ATSC5010

Homework #2 (Sept 12)

Due beginning of class Sept 20

1. Consider two processes, one reversible and one irreversible. The two processes have the same initial state and the same final state.
   a. Compare the change in entropy of the system for the two processes. Is one greater than the other? If so, which one?
   b. What can you (if anything) about the change in entropy of the environment for each of the two processes?

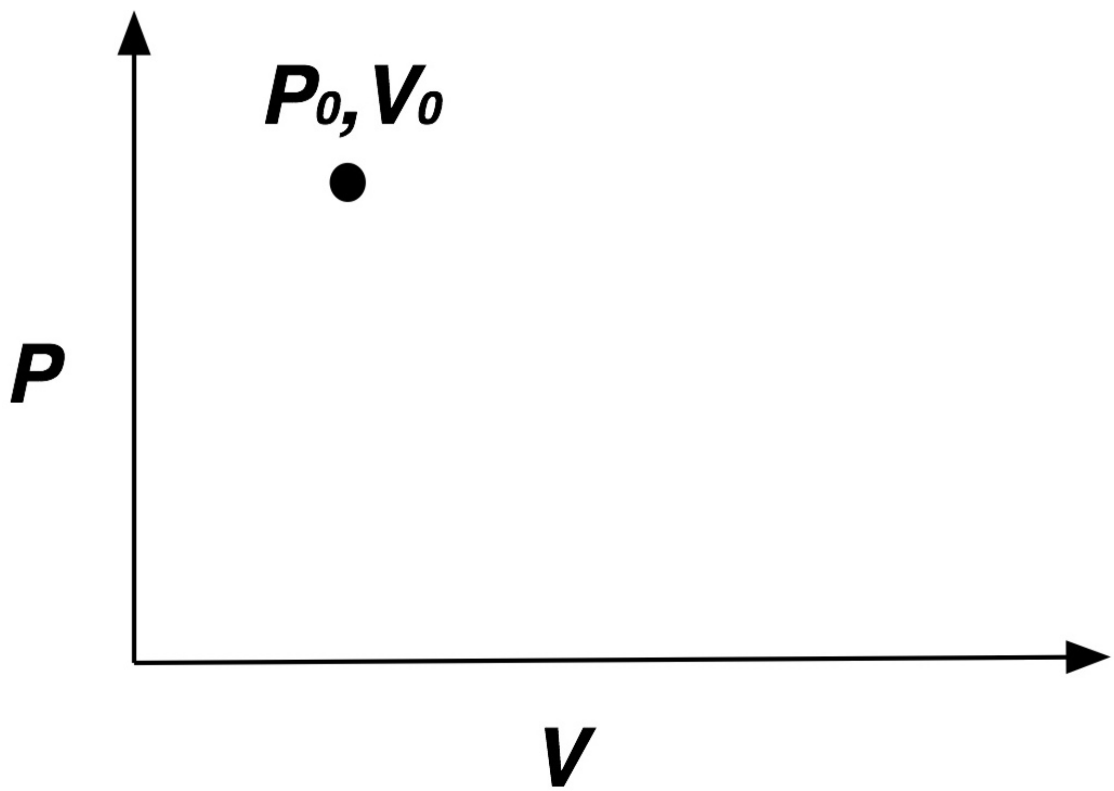
2. Calculate the change in specific internal energy and specific enthalpy for each of the following:
   a. Isothermal expansion from v = 800 to 750 cm^3 g^{-1}, at T=290K
   b. Isobaric heating from -10 to +10C at p=900 hPa.

3. A sealed 1 m^3 'rigid box' of dry air is allowed to cool through a reversible process (without losing or gaining any gas). Initially its temperature is 15 C. Its final temperature is 0 C. How much has the gas cooled (what is the change is specific heat)?

4. A sample of 50 g of dry air is initially at a pressure of 1000 mb and a temperature of 10 C. It is heated in an isobaric process during which the sample expands by 10% of its original volume. Calculate the final temperature of the air, the 'work' done, and the amount of heating.

5. An Ideal Gas is confined to a volume, Va in an insulated rigid container. The container has an adjoining volume Vb, initially evacuated. Assume Va and Vb are equal. Further assume that the initial pressure in Va is 1000 mb. A valve is opened and gas flows freely from Va to Vb.
   a. Calculate the work done by the gas in expansion.
   b. Calculate the change in internal energy of the gas.
   c. Calculate the change in entropy of the gas.
   d. Is this process adiabatic?
   e. Is this process reversible?

6. Consider two reversible processes operating on two separate systems. Both systems have the same initial state (P_0, V_0). One process is an isothermal expansion, the other is an adiabatic expansion. Assume that at the end of the processes, the pressure of the two systems is the same (both have a final pressure of P_1). Compare the change in volume between the two systems, which system has the larger final volume and by how much? Sketch the two processes on a P-V diagram. (You will add two points to the diagram, one will be P_1, V_{1_iso} and the other will be P_1, V_{1_adiab}). For both, approximate the pressure/volume curve throughout the process.



7. Hurricanes are sometimes considered to be a natural example of a 'Carnot Engine'. During a Carnot Cycle, gas is expanded first isothermally (by heating it) and then adiabatically (by not allowing heat exchange with the environment). Following this, the gas is compressed isothermally and then adiabatically until it returns to its initial state. Over the entire cycle, there is a net influx of heat (more heating occurs during isothermal expansion than does cooling during isothermal compression). This 'excess heat' (energy) is converted to work (NOTE---the First Law tells us that the total energy must remain constant). For our example of a hurricane, 'work' is mostly realized as wind. This *may be* an overly simplistic view, but let's examine it none-the-less.

   The diagram below shows a cross-section of a hurricane plotted a distance from the center of the storms 'eye' (Radius=0 km). Air at the surface begins well away from the eye at point A and flows in towards point B. During this process, the air is heated (from the water surface below) *isothermally.* By the time the air reaches point B it begins to ascend (through convective instabilities that we will learn about later) and expands *adiabatically* until it reaches point C (note that its temperature is now significantly less). From point C, the air is compressed *isothermally* until it reaches point D. Finally, the air continues to undergo compression, but now *adiabatically* until it returns to point A.

   a. Consider the changes that occur (entropy, temperature, heat flow) to the system (the hurricane) during each of the four processes (A→B, B→C, etc). Complete the following table.

Procress Legs	*q*, Heating (Heated/Cooled/Same)	*T*, Temperature (Incr/Decr/Same)	*η*, Entropy (Incr/Decr/Same)
A→B			
B→C			
C→D			
D→A			

   b. Consider a P-V diagram (similar to the one in problem 6). Roughly sketch the 4 points (P_A,V_A; P_B,V_B; etc.). Indicate during which legs heat is flowing into/out of the system. Shade in the area that represents the net work accomplished by the system through the cycle.