

1. Determine which of the following systems are in equilibrium.
  - (a) A rigid insulated cylinder is divided by an insulated piston into two equal parts. One part contains oxygen at 50 °C and 300 kPa, and the other part contains nitrogen at 30 °C and 100 kPa. The piston is held in place by a stop.
  - (b) Same as part a, but the stop is removed.
  - (c) A rigid insulated cylinder is divided by a copper piston into two equal parts. One part contains oxygen at 50 °C and 300 kPa, and the other part contains nitrogen at 30 °C and 100 kPa.
  - (d) A rigid insulated cylinder is divided by a copper piston into two equal parts. One part contains oxygen at 30 °C and 100 kPa, and the other part contains nitrogen at 50 °C and 100 kPa.
  - (e) A rigid insulated cylinder is divided by a copper piston into two equal parts. One part contains oxygen at 30 °C and 100 kPa, and the other part contains nitrogen at 30 °C and 100 kPa. A small hole is made in the piston.
  - (f) Twenty grams of salt crystals are put in a container together with 1000 cm<sup>3</sup> of water.
  - (g) Twenty grams of salt crystals are put in a container together with 1000 cm<sup>3</sup> of saturated saline solution.
2. A perpetual motion machine of the first kind (PMM1) is defined as an *adiabatic* system for which the work in a cycle is not zero. Is the first law equivalent to the statement that a PMM1 is impossible? Explain.
3. The solar energy can be harnessed to produce electric work. A PV solar panel produces 100 kW of electric power per day in summer, which is used to charge a storage battery. The battery loses heat to the environment at a rate of 3 kW. How much energy is stored in the battery after 6 h of operation?
4. The envelope of an elastic balloon exerts a pressure on its contents proportional to its area. The balloon is inflated from a volume of 10 L and a pressure of 200 kPa to a volume of 25 L.
  - (a) Calculate the final pressure in the balloon.
  - (b) Calculate the work of the balloon envelope.
5. For a simple compressible system, indicate whether the following statements are true, sometimes true, or false:
  - (a) The work done by a system when changes from states 1 to 2 depends on its volume.
  - (b) When a gas expands, its energy increases.
  - (c) The work of an adiabatic cycle is equal to 0.
  - (d) The work in a cycle is equal to 0.
  - (e) The energy change from states 1 to 2 depends on the work of the system.
  - (f) When a gas is compressed in a cylinder, its energy does not change.
6. The specific energy of a certain substance is given by  $U = A + BPV$ , where  $A = 60$  kJ/kg,  $B = 8$ ,  $P$  units are kPa, and  $V$  is expressed in m<sup>3</sup>/kg. Find the work done by a system of this substance when its volume increases adiabatically from 1.5 MPa and 60 to 150 L.

Due date: Tuesday, August 20th.