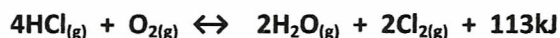


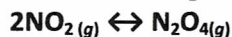
Chemistry 122

Worksheet: Chemical Equilibrium Review

1. What main idea explains chemical equilibrium?
2. List three ways that reaction rates can be increased.
3. Define Le Chatelier's Principle.
4. How does a change in volume affect the pressure of the system?
5. For each of the following descriptions, write a chemical equation for the system at equilibrium. Communicate the position of the equilibrium with equilibrium arrows. Then write a mathematical expression of the equilibrium law for each chemical system.
 - (a) The formation of ammonia (NH_3) provides a percent yield of 10.0%.
 - (b) The formation of water vapor from hydrogen and oxygen is quantitative.
 - (c) The reaction of carbon monoxide with water vapor to produce carbon dioxide and hydrogen has a percent yield of 67%.
6. Predict the shift in the following equilibrium system resulting from each of the following changes.



- (a) an increase in the temperature of the system
 - (b) a decrease in the system's total pressure due to an increase in the volume of the container
 - (c) an increase in the concentration of oxygen
 - (d) the addition of a catalyst
7. The equilibrium constant for the reaction of nitrogen dioxide to form dinitrogen tetroxide is 5.6.



In a one-liter container, the amount of N_2O_4 , at equilibrium, is 0.66 mol. What is the equilibrium concentration of NO_2 ?

8. Hydrogen sulfide gas decomposes into its elements and establishes an equilibrium at 1400°C .



A liter of this gas mixture at equilibrium contains 0.18 mol H_2S , 0.014 mol H_2 , and 0.035 mol S_8 . Calculate the equilibrium constant, K_{eq} , for this reaction.

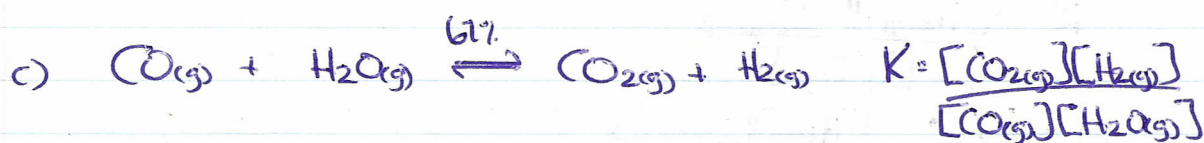
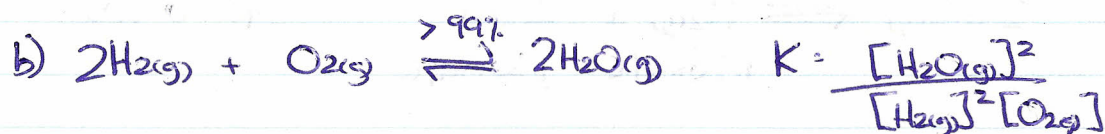
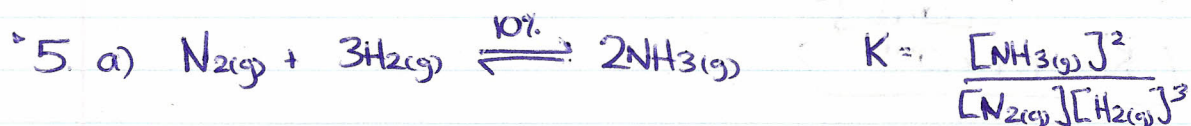
9. For the equilibrium $2\text{HI}_{(g)} \leftrightarrow \text{H}_{2(g)} + \text{I}_{2(g)}$, $K_{\text{eq}} = 0.905$ at 60.0°C . If $[\text{H}_{2(g)}] = [\text{I}_{2(g)}] = 1.20$ mol/L, calculate the $[\text{HI}_{(g)}]$. Is this a reactant-favoured or product-favoured reaction?

Calculate the percent reaction and write the reaction expression for the following equilibria.

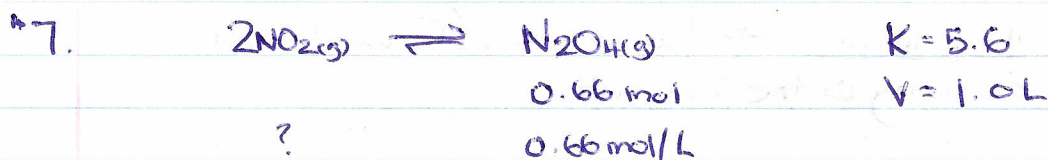
10. 384 g of $\text{S}_{8(g)}$ reacts with 205 g of oxygen gas to produce 380. g of sulfur dioxide gas.
11. 12.70 g of nitrogen reacts with 6.24 g of hydrogen to produce 3.77 g of ammonia.

