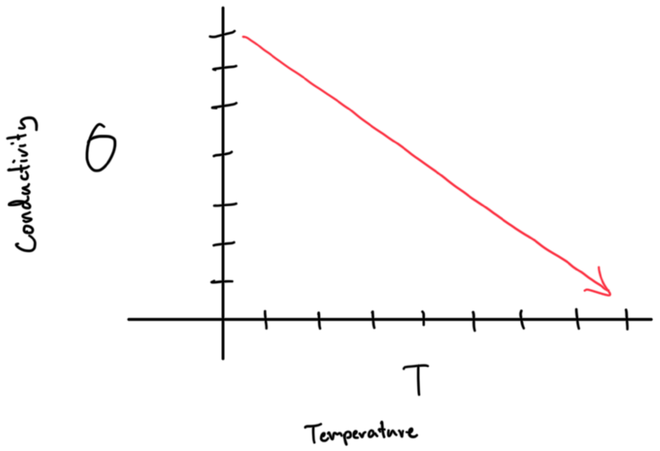
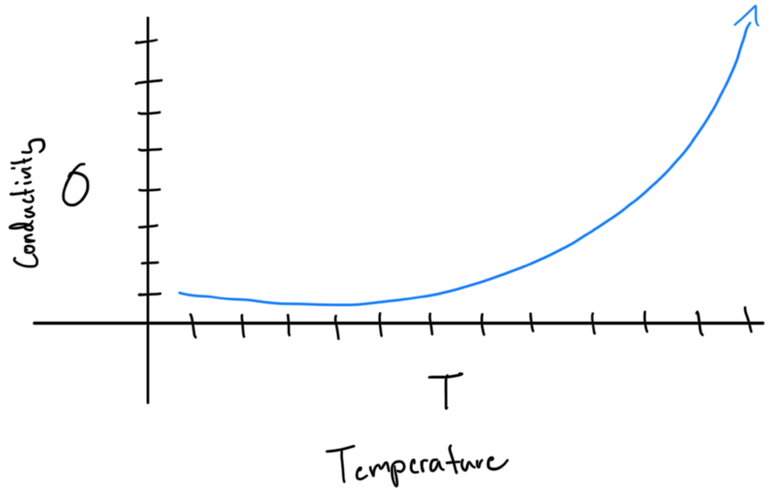
1) Draw two curves to show how the conductivity changes (σ) with temperatures (T) for both metals and semiconductors.

a) σ vs. T ~ metals



b) σ vs. T ~ semiconductors



c) Explanation of the specific trends

~ For metals as the temperature increases, the conductivity of the metal decreases. This is because as the temperature increases more electrons begin to scatter & impedes their flow which reduces the conductivity.

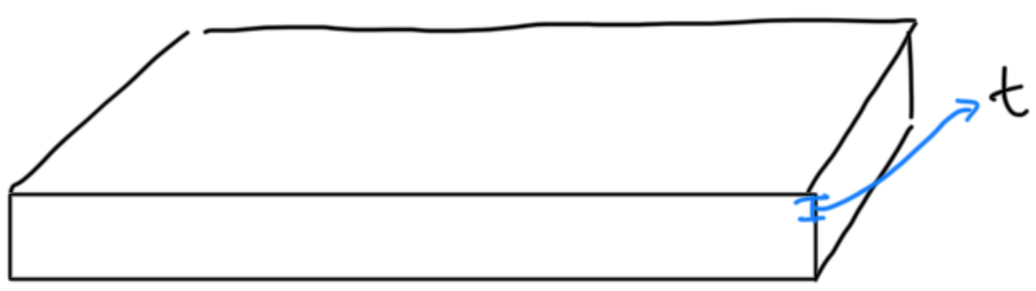
~ For semi-conductors as the temperature increases, the conductivity increases alongside it as well. The increased temperature allows for electrons to gain enough energy to jump from the valence to the conduction band which increases the number of charge carriers → leading to increased conduction.

2) Suppose we want to achieve high sensitivity of the Hall sensor. There are three choices for the material of the sensing element chosen below: copper, silicon oxide, silicon.

1) Which material should we choose & why?

The best material for a Hall sensor depends on their sensitivity to magnetic fields, temperature stability, and the conductivity. Silicon is the best choice because it has very good temperature stability, decent sensitivity, and it has high conductivity. Silicon Oxide would not work due to it being an insulator. Copper while a good conductor has low electron mobility compared to a semi-conductor such as silicon.

