

### 18 • Equilibrium

#### LE CHATELIER'S PRINCIPLE WORKSHEET

**The Rules:**

- Add a reactant, shift to the products. Add a product, shift to the reactants.
- Increase temperature, shift away from heat. Decrease temperature, shift toward heat.
- Increase pressure (reduce volume), shift toward side with fewer moles of gas. Decrease pressure (increase volume), shift toward side with more moles of gas.
- Concentration of solids and liquids cannot change, adding a solid or liquid will not shift the equilibrium.

**For each reaction,**

- (1) determine the stress (too much \_\_\_\_\_ or too little \_\_\_\_\_)
- (2) state which direction the system will shift (↔ or ↷)
- (3) state whether each component of the system will increase (↑) or decrease (↓) or remain unchanged (—).

1. Given the following reaction:  $\text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons \text{PCl}_5(\text{g})$   
 How would the following changes affect the amount of each gas at equilibrium?

Stress	$\text{PCl}_3$	$\text{Cl}_2$	Shift	$\text{PCl}_5$
(a) Add $\text{PCl}_3$	↑	↓	↷	↑
(b) Remove $\text{Cl}_2$	↑	↓	↷	↓
(c) Remove $\text{PCl}_5$	↓	↓	↷	↓
(d) Decrease the volume of the container. <i>less room!</i>	↓	↓	↷	↑

2. Given the following reaction:  $\text{H}_2(\text{g}) + \text{CO}_2(\text{g}) \rightleftharpoons \text{H}_2\text{O}(\text{g}) + \text{CO}(\text{g}) + \text{heat energy}$   
 Indicate how each of the following changes affects the amount of each gas in the system below:

Stress	$\text{H}_2$	$\text{CO}_2$	Shift	$\text{H}_2\text{O}$	$\text{CO}$
(a) Add $\text{CO}_2$	↓	↑	↷	↑	↑
(b) Add a catalyst	—	—	No change	—	—
(c) Increase the temperature	↑	↑	↷	↓	↓
(d) Decrease the volume of the container.	—	—	No change	—	—

3. Given the following reaction:  $2\text{N}_2\text{O}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 4\text{NO}(\text{g})$   
 How would the following changes affect the amount of each chemical at equilibrium?

Stress	$\text{N}_2\text{O}$	$\text{O}_2$	Shift	$\text{NO}$
(a) Add $\text{N}_2\text{O}$	↑	↓	↷	↑
(b) Remove $\text{O}_2$	↑	↓	↷	↓
(c) Increase the volume of the container. <i>more room!</i>	↓	↓	↷	↑
(d) Add a catalyst	—	—	No change	—

4. Given the following reaction:  $4\text{NH}_3(\text{g}) + 3\text{O}_2(\text{g}) \rightleftharpoons 2\text{N}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l})$   
 How will the concentration of each chemical be affected?

**Note:** When the question asks about concentration of chemicals rather than amount, a subtlety occurs. Concentration is moles per Liter. A solid or a liquid cannot change concentration, so it will always be (—). The amount of a solid or liquid can change, but the concentration will not change.

Stress	$\text{NH}_3$	$\text{O}_2$	Shift	$\text{N}_2$	$\text{H}_2\text{O}$
(a) Add $\text{O}_2$	↓	↑	↷	↑	—
(b) Add $\text{N}_2$	↑	↑	↷	↑	—
(c) Remove $\text{H}_2\text{O}$ from the system. <i>liquids don't shift</i>	—	—	No change	—	—
(d) Decrease the volume of the container. <i>less room! 7mol(g) → 2mol(g)</i>	↓	↓	↷	↑	—

5. Given the following reaction:  $\text{CaCO}_3(\text{s}) \rightleftharpoons \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$   
 How will the concentration of each chemical be affected?

Stress	$\text{CaCO}_3$	Shift	$\text{CaO}$	$\text{CO}_2$
(a) Add $\text{CaCO}_3$ . <i>Solids don't shift</i>	—	No change	—	—
(b) Add $\text{CO}_2$	—	↷	—	↑
(c) Remove $\text{CaO}$ from the system. <i>Solids don't shift</i>	—	—	—	—
(d) Decrease the volume of the container. <i>less room! 0 mol(g) ← 1 mol(g)</i>	—	↷	—	↓