the target anode is shown in the diagram below.



The required stopping voltage (V) to reduce the current reading in the ammeter to zero for a variety of light frequencies was recorded.

Frequency ($\times 10^{15}$ Hz)	Stopping voltage (V)	Max Kinetic Energy of Photoelectrons ($\times 10^{-19}$ J)
1.0 ± 0.2	-	-
1.5 ± 0.2	1.10	1.76
1.9 ± 0.2	2.76	4.42
2.3 ± 0.2	4.42	7.07
2.9 ± 0.2	6.90	

(a) The lowest incident frequency used did not have a stopping potential measurement. Suggest a reason why. (2 marks)

This frequency is below the threshold frequency and unable to provide enough energy for an electron to be removed from the anode. 1-2

(b) Calculate the maximum kinetic energy of the photoelectrons produced from a 2.90×10^{15} Hz light source. Add this value to the table of results. (2 marks)

$E = Vq = 6.90 \times 1.6 \times 10^{-19} = 11.0 \times 10^{-19}\ J$ 1-2

(c) Draw a graph maximum kinetic energy (E_k) of the photoelectrons (in joules) vs frequency (f). Your vertical scale must allow for the vertical intercept to be shown. Add error bars for the frequency values. Include a line of best fit. (5 marks)

Suitable labels with units 1
Good scale 1
Accuracy of points 1
Suitable sized error bars 1
Line of best fit 1

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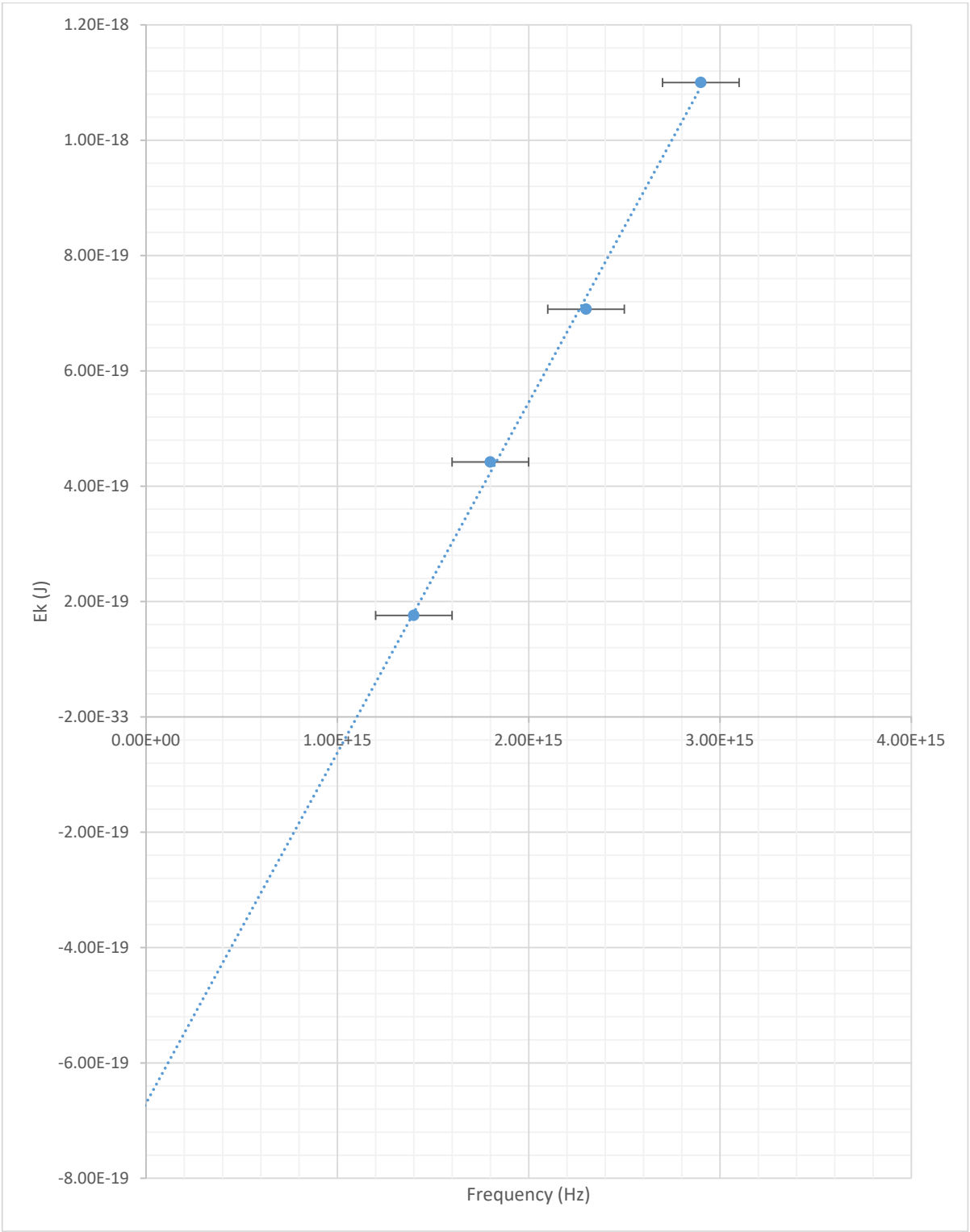

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(d) Using the graph, determine the work function (W) of copper. Justify your answer.
(2 marks)

Approx 6.7×10^{-19} J or 4.2 eV 1
Based on the vertical axis intercept 1
OR
Approx 7.3×10^{-19} J 1
Using the cutoff f (horizontal intercept) and E=hf 1

Note answers differ based on approach as gradient $\neq 6.63\times10^{-34}$

(e) Calculate the gradient of the graph and use this value to determine Planck's constant.
(3 marks)

Shows sufficient working for gradient calc 1
Uses graph values, not table 1

$h = gradient = 6.3 \times 10^{-34}\ J\ s$ (approx, based on line of best fit) 1