Kinetics and Equilibrium **Name**_____

LeChatelier's Principle

Read **Lesson 3 LeChatelier's Principle** in the **Chemistry Tutorial Section, Chapter 14** of **The Physics Classroom**.
Part a: Disturbances and Stress Part b: Predicting the Direction of Shift

Le Chatelier's Principle: When a system at equilibrium is disturbed (by changes in concentration, pressure, or temperature), it shifts in a direction that counteracts the disturbance and re-establishes equilibrium.

1. Change in Concentration

- *Adding reactants* → Shifts right (toward products)
- *Adding products* → Shifts left (toward reactants)
- *Removing reactants* → Shifts left
- *Removing products* → Shifts right

2. Change in Pressure (for gaseous systems)

- *Increasing pressure or decreasing volume*→ Shifts toward side with fewer moles of gas
- *Decreasing pressure or increasing volume* → Shifts toward side with more moles of gas

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3. Change in Temperature

- *Endothermic reaction ($\Delta H > 0$)*
  - Increasing temperature → Shift right
  - Decreasing temperature → Shift left
- *Exothermic reaction ($\Delta H < 0$)*
  - Increasing temperature → Shift left
  - Decreasing temperature → Shift right

Questions

1. Predict what would happen in this reaction: $\mathbf{C\ (s) + CO_2\ (g) \rightleftarrows 2\ CO(g)\ \Delta H = +\ 173\ kJ}$. Explain your predictions using Le Chatelier's Principle.
   a. if the temperature is increased.

   b. if CO_2 (g) is removed.

   c. if the volume of the system is increased.

   d. Would any of these changes affect the equilibrium constant K_p?

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2. For each scenario in the chart, indicate the direction of the equilibrium shift by writing "**left,**" "**right,**" or "**none.**" Then describe the resulting change in the amount of **reactants** and **products** by writing "**increase,**" "**decrease,**" or "**remains the same.**"

$$4\ NH_3(g) + 3\ O_2(g) \rightleftarrows 2\ N_2(g) + 6\ H_2O(g) \quad \Delta H = -1532\ kJ$$

	Change in system	Direction of equilibrium shift	$NH_3(g)$	$O_2(g)$	$N_2(g)$	$H_2O(g)$
	Add NH_3	**right**	**———**	**decrease**	**increase**	**increase**
a.	**Add O_2**			**———**		
b.	**Add N_2**				**———**	
c.	**Remove H_2O**					**———**
d.	**Remove NH_3**		**———**			
e.	**Increase temperature**					
f.	**Decrease temperature**					
g.	**Increase volume**					
h.	**Decrease volume**					

3. Sulfuric acid is the most produced chemical compound in the world. A key step in its production is the reaction:

$$2\ SO_2(g) + O_2(g) \rightleftarrows 2\ SO_3(g)\ \Delta H = -200\ kJ$$

To maximize the production of sulfur trioxide (SO_3) rapidly, the chemical company *Solvent Solutions* can apply Le Chatelier's Principle to strategically shift the reaction toward the products. What are three approaches that they could use? Explain how each approach would shift the reaction toward the products.