Please answer the questions below to the best of your ability either in the space provided. Everything should be scanned or photographed and submitted through gradescope.com.

Objective: *I can calculate the specific heat of a material at a variety of temperatures given only microscopic information about the material.*

1. Cobalt is used extensively in modern lithium batteries used by Tesla and Apple, and is indeed the most likely bottleneck for production issues owing to its relative scarcity. Peak battery performance is often times related to temperature, and thus ol' Elon is curious about the specific heat of cobalt at a variety of temperatures. Cobalt has a molar mass of 58.933 g/mol and a Young's Modulus of 209 GPa. Measurements place the density of cobalt at 8900 kg/m^3.

(2) (a) What is the diameter of a Cobalt atom?

(2) (b) What is the energy in joules of one cobalt quanta of energy?

(6) (c) Assume two reasonably large numbers for the number of quanta you wish to add to the system and the number of cobalt atoms you wish to consider as your system. You can improve the size of the numbers you can use by utilizing `combin(q+N-1,q)` instead of using the factorial expression explicitly (this works in any spreadsheet program or Glowscript and is functionally identical to using the factorial expression for calculating numbers of microstates). Go through the steps to determine the specific heat at different temperatures. From your results, create a plot of the specific heat vs temperature. Your values should approach $3k_b$ as the temperature increases. Do they?

(2) (d) The given specific heat of cobalt is $421\,\mathrm{J/(kg\,K)}$ at a temperature of $273\,\mathrm{K}$. How do your results compare? What is the percent difference between your answer and the established value? (*Being off by around 10% isn't totally unexpected here, so don't freak out if you are around that. If you are like 50% off though you should probably check some numbers...*)