Chapter 3 Problems

1. Calculate the work done (in Joules) by the expansion in Figure 3.6 (of an ideal gas) if $\mathbf{V}_1 = 1000\,\text{cm}^3$, $P'_{ext} = 5\,\text{bar}$, and $P''_{ext} = 18\,\text{bar}$. After the expansion at P''_{ext}, the piston is at equilibrium with no stops. However, during the expansion at P'_{ext}, the piston hits the upper stops, at that point the P'_{ext} suddenly increases to 10 bars.

2. Calculate the work done if there are four expansions having P_{ext} values of 18, 16, 14, and 10 bars.

3. Calculate the maximum amount of work available from the expansion of this gas.

4. Calculate the work done if the gas is compressed from $\mathbf{V}_2$ to $\mathbf{V}_1$ by placing a large weight on the piston equivalent to $P_{ext} = 22$ bars.

5. Why don't we use real gases instead of ideal gas in this type of question?

6. How much work is done when one mole of corundum combines with 3 moles of water to form one mole of gibbsite [reaction (2.2)], at atmospheric pressure?

7. Calculate the change in internal energy ($\Delta_r U^\circ$) for reaction (2.2).

$$Al_2O_3(s) + 3\,H_2O(l) = Al_2O_3 \cdot 3H_2O(s) \tag{2.2}$$

8. Calculate the standard heat of reaction for reaction (2.3),

$$C_8H_{16}N_2O_3(aq) + H_2O(l) = C_6H_{13}NO_2(aq) + C_2H_5NO_2(aq) \tag{2.3}$$

9. Calculate the maximum amount of useful work available from reactions (2.3) and (2.5) under standard conditions. This would allow you to put some numbers on the vertical axis of Figure 2.8.

10. Calculate the work of expansion against atmospheric pressure for reaction (2.5), and compare with the maximum useful work available.

11. The unit of energy used by nutritionists is the Calorie (with a capital C), which is 1000 calories, or 1 kcal. In Appendix A, we see that 1 calorie = 4.184 Joules, so 1 Cal = 4184 J. The basal metabolic rate for humans varies from about 1300 to 1800 kcal/day. Any physical activity adds to this basal energy requirement. In other words, a person at rest would use the energy in a glass of orange juice (100 Cal) in about 100/1500 days, or 1.6 hours. How long would the energy ($\Delta_r H^\circ$) from reaction (2.2) last an average human, if it was available?

12. The C_P for (supercooled) water between 0 and -10°C is $76.1\,\text{J mol}^{-1}\,\text{K}^{-1}$. The C_P for ice between 0 and -10°C is $36.5\,\text{J mol}^{-1}\,\text{K}^{-1}$. If the heat of fusion of ice at 0°C is $6008\,\text{J mol}^{-1}$, what is it at -10°C? (see equation (3.25)).