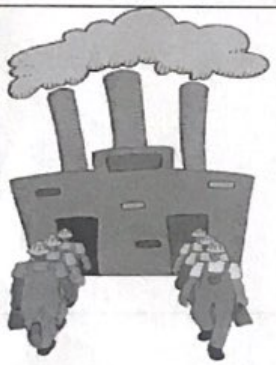
Name: KEY Period: _____ **Equilibrium & Le Châtelier's Principle Notes #7**

When opposing forces or issues are balanced, a system is said to be in equilibrium. Equilibrium in chemical reactions is dynamic because the forward and reverse reactions are occurring continuously and simultaneously at the same rates. Placing a stress on any equilibrium system, whether it is chemical, biological, societal, environmental, or personal, causes the equilibrium position to change. Le Chatelier's Principle allows us to predict the results that follow from changing the conditions of a system at chemical equilibrium. This allows scientists to develop techniques to control chemical reactions in natural and industrial settings in order to obtain desired products.

MODEL 1: Dynamic Equilibrium



Acme Manufacturing has been restricted to 100 employees in the building at one time. Throughout the day, twenty employees go on break each hour as twenty other employees return from break.

Chemical Equilibrium

$$2H_2\,(g) + O_2\,(g) \leftrightarrow 2H_2O\,(g) + \text{energy (heat)}$$

Questions:

1. How many employees move in and out of the factory building during each hour? 40
2. Are the employees who move in and out of the building each hour the same people? Explain your answer.
   No, they replace each other. The same people won't go on back to back breaks.
3. Does the number of employees in the building change from hour to hour? Explain your answer.
   No, they're swapping spots
4. Over the course of a day, the employees in the Acme Manufacturing Plant are said to be in a "dynamic equilibrium." Based on your understanding of how the staff move in and out of the plant, explain what is meant by the term "dynamic equilibrium." 20 people move in & 20 people move out at the same time
5. A new faster and simpler check-in/check-out process has been proposed for workers at the Acme Manufacturing Plant. Some workers have said that this new process acts like a catalyst. (A catalyst is a substance that speeds up a chemical reaction without changing the outcome of the reaction and without being used up in the process.)
   a. Would this new check-in/check-out process change the number of people in the building at any given time? Why or why not? No, the same numer (20) are going on/off break at the same time
   b. What would be the effect of the new check-in/check-out process on the workers at the factory? The workers would move in/out faster

Like the Acme Manufacturing Plant, chemical reactions can also reach equilibrium. Answer the following question about the chemical equation in Model 1 by applying insight you gained from the Acme Manufacturing Plant questions.

$2\,H_2\,(g) + O_2\,(g) \leftrightarrow 2\,H_2O\,(g)$ + energy (heat)

6. When the reaction between hydrogen and oxygen **reaches equilibrium:**
   a. Does the number of molecules in the reaction container change? Explain.

No, the forward & reverse reactions are going at the same time

   b. Is the reaction still proceeding in the forward direction?

Yes

   c. Is the reaction still proceeding in the reverse direction?

Yes

   d. Are the concentrations of the products and reactants changing?

No

   e. Are the rates of the forward and reverse reactions the same?

Yes

   f. Does the heat content of the system become constant?

Yes

Start Notes

MODEL 2: LE CHATELIER'S PRINCIPLE

Reactant: Increase (↑) causes the equilibrium to shift to the right (→)
Decrease (↓) causes the equilibrium to shift to the left (←)

Product: Increase (↑) causes the equilibrium to shift to the left (←)
Decrease (↓) causes the equilibrium to shift to the right (→)

Temperature: A change in temperature corresponds to a change in energy therefore by using the 'energy' term in the equation itself, it can be treated like a reactant or product (see above).

Pressure: An increase (↑) in pressure causes the equilibrium to shift towards the "smaller number of moles *of gas*" side.
A decrease (↓) in pressure causes the equilibrium to shift towards the "larger number of moles *of gas*" side.
Note: If the number of moles of gas is the same on both sides, then a change in pressure has no effect in the equilibrium.

The following equation describes a system that is at equilibrium:

$$2H_2\,(g) + O_2\,(g) \leftrightarrow 2H_2O\,(g) + \text{energy (heat)}$$

In Table 1 apply Le Chatelier's Principle and indicate the direction of the shift in equilibrium if the indicated stress is applied to the reaction system. (The first one is completed for you.)

$2H_2 + O_2 \leftrightarrow H_2O$ + energy (heat)

3 moles 1 mole

Table 1:

Stress	Shift Direction (left, right, no change)
Concentration H_2 increases	Shifts right
Concentration H_2 decreases	shift left
Concentration O_2 increases	shift right
Concentration O_2 decreases	shift left
Concentration H_2O increases	shift left
Concentration H_2O decreases	shift right
Temperature increases	shift left
Temperature decreases	shift right
Pressure increases	shift right
Pressure decreases	shift left
Catalyst added	no change

Answer the following questions based on your answers to the table above:

1. In general terms, describe the direction of the equilibrium shift when the concentration of a reactant increased.
   shift towards products
2. If an equilibrium shifts to the right, which reaction speeds up, the forward or the reverse?
   reverse
3. What happens to the concentrations of the reactant H_2 and O_2 when the reaction in Model 2 shifts to the right?
   decreases
4. What happens to the concentration of the product H_2O when the reaction in Model 2 shifts to the right?
   increases
5. If an equilibrium shifts to the left, which reaction speeds up, the forward or the reverse?
   forward
6. What happens to the concentrations of the reactants H_2 and O_2 when the reaction in Model 2 shifts to the left?
   increase
7. What happens to the concentration of the product H_2O when the reaction in Model 2 shifts to the left?
   decreases
8. What is true of the reaction rates for the forward and reverse reactions when a new equilibrium is established?
   the forward & reverse reactions are equal

Fill in the blanks in the chart below, given the reaction to form nitrogen oxide in a container.

N_2 (g) + O_2 (g) + heat ↔ 2 NO (g)

	Stress	**Shift** (right/left)	**Amount** (increases/decreases)
1.	N_2 added	right	of NO increases
2.	O_2 removed	left	of N_2 increases
3.	NO removed	right	of N_2 decreases
4.	Heat added	right	of NO increases
5.	Catalyst added	no change	of NO no change