1. Equal lengths of thin steel and aluminum wire are joined to make a single wire of uniform diameter. The wire is attached to fixed supports so that it is straight but without tension. After being cooled, the aluminum is found to have increased in length by 0.0230% (and the steel decreased in length by the same percentage.) Find the stress in the wire and the difference in temperature by which it was cooled.

2. A single-pane window is a piece of glass 8.00 mm thick with conductivity 0.530 W/m-K. A double-pane window has the same area and is constructed of two single-panes with a layer of argon gas 10.0 mm thick in between. Find the percentage by which the rate of heat flow would be reduced if the single-pane window was replaced by a double-pane window. (Note: for argon, k = 0.0179 W/m-K)

3. A very large hot air balloon and its accompanying structure (i.e. the basket, rigging, equipment, etc) have a mass of 400 kg. The air inside the balloon must be heated to a temperature of 200 °C for the balloon to lift off the ground when the outside air temperature is 16.0 °C. To what temperature must the air be heated if the balloon is to lift off with three 80.0-kg people aboard?

4. Through a room at 20.0 °C, a thin-walled metal pipe with diameter 7.00 cm and length 6.00 m is used to transport steam at 100 °C and pressure of 1.40 atm. The pipe is surrounded by insulation 3.00 cm thick with conductivity k = 0.0400 W/m-K. Find the speed of the steam, if only 1.00% of it is allowed to condense as it moves through the pipe. (This problem is mildly tricky. It involves conduction, calorimetry and ideal gas law. Each of these are simple pieces of the puzzle, you just have to figure out how to fit them together. A good picture will help, of course.)

5. Commercial divers use lift bags to aid in lifting of heavy objects underwater. Air is added to a certain bag when it is at a depth of 30.0 m in a freshwater lake. At this depth, the temperature of the water is 10.0 °C and the buoyant force on the bag is 200 N. The bag expands as it rises to a depth of 10.0 m, where the temperature is 23.0 °C. Find the buoyant force acting on the bag at the shallower depth. (When using a lift bag, the buoyant force acting on the bag determines how much the bag can lift.)
6. One mole of a diatomic ideal gas is allowed to expand at constant temperature from an initial volume of 10.0 Liters to a final volume of 36.4 Liters. If the final pressure of the gas is 1.00 atm, find the work done by the gas during this process.

7. A **turbocharger** is essentially an air compressor in the air intake of your car's engine. Air enters the intake at a temperature of 15.0 °C and pressure of 14.7 psi, and is compressed to 17.1 psi. Assume that the compression is adiabatic. Draw a pV diagram of the compression, then find the final temperature of the air and the percent increase in the density of the air. *(Note: this is also the approximate increase in power output of the engine.)*

8. One mole of a monatomic ideal gas is initially at a temperature of 100 °C and a volume of 20.0 L. It is compressed isothermally to a pressure of 7.00 atm. It is then allowed to expand at constant pressure to a volume of 20.0 L. Finally, the gas is cooled at constant volume until it reaches its original state. Draw a pV diagram of this cycle, make a table of p, V, T & pV for each state and a table of ΔE, W & Q for each process. Then find the efficiency of the heat engine represented by the cycle.

9. A certain coal burning power plant is a heat engine that takes in heat from a reservoir at 1700 °C and expels exhaust heat to a reservoir at 20.0 °C. The engine has an actual efficiency that is only ¾ of the theoretical maximum. Operating continuously, it produces a steady output (i.e. work) of 800 MW. If the combustion of 1.00 kg of coal produces 21.0 MJ of heat, how much coal does this power plant use each day? *(This is approximately how much each coal-burning power plant in the United States, which collectively provide about 30% of our electricity, consumes each day. Even at this rate, we have enough coal to last about 200 years.)*

10. A simple refrigerator can be described by a cycle of four processes: a monatomic ideal gas with volume 4.00 L and pressure 1.00 atm is compressed isothermally to a pressure of 2.50 atm; it is then cooled at constant volume to a pressure of 1.50 atm; it then expands isothermally to a pressure of 1.00 atm; finally, the gas absorbs heat at constant pressure until it reaches its original state. Draw a pV diagram for this cycle, create tables for the states and processes, and calculate the COP for this refrigerator.

11. A styrofoam cup contains 10.0 grams of ice and 100 grams of water. A copper block, initially at 200 °C, is added to the ice water. If the final temperature of the system is 28.0 °C, find the mass of the copper and the total change in entropy of the system.

12. Ten grams of steam at 100 °C is added to 100 grams of water at 20.0 °C. Find the final temperature and the total change in entropy of the system.

**Answers**

1. -41.5 °C  5.37 x 10^7 Pa  
2. 97.4%  
3. 2.72 m/s  492 °C  
4. 2.72 m/s  
5. 415 N  
6. 47.0 atm-L  
7. 27.7 °C  11.4%  
8. 23.0%  
9. 5150 metric tons  
10. 4.55  
11. 95.5 g  270 J/K  
12. 76.4 °C  10.4 J/K