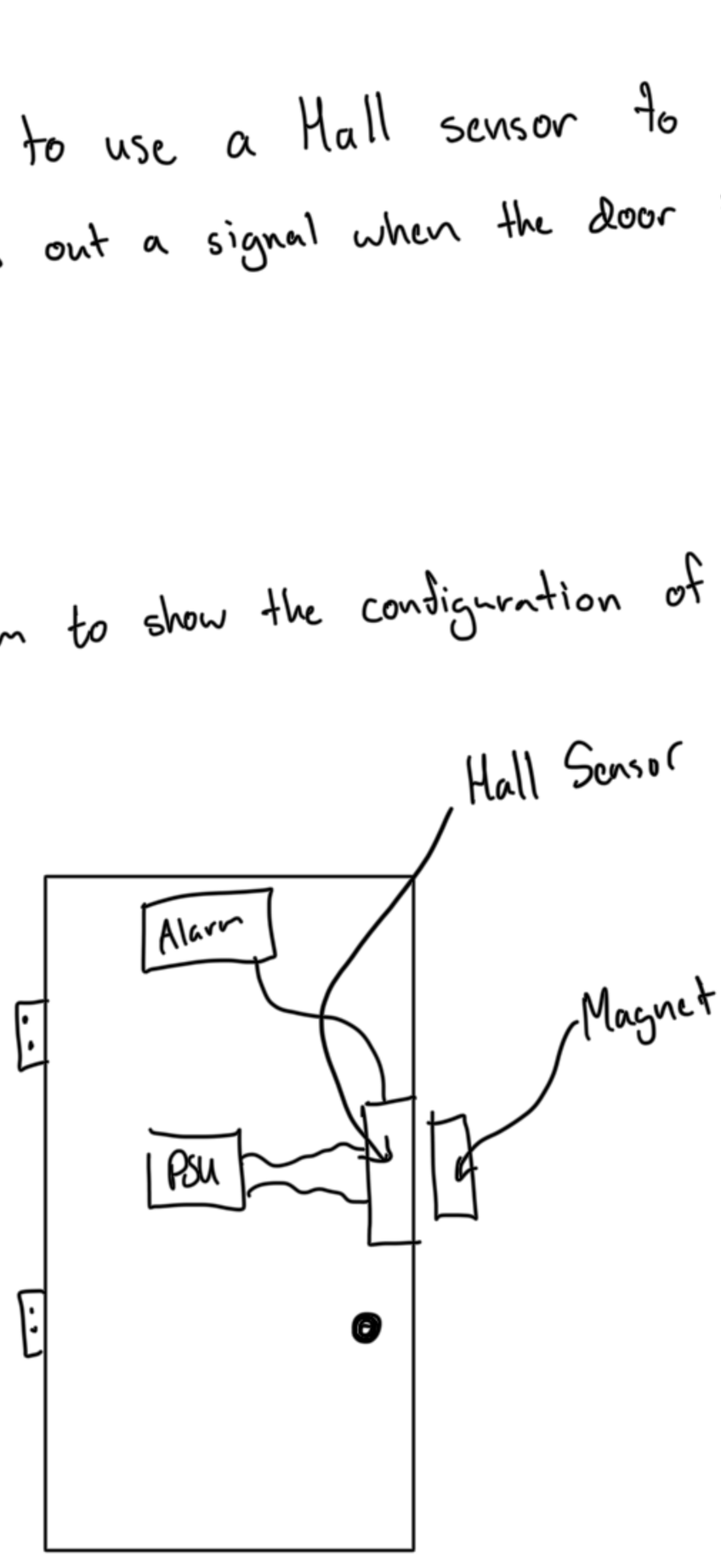
2) On the sensing element, mark the thickness (t) that could provide the best sensitivity & explain why



~ I chose to have a small thickness. Hall Sensors work well when the thickness is smaller as it allows for a higher Hall Voltage which makes the sensor more sensitive to the magnetic field

3) Suppose we want to use a Hall sensor to build a door alarm system (which gives out a signal when the door is opened)

1) Draw a diagram to show the configuration of the system



2) The door alarm operates using a Hall effect sensor positioned near a magnet attached to the door. When the door is closed, the magnet's proximity to the sensor generates a Hall Voltage indicating the door is shut. Opening the door moves the magnet away, causing the Hall Voltage to drop or change, which the circuit then detects. Given this change the alarm signals the door has opened.

4) Suppose an electron beam (NA = .01) with a wavelength of 1 nm is used for imaging

1) Estimate the highest (theoretical) resolution that can be achieved.

$$d = \frac{\lambda}{2 \times NA}$$

$$d = \frac{10^{-9}\ m}{2 \times (.01)}$$

$$d = 50\ nm$$

2) Explain how to improve it?

There are 2 ways

~ decrease the λ

~ increase the NA