Some useful equations:

\[ c = \lambda \cdot \nu \quad E = h \cdot \nu \quad \frac{\lambda - \lambda_0}{\lambda_0} = \frac{\Delta \lambda}{\lambda_0} = \frac{\nu}{c} \]

\[ E = \sigma T^4 \quad \lambda_{\text{peak}} T = 2.9 \times 10^7 \ \text{Å} \cdot \text{K} \]

1. **(10 points)**

(a) Some examples of electromagnetic waves are visible light waves and x-rays. Name two more. (6 points)

(b) There are two photons, A and B, traveling through space. One has a wavelength \( \lambda_A \) and the other has wavelength \( \lambda_B \). Photon A has a longer wavelength, ie. \( \lambda_A > \lambda_B \). Which one has a higher energy? (4 points)

2. **(10 points)** Sketch two blackbody curves at different temperatures in the space below. Label each of the following:

- The x-axis with the direction it is increasing
- The y-axis with the direction it is increasing
- Which curve represents the hotter blackbody
- The peak wavelength, \( \lambda_{\text{peak}} \), of each
3. (10 points) Looking at a distant galaxy, you observe an emission line of madeupium at a wavelength of 495 nm. When you produce this emission line in the laboratory, it has a wavelength of 500 nm.

   (a) Is the galaxy moving toward you or away from you? (4 points)

   (b) If you send a burst of light with wavelength 500 nm at this same galaxy and an alien there observes it, what wavelength will the alien observe? Justify your answer. (6 points)

4. (10 points)

   (a) Is the Sun a perfect blackbody? (3 points)

   (b) What data or observation shows this? Explain. (7 points)