Meteorology 3510
Exercise #3
Due Thursday, January 31, 2008

These exercises cover the concepts of work, energy transfer by heating, and associated temperature changes.

1. Two containers, 1 and 2, of volumes $V_1 = 900$ cm^3 and $V_2 = 600$ cm^3, respectively, are connected by a tube that opens and closes with a valve. The containers are filled with a gas at the same temperature but under pressures of 1000 mb and 700 mb, respectively. If we open the valve, what will be the final pressure in each of the containers? Assume that the temperature does not change. *Hint:* Use Dalton's Law.

2. How much heating (internal energy) is generated by braking a car with a mass of 1000 kg from a speed of 30 m/s? If this energy was entirely converted to electricity and stored in battery, how long would that energy power a 100 Watt light bulb?

3. A 75 g block of copper, taken from a furnace, is dropped into a 200 g glass beaker containing 300 g of water. The temperature of the water rises from 12 to 27° C. What was the temperature of the furnace? The specific heat of glass is 0.12 kcal kg^{-1} K^{-1}.

4. Derive the mathematical expression for the work done per unit mass by an ideal gas that expands isothermally, from an initial specific volume α_1 to a final specific volume α_2.

5. Calculate the work done by 2 kg of dry air that isothermally expands to ten times its original volume at $T = 20°$ C.

6. A sample of aluminum with a mass of 0.2 kg and a temperature of 100° C is put into 0.4 kg of water at 20° C contained in a copper vessel with a mass of 0.1 kg. What is the temperature of the system (aluminum, water, and copper) at thermal equilibrium?

7. A sample of 50 g of dry air is initially at a pressure of 1000 mb and a temperature of 280 K. Energy is added by heating in an isobaric process during which the sample expands by 20 per cent of its original volume. Calculate the final temperature of the air, the work done against its surroundings (in joules), and the energy added by heating (in kilocalories).

8. Calculate the final temperature, the energy added (or lost) by heating, and the work done in compressing isobarically 5 kg of dry air to a third of its original volume at a pressure of 850 mb. The initial temperature is 290 K.

9. Consider an enclosed volume of dry air of 50 m^3 at 20° C and 1000 mb.
   (a) What is the specific volume?
   (b) What is the mass of this sample?
   (c) The volume is insulated (so that no energy can be transferred by heating through the enclosure) and contains a heater that converts electrical energy to internal energy at a rate of 500 watts (1 watt = 1 joule sec^{-1}). What will be the temperature of the air after 1 hour of heating? (Assume that the volume remains unchanged.)
   (d) What will be the pressure of the air after 1 hour?