Chapter-19

1. You are working in your kitchen preparing lunch for your family. You have decided to make egg salad sandwiches and are boiling six eggs, each of mass 55.5 g, in 0.750 L of water at 100oC. You wish to take all the eggs out of the boiling water and immediately place them in 23.0oC water to cool them down to a comfortable temperature to hold them and peel them. You decide that you wish the mixture of the water and the eggs to reach an equilibrium temperature of 40.0oC. Explaining this to a family member, she challenges you to determine exactly how much water at 23.0oC you need to achieve your desired equilibrium temperature. Take the average specific heat of an egg over the expected temperature range to be 3.27X 103 J/kg **.** oC

Ans:

**Conceptualize** When the eggs are cooking, they are in boiling water, so their temperature is 100°C. They are then transferred to 23.0°C water, and the combination of eggs and water reaches an equilibrium temperature of 40.0°C.

**Categorize** This is a calorimetry problem: you are mixing hot eggs and cool water.

**Analyze** We use Equation 19.5:

 (1)

Substitute for each side of the equation, water on the left, eggs on the right:

 (2)

Solve for the required mass of water:

 (3)

Substitute numerical values:



**Finalize** The mass of water that we found corresponds to a volume of about a liter of water, or, in common U.S. kitchen measurements, close to a quart.

*Answer:* 0.918 kg

1. (a) How much work is done on the steam when 1.00 mol of water at 100oC boils and becomes 1.00 mol of steam at 100oC at 1.00 atm pressure? Assume the steam to behave as an ideal gas. (b) Determine the change in internal energy of the system of the water and steam as the water vaporizes.

Ans:

(a) We choose as a system the H2O molecules that all participate in the phase change. For a constant-pressure process,

 **

where *Vs* is the volume of the steam and *Vw* is the volume of the liquid water. We can find them respectively from

 

 Calculating each work term,

 

 Thus the work done is

 *W* = −3 101 J + 1.82 J = 

 (b) The energy input by heat is

 **

 so the change in internal energy is

 

1. For bacteriological testing of water supplies and in medical clinics, samples must routinely be incubated for 24 h at 37oC. Peace Corps volunteer and MIT engineer Amy Smith invented a low-cost, low-maintenance incubator. The incubator consists of a foam-insulated box containing a waxy material that melts at 37.0oC interspersed among tubes, dishes, or bottles containing the test samples and growth medium (bacteria food). Outside the box, the waxy material is first melted by a stove or solar energy collector. Then the waxy material is put into the box to keep the test samples warm as the material solidifies. The heat of fusion of the phase-change material is 205 kJ/kg. Model the insulation as a panel with surface area 0.490 m2, thickness 4.50 cm, and conductivity 0.012 0 W/m **.** oC. Assume the exterior temperature is 23.0oC for 12.0 h and 16.0oC for 12.0 h. (a) What mass of the waxy material is required to conduct the bacteriological test? (b) Explain why your calculation can be done without knowing the mass of the test samples or of the insulation.

Ans:

(a) The heat leaving the box during the day is given by



 

 The heat lost at night is

 

 The total heat is 1.19 × 105 J + 7.90 × 104 J = 1.98 × 105 J. It must be supplied by the solidifying wax: *Q* = *mL*

 

 (b) 