Question 15 **(19 marks)**

An experiment was conducted to determine a value for Planck's constant. The experiment involved setting up five individual, single frequency light emitting diodes (LEDs). Each LED only emits one frequency of light when a turn on voltage (voltage above a certain threshold value) is applied across its terminals.

The relationship between the frequency of the emitted light and the voltage is given by the equation below.

$E = hf = q_e(V_0 + \text{k})$ where h is Planck's constant
f is the frequency of light emitted by the diode
q_e is the charge on an electron
V_0 is the turn on voltage
k is the threshold voltage (constant dependent on the material)

The experiment produced the following results.

LED colour	Maximum wavelength (λ) (nm)	Turn on voltage (V_0)	1/λ (m^{-1})
Blue	450	2.53	
Green	550	2.04	
Yellow	570	1.88	
Red	690	1.37	
Infra-red	890	0.88	

(a) Complete the table above for values of 1/λ. (2 marks)

(b) Plot a graph of voltage against 1/λ, with voltage on the y-axis, and draw a line of best fit. Error bars are not required. (5 marks)

(c) Use the graph to calculate the gradient of the line of best fit. Show construction lines. (3 marks)

(d) Use the gradient from part (c) and the provided equation to calculate a value for Planck's constant. (3 marks)

Answer _____ J s

(e) From your graph, determine the value for k in this experiment. (2 marks)

Answer _____ V

(f) Describe **two** possible sources of experimental error in the performance of this experiment and how they might be modified to produce a more accurate result. (4 marks)

One: _____

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Two: _____

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