Week 5 Challenge Homework

Entropy, Processes and Cycles

Submit a digital copy (PDF, jpg, etc.) to gradescope.com. Please use the Gradescope interface to associate each page of your submission with the corresponding question number! It makes grading much easier.

Every page should be labeled on the top left with the question number and there should be only be one solution per page. If a solution takes more than one page, be sure to label that it is a continuation of the previous page's solution. If data is needed to complete a problem, be sure to cite the source you've acquired your data from. See the course website for further details.

You will be asked to apply sense-making in some problems. Use the list below as a reference to the different sense-making techniques. More information about sense-making can be found on the BoxSand menu under Math Tools => Sense-making.

- *Sign:* Check the **sign** of each quantity makes sense.
- *Dimensionality:* Check the **dimensionality** and units of each quantity makes sense.
- *Order of Magnitude:* Check the **order of magnitude** of the final answer and other important quantities is within a a factor of 10 of what you think it should be.
- *Graphical Analysis:* Use a **graph** to see if the behavior of a solution makes sense.
- *Proportionality:* Using a symbolic solution, check the behavior of the answer when you change a given quantity on which it is dependent. Does the answer vary **proportionally** to what you expect?
- *Special Cases:* Check the behavior of a derived equation in limiting (**special**) cases makes sense, e.g. as x goes to 90 degrees in sin(x).
- *Self-consistency:* Check derived equations, functions, or values, are **self-consistent**, e.g. check that the slope of a derived position plot matches the values of the given velocity plot
- *Known Values:* Compare given or derived quantities with common well **known values**.
- *Related Quantities:* Compare the relative magnitude of two **related quantities**.

Question 1:

Liquid supersaturated sugar solution can evaporate in an open beaker. What is left is a solid of sugar crystals.

(a) Did the sugar gain or lose entropy going from a liquid to crystalline form? Explain.

(b) Does this violate the second law of thermodynamics? Explain.

Question 2:

3.0 moles of an ideal gas are subjected to the following processes. First the volume is tripled in an isobaric process. Then it undergoes an isothermal process to a pressure of 9.0 kPa. The volume is then halved in another isobaric process. Finally, it returns to the original state in an isochoric process.

(a) Draw a PV diagram of the cycle. Label each state (vertex) with a letter (A, B, …) and each transition with a number and arrow showing the direction of the process.

(b) Is this a heat engine or heat pump? Explain without using "clockwise" or "counterclockwise".

(c) If the isothermal process occurs at a temperature of 900 K, what is the pressure, temperature, and volume for each state.

(d) Find the work done on the gas, the heat in and out of the gas, and the change in thermal energy for each of the processes.