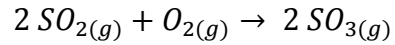


**Exercise 7.3**  
**Calculating Free Energy for Reactions Under Nonstandard Conditions**

1. Consider the reaction between carbon disulfide and hydrogen to give methane and hydrogen sulfide. All reactants and products are in the gas phase.
  - (a) Write a balanced chemical equation for this reaction.
  
  
  
  
  
  
  
  
  
  
  - (b) Calculate the standard free energy change for this reaction at 25 °C.
  
  
  
  
  
  
  
  
  
  
  - (c) Calculate the free energy for this reaction at 25 °C when the partial pressures of the gases are  $p_{CS_2} = 0.15 \text{ bar}$ ,  $p_{H_2} = 1.65 \text{ bar}$ ,  $p_{CH_4} = 1.25 \text{ bar}$  and  $p_{H_2S} = 0.35 \text{ bar}$ .

2. Sulfur trioxide, a very important industrial material used to make sulfuric acid, is synthesized using the following reaction:



- (a) In a reactor, the partial pressures of the gases are  $p_{SO_2} = 0.48 \text{ bar}$ ,  $p_{O_2} = 0.18 \text{ bar}$  and  $p_{SO_3} = 0.72 \text{ bar}$ . In which direction must the reaction proceed to reach equilibrium at 25 °C? Justify your answer.

- (b) What effect would the use of a catalyst have on the position of this equilibrium? Why?