Homework 2

Due Friday, February 4 (Problems 4 and 5 corrected on Wed. afternoon, 2-2-22)

1) 1 mole of a monatomic ideal gas initially at 70 °F and 0.83 atm is cooled to 30 °F by placing the gas in thermal contact with the surroundings at 30 °F. (a) Calculate $W, Q, \Delta U$, and ΔH in Joules if the cooling takes place at constant pressure. (b) Calculate $W, Q, \Delta U$, and ΔH in Joules if the cooling takes place at a constant volume.

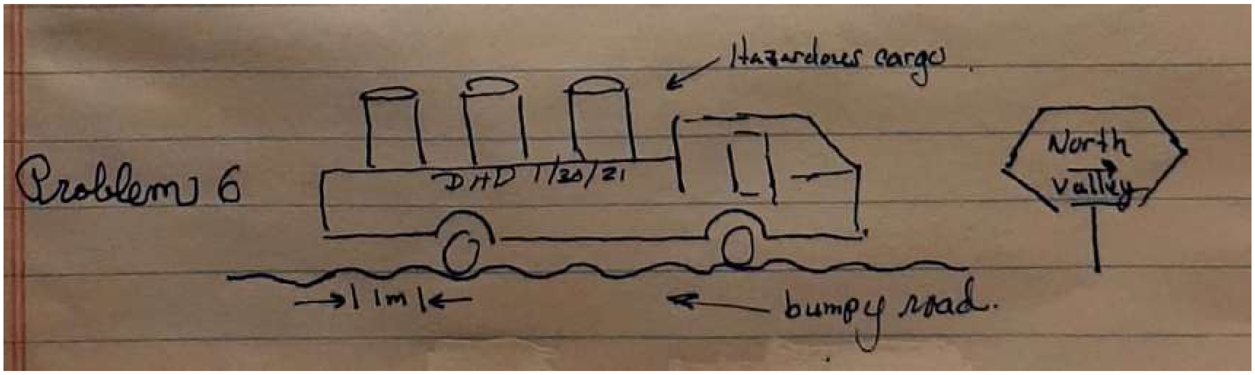
2) A dog's bowl with 1000 g of water was left out overnight in the South Valley last night, when the temperature slowly sank to 19 degrees F this morning. The water was pure enough to remain in the liquid state, becoming supercooled. When the bowl was perturbed this morning, the water suddenly changed to ice – a spontaneous transformation from liquid to solid at constant temperature and pressure. Calculate the change in enthalpy (in Joules) for this irreversible isothermal process by integrating dH over a hypothetical reversible path. You will need to look up the relevant specific heats of water and ice, and the latent heat of fusion.

3) A mole of <u>monatomic</u> ideal gas at an initial pressure of 1 atm and an initial temperature of 70 degrees Fahrenheit is adiabatically compressed by a constant external pressure. What does this pressure need to be (in atm) so that the final temperature is 451 degrees F? How much work (in Joules) is performed on the gas to reach 451 degrees F in such a process?

4) Air is confined to a vertical cylinder with a 2 cm diameter and 1 meter length that is closed at the top with a well-lubricated piston weighing 10 N. The cylinder is insulated. Initially the air is at room temperature and at the ambient pressure in Albuquerque, and the weight of the piston is supported by a couple of pins. When the pins are removed, the air is compressed under the additional weight of the piston. How far will the weight fall before coming to equilibrium? Work this problem two different ways. First, assume a compression at a constant external pressure. Second, assume a reversible compression. Assume ideal gas behavior.

5) Air, initially at 373 K , 1 atm , and V_1 = 1 liter undergoes two successive reversible expansions – a reversible isothermal expansion to some intermediate volume V_a , followed by a reversible adiabatic expansion to a final volume $V_2 = 3$ liters, cooling the gas to final temperature of 273 K. Calculate V_a, Q, and W, for the process. Assume ideal gas behavior.

6) A mole of monatomic gas initially at 0.83 atm and in thermal contact with the surroundings at 294 K undergoes a reversible isothermal expansion to a new pressure of 0.7 atm. Then it is put in contact with a cold reservoir at 273K, and cooled to 273 K, while the volume is held constant (isochoric cooling). Then it is reversibly and isothermally compressed at 273 K to its original volume, at which point it is placed in contact with the surroundings at 294 and heated at constant volume until the temperature returns to 294 K. Calculate ΔU , Q, and W for each of the four stages, and the ratio of the net work for a cycle to the heat absorbed from the hot reservoir. How does the efficiency compare to the efficiency of a Carnot engine operating between the same two temperatures?



7) A perfectly insulated cylinder sits vertically in the back of a delivery truck driving over a bumpy dirt road in the north valley in high summer. Unbeknownst to the driver, inside the cylinder is an explosive stoichiometric mixture of hydrogen and oxygen gases, confined to the cylinder by a weighted piston applying an external pressure of approximately 0.83 atm - the ambient pressure in Albuquerque. The temperature of the gas mixture is initially 90 degrees Fahrenheit, but every time the truck goes over a bump, the temperature rises and falls. While passing over a bump the piston slides in and the pressure reaches 0.90 atm; afterwards the piston moves back out and the pressure drops back to 0.83 atm. The specific heat at constant volume $\bar{C}_V = (5/2)R$.

(a) If we model a bump as a cycle consisting of two reversible adiabatic processes, a reversible compression increasing the pressure to 0.90 atm, followed by reversible expansion lowering the pressure back to 0.83 atm, what will be the temperatue of the gas after 10 complete cycles?

(b) If we model each bump-cycle as consisting of two constant-pressure adiabatic processes, a compression taking place at a constant pressure of 0.90 atm, followed by an expansion at constant pressure of 0.83 atm, what will be the termperature of the gas after 10 bumps? A gaseous mixture of hydrogen and oxygen will explode spontaneously if the temperature exceeds 932 °F. How many bump-cycles will it take to reach this temperature?