WORKSHEET: CHEMICAL EQUILIBRIUM REVIEW

- *1. Chemical equilibrium \rightarrow two processes (forward and reverse) occurring at the same rate.
- *2. Reaction rates can be increased by:
- 1) Adding a catalyst
 - 2) Increasing the temperature
 - 3) Decreasing the particle size
- *3. Le Chatelier's Principle \rightarrow when a stress is placed on a system, the system will act to relieve the stress and re-achieve equilibrium.
- *4. Changing the volume of a system will result in the opposite change of pressure.
i.e. Decrease volume, increase pressure.
Increase volume, decrease pressure



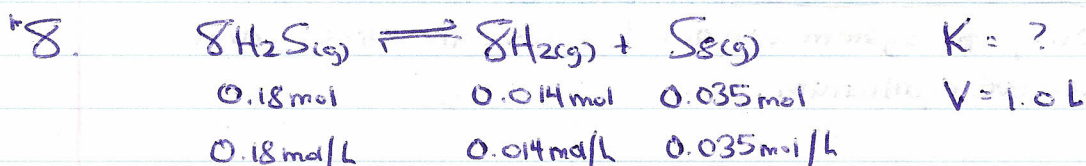
- | | |
|--------------------------------------|-------------|
| a) increase temperature | SHIFT LEFT |
| b) decrease pressure | SHIFT LEFT |
| c) increase $[\text{O}_2(\text{g})]$ | SHIFT RIGHT |
| d) add a catalyst | NO CHANGE |



$$K = \frac{[\text{N}_2\text{O}_4(g)]}{[\text{NO}_2(g)]^2}$$

$$[\text{NO}_2(g)] = \sqrt{5.6 [0.66]}$$

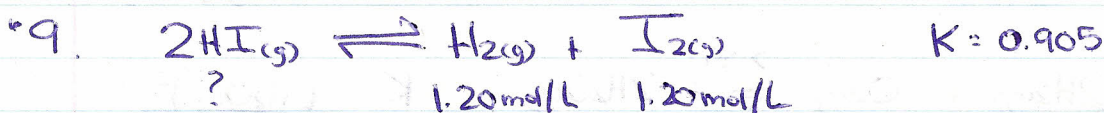
$$[\text{NO}_2(g)] = 1.9 \text{ mol/L}$$



$$K = \frac{[\text{H}_2(g)]^8 [\text{S}_8(g)]}{[\text{H}_2\text{S}(g)]^8}$$

$$K = \frac{[0.014]^8 [0.035]}{[0.18]^8}$$

$$K = 4.7 \times 10^{-11}$$

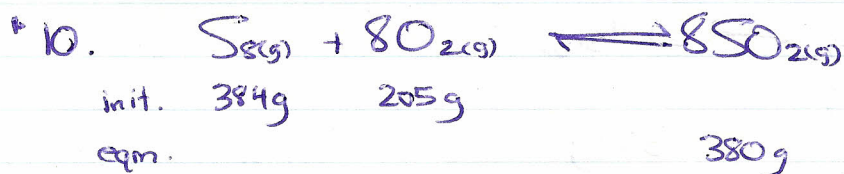


$$K = \frac{[\text{H}_2(g)] [\text{I}_2(g)]}{[\text{HI}(g)]^2}$$

$$[\text{HI}(g)]^2 = \frac{[\text{H}_2(g)] [\text{I}_2(g)]}{K}$$

$$[\text{HI}(g)] = \sqrt{\frac{[1.20][1.20]}{0.905}}$$

$$[\text{HI}(g)] = 1.26 \text{ mol/L}$$



Final max. product

If S is L.R.:

$$384g S_s \times \frac{1 \text{ mol } S_s}{256.48g S_s} \times \frac{8 \text{ mol } SO_2}{1 \text{ mol } S_s} \times \frac{64.06g SO_2}{1 \text{ mol } SO_2} = 767.28g SO_2$$

If O₂ is L.R.

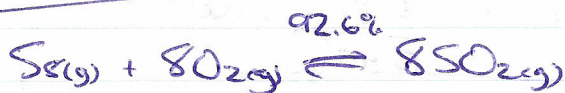
$$205g O_2 \times \frac{1 \text{ mol } O_2}{32.00g O_2} \times \frac{8 \text{ mol } SO_2}{8 \text{ mol } O_2} \times \frac{64.06g SO_2}{1 \text{ mol } SO_2} = 410.38g SO_2$$

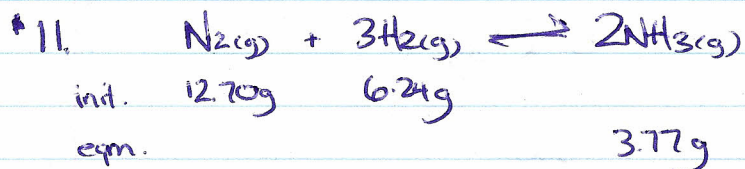
∴ O₂ is L.R.

$$\% \text{ rxn} = \frac{\text{exp}}{\text{theor.}} \times 100\%$$

$$\% \text{ rxn} = \frac{380g}{410.38g} \times 100\%$$

$$\% \text{ rxn} = 92.6\%$$





Find max. product.

If N_2 is L.R.:

$$12.70\text{g N}_2 \times \frac{1\text{ mol N}_2}{28.02\text{g N}_2} \times \frac{2\text{ mol NH}_3}{1\text{ mol N}_2} \times \frac{17.04\text{g NH}_3}{1\text{ mol NH}_3} = \boxed{15.45\text{g NH}_3}$$

If H_2 is L.R.:

$$6.24\text{g H}_2 \times \frac{1\text{ mol H}_2}{2.02\text{g H}_2} \times \frac{2\text{ mol NH}_3}{3\text{ mol H}_2} \times \frac{17.04\text{g NH}_3}{1\text{ mol NH}_3} = 35.09\text{g NH}_3$$

$\therefore \text{N}_2$ is L.R.

$$\% \text{ rxn} = \frac{\text{exp.}}{\text{theor.}} \times 100\%$$

$$\% \text{ rxn} = \frac{3.77\text{g}}{15.45\text{g}} \times 100\%$$

$$\% \text{ rxn} = 24.4\%$$

