1. Calorimeters are often calibrated using benzoic acid (C₆H₅COOH).
   a. Write a balanced equation for the combustion of benzoic acid.
   b. Use your balanced equation to calculate the enthalpy of combustion for benzoic acid.
   c. 1.5 g of benzoic acid was combusted in a calorimeter; the measured temperature increased from 21.97°C to 25.15°C. Calculate the heat capacity of the calorimeter.
   d. Determine the change in entropy for the combustion of benzoic acid.
   e. Predict the range of temperatures over which the combustion of benzoic acid is spontaneous.
f. Identify the intermolecular forces of attraction between different benzoic acid (C₆H₅COOH) molecules; draw a diagram clearly showing the strongest interaction.

g. Predict whether you would expect benzoic acid to be soluble in water. Use thermodynamics to fully support your prediction.

h. At T = 298.15 K, the apparent molar enthalpy of solution, ΔH_sol, for benzoic acid is +25.5 kJ/mol. Use this to predict how benzoic acid’s solubility in water would be expected to change with an increase in temperature. Use thermodynamic and equilibria fundamental principles to fully support and to explain your rationale for this prediction.

i. 1.5 grams of benzoic acid (C₆H₅COOH) was dissolved into 100.0 mL of water at 298.15 K. Use the molar enthalpy of solution, ΔH_sol, for benzoic acid (+25.5 kJ/mol) to determine the final temperature of the water. Assume that all the heat gained or lost is used to heat or cool the water.
2. A recent patent was issued on a process that uses elemental magnesium sublimation to coat silicon carbide fibers for ceramic composite materials.

   a. Calculate the enthalpy of sublimation for elemental magnesium Mg (s).

   b. Determine the entropy of sublimation for elemental magnesium Mg (s).

   c. Determine the temperature at which elemental magnesium sublimates (its vapor pressure is one atmosphere).

   d. Calculate the Gibbs Free Energy of magnesium sublimation under standard conditions. Explain why your answer does or does not make sense.

3. For the chemical reaction: \( \text{PCl}_5 (g) \rightleftharpoons \text{PCl}_3 (g) + \text{Cl}_2 (g) \)

   a. Predict how the equilibrium would shift if pressure were increased by adding He gas.

   b. Predict how the equilibrium would shift if temperature were increased. Fully support your prediction with calculations.

   c. The \( K_c \) for this reaction is 0.040 at a temperature of 270°C. A 5.0 L reaction vessel contains 0.75 moles of \( \text{PCl}_5 \) (g), 0.15 moles of \( \text{PCl}_3 \) (g), and 0.20 moles of \( \text{Cl}_2 \) (g). Is this mixture at equilibrium? If not predict which way it would spontaneously shift to attain equilibrium.