1. Derive explicit expression for the reversible work of isothermal expansion done in each of the following cases:
   (a) $dV$ is obtained from the equation of state $pV = RT + Bp + Cp^2$.
   (b) $dV$ is obtained from the Berthelot equation [Eq. (4.12) on p. 162].

2. Calculate $w$, $\Delta U$, $q$, $\Delta H$, and $\Delta S$ in an isothermal reversible expansion of 1 mole of a gas that obeys the equation of state $pV = RT + Bp$. [Hint: $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial p}{\partial T}\right)_V - p$.]

3. (a) Calculate the standard enthalpy change $\Delta_r H^\circ$ for the reaction at 298.15 K

   \[ \text{N}_2(g) + 3 \text{H}_2(g) \rightarrow 2 \text{NH}_3(g) \]

   from standard enthalpies of formation obtained from standard references or the National Institute for Standards and Technology website: http://webbook.nist.gov/chemistry.

   (b) Calculate the enthalpy of reaction at 800 K using the results of part (a) and the $C_{p,m}$ data given in Table 2.1 (p. 50).

4. (a) The standard enthalpy of combustion of benzoic acid ($C_6H_5-COOH$) is 3,227.0 kJ mol$^{-1}$. In a bomb calorimeter experiment, 1.0084 g of benzoic acid produced a temperature difference of 2.53 °C, and 0.9843 g of a substance with the chemical formula $C_{10}H_8$ resulted in a temperature difference of 3.56 °C. What is the enthalpy of combustion of the unknown substance?

   (b) In high-precision calorimetry, one must also account for the amount of heat contributed by the burning of the fuse used to ignite the samples. Given that the heat produced by the fuse in the calibration run and the sample run above were 45.6892 J and 60.3332 J, respectively, recalculate the enthalpy of combustion of the unknown substance incorporating this correction.

5. One mole of super-cooled liquid water at $-10 \degree C$ and 1 bar pressure is allowed to spontaneously turn into ice. The surroundings are maintained at $-10 \degree C$. Calculate $\Delta H$, $\Delta S$, and $\Delta S_{univ}$ for this process, making use of the following data:

   \[
   C_{p,m}(\text{water}) = 75.3 \text{ J K}^{-1} \text{ mol}^{-1} \\
   C_{p,m}(\text{ice}) = 37.7 \text{ J K}^{-1} \text{ mol}^{-1} \\
   \Delta_{fus}H^\circ = 6.02 \text{ kJ mol}^{-1} \text{ at } 0 \degree C
   \]