Name:		Date:			
Chemistry ~ Ms. Hart	<u>Class:</u>	Anions	or	Cations	SCHOOL FOR CRIMINAL JUSTICE
7.3 Le Ch	atelier's Pri	nciple			
Any change in				_, or	on an
equilibrium system is called a		•			
• LeChatelier's Principle explain	s how a reacti	ion system a	t equi	librium resp	onds or
to		the stress	s.		
Concentration Change:					
Consider the following reaction:					
$C_{6}H_{8}O_{7}(aq)$ -	+ 3NaHCO ₃ (a	q) ≓ 3H₂O(l)) + 3C	$O_2(g) + Na_3$	$C_6H_5O_7$
When we add more reactants (C ₆ H	I ₈ O ₇ and NaH	CO_3), we cre	ated a	1	on the system.
• Reaction went to the		: The ra	ate of	the	rxn increase and
more	formed				
What would happen if we added m	nore $CO_2(g)$?				
• Reaction will go to the	_	: The ra	ate of	the	rxn will
increase and more		will form.			
Example:					
The following example shows	how a change	e in concentr	ration	affects equi	librium. A plus sign (+)
means the concentration incre	eases, and a m	ıinus sign (-) mea	ns that the c	concentration decreases.
$4\mathrm{NH}_3$	$(g) + 5O_2(g)$	≠ 4NO (g) +	- 6H ₂ (O (g) + heat	
Stress: More NH_3 (g) is addee	1				
Response: $4NH_3(g) + 5O_2(g)$) ≠ 4NO (g) +	- 6H ₂ O (g) +	heat		
<u>Stress:</u> More H₂O is added					
Response: $4NH_3(g) + 5O_2(g)$) ≠ 4NO (g) +	- 6H ₂ O (g) +	heat		
Stress: O ₂ (g) is removed					
Response: $4NH_3(g) + 5O_2(g)$) ≠ 4NO (g) +	- 6H ₂ O (g) +	heat		
Temperature Change:					
Consider the production of ammo	nia:				
_	$N_{2}(g) + 3H_{2}$	$(g) \neq 2NH_3$	(g) +	heat	
Is heat on the product side or the i	reactant side?				_
• If we add more heat (raising te	emperature), t	he reaction v	will go	o to the	and more
will form	n.		0		
• If we release heat (lowering ter	nperature), th	ne reaction w	rill go	to the _	and more

_____ will form.

Example:

Given the following balanced equation:

 $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g) + heat$

Stress: Raise temperature

<u>Response</u>: $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g) + heat$

Stress: Lower temperature

<u>Response</u>: $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g) + heat$

Given the following balanced equation: (notice that heat is on the reactant side now)

 $A + B + heat \rightarrow C$

<u>Stress</u>: Raise temperature

<u>Response</u>: $A + B + heat \rightarrow C$

Stress: Lower temperature

<u>Response</u>: $A + B + heat \rightarrow C$

Pressure Changes:

An <u>increase</u> in pressure will favor the reaction toward the side with the fewer ______

(less ______ = fewer ______) $N_2(g) + 3H_2(g) \Rightarrow 2NH_3(g)$ Step 1: What is the total number of moles of reactants? (hint: add the coefficient together on the left side) ______ Step 2: What is the total number of moles of products? (hint: add the coefficient together on the right side) ______ If pressure is increased, which way will the reaction go? _______ If pressure is decreased, which way will the reaction go? _______ **Example:** $dNH_3(g) + 5O_2(g) \neq 4NO(g) + 6H_2O(g) + heat$ If pressure is increased, which way will the reaction go? _______ If pressure is decreased, which way will the reaction go? _______ If pressure is decreased, which way will the reaction go? _______ If pressure is decreased, which way will the reaction go? _______ If pressure is decreased, which way will the reaction go? _______ If pressure is decreased, which way will the reaction go? _______ If pressure is decreased, which way will the reaction go? _______ If pressure is decreased, which way will the reaction go? _______ NOTE: Decrease in _______ = ______ in PRESSURE

Increase in ______ = _____ in PRESSURE

<u>Classwork:</u>

Consider the equation for the following reaction at equilibrium and answer questions 1 - 5 $X + Y \leftrightarrow 2Z + heat$

- 1. If the concentration of X is increased, which way will the reaction proceed according to Le Chatelier's Principle?
- 2. What will happen to the concentration of Y once the reaction responds to the increase in X?

- 3. If the concentration of Z is increased, which way will the reaction proceed according to Le Chatelier's Principle?
- 4. The concentration of the product could be increased by (1) adding catalyst(2) adding more heat to the system
 - (3) increasing the concentration of Y
 - (4) decreasing the concentration of X
- 5. Which way will the reaction proceed if heat is added to the system?
- 6. Consider the following equation. $N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g) +$

heat What stress would cause the equilibrium to shift to the left?

- (1) decreasing the temperature
- (2) adding $N_2(g)$ to the system
- (3) adding $H_2(g)$ to the system
- (4) adding NH_3 to the system
- 7. Consider the following equation.

 $Zn(s) + HCl(aq) \leftrightarrow ZnCl_2(aq) + H_2(g)$ As the concentration of the HCl(aq) decreases at constant temperature, the rate of the forward reaction

- (1) decreases
- (3) remains the same
- (2) increases
- (4) equals the rate of the reverse reaction

- 8. Consider the following reaction. H₂ (g) + Cl₂ (g) ↔ 2HCl (g) + heat Which change will result in an increase in the concentration of Cl₂(g)?
 (1) decreasing the temperature of the system
 (2) decreasing the concentration of HCl
 - (3) increasing the concentration of $H_2(g)$
 - (4) increasing the concentration of HCl
- 9. Consider the following equation. N₂ (g) + O₂ (g) ↔ 2NO (g) As the concentration of N₂(g) increases, the concentration of O₂(g) will

 decrease
 - (2) increase
 - (3) remain the same
 - (4) vary directly

Complete the following questions in FULL SENTENCES using the format in the example. Methanol (methyl alcohol) can be manufactured using the following equilibrium reaction:

 $\mathrm{CO}(g) + 2\mathrm{H}_2(g) \leftrightarrow \mathrm{CH}_3\mathrm{OH}(g) + \mathrm{energy}$

Predict the effect of the following stresses on the equilibrium concentration of $CH_3OH(g)$. Note that you should first determine the shift.

EXAMPLE: Removing CO(g) to the system.

Answer: The equilibrium will shift to the left and the concentration of CH₃OH will DECREASE.

10. Increasing the volume of the system.

11. Adding $H_2(g)$.

- 12. Increasing the pressure of the system.
- 13. Decreasing the temperature of the system.

Use the equation above to fill out the chart below. Write FORWARD or REVERSE in the right column.

Direction of stress	Shift observed
Concentration of reactant decreases.	
Temperature decreases.	
Concentration of product increases.	
Volume decreases (pressure increases)	
Concentration of product decreases	
Concentration of reactant increases	
Temperature increases.	
Volume increases (pressure decreases)	
A catalyst is added.	

*Tarendash, A.S., Barron's Review: Chemistry The Physical Setting, pg. 284

Concentration:

If the concentration of the (*reactant/product*)(*increases/decreases*), then the number of effective collisions (*increases/decreases*). To relieve this stress, the reaction equilibrium will shift (*left/right*) and make more (*product/reactant*).

Volume:

If the volume (*increases/decreases*), then the pressure will (*increase/decrease*). To relieve the stress of this change in pressure, the reaction equilibrium will shift (*left/right*) to produce (*fewer/more*) molecules.

Temperature:

If the temperature (*increases/decreases*), the reaction equilibrium will shift (*left/right*) towards heat being (*produced/released*).

MORE PRACTICE

14. In the equilibrium reaction:

 $2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g) + energy$

- a. What will be the change in the equilibrium concentration of SO_3 if energy is added to the system?
- b. What will be the change in the equilibrium concentration of O_2 if the temperature of the system is decreased?
- c. Should the temperature be increased or decreased in order to increase the concentration of NO?

- d. Explain in words, using Le Chatelier's Principle, why decreasing the volume of the system results in an increase of oxygen being produced.
- 15. Use Le Chatelier's principle to predict how the changes listed will affect the following equilibrium reaction:

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9.4 kJ + 2HI(g) \leftrightarrow H<sub>2</sub>(g) + I<sub>2</sub>(g)
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- e. Explain **why**, using *Le Chatelier's Principle*, the concentration of HI increases when a small amount of H_2 is added.
- f. What is the effect on the concentration of HI if a catalyst is added?
- g. **EXPLAIN** how an increase in the volume of the system affects the concentration of $I_2(g)$. Include your reasoning.
- h. How does [HI] change if the temperature of the system is decreased?
- i. If argon gas is added to the reaction, pressure does increased, but the equilibrium does NOT shift. Why not?
- 16. Methanol (methyl alcohol) can be manufactured using the following equilibrium reaction:

 $CO(g) + 2H_2(g) \leftrightarrow CH_3OH(g) + energy$

Predict the effect of the following changes on the equilibrium concentration of $CH_3OH(g)$. a. an increase in pressure

- b. addition of $H_2(g)$
- c. addition of a catalyst
- d. removing CO(g)

- e. increasing the temperature of the reaction.
- f. Using Le Chatelier's Priniciple, explain why an increase in the concentration of $CH_3OH(g)$ results in a increase in the concentration of CO(g).
- 17. For the following reaction:

$$N_2O_4(g) + 58.9 \text{ kJ} \leftrightarrow 2NO_2(g)$$

How will the equilibrium concentration of NO2 be affected by the following conditions?

- g. the addition of Neon gas.
- h. an increase in volume.
- 18. Explain one way (not involving a change in volume), that you could use to shift the equilibrium position in favor of increasing $N_2O_4(g)$ concentration.

19. Explain, in terms of crowding, the effect a decrease in volume would have on the system.

20. Explain the main idea behind Le Chatelier's Principle in your own words.