

Reaction Quotients

Reaction Quotient

- * **Reaction quotient (Q):** value obtained by substituting initial concentrations into the equilibrium expression

Reaction Quotient

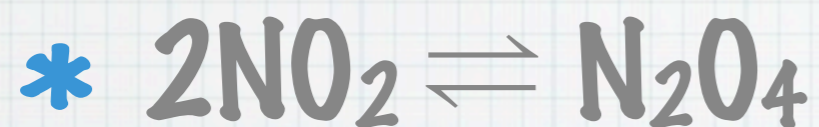
$$Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Determining the Direction of a Reaction

- * $Q > K$: ratio of products to reactants is too large, reaction will proceed in reverse direction to reach equilibrium
- * $Q = K$: the system is at equilibrium
- * $Q < K$: ratio of products to reactants is too small, reaction will proceed in forward direction to reach equilibrium

Example

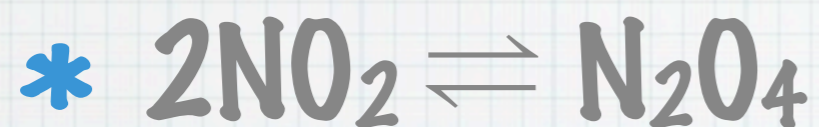
* In the following reaction K was determined to be 0.45



	$[\text{NO}_2]_i$	$[\text{N}_2\text{O}_4]_i$	Q	
1	1.00	0		
2	0.30	0.010		
3	0.20	0.018		
4	0.50	0.25		
5	0	1.0		

Example

* In the following reaction K was determined to be 0.45

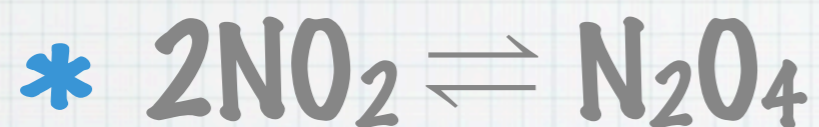


Calculate $Q = \frac{[\text{N}_2\text{O}_4]}{[\text{NO}_2]^2}$

	$[\text{NO}_2]$	$[\text{N}_2\text{O}_4]$	Q	
1	1.00	0		
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Example

* In the following reaction K was determined to be 0.45

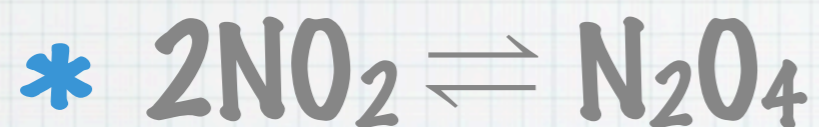


Calculate $Q = \frac{[\text{N}_2\text{O}_4]}{[\text{NO}_2]^2}$

	$[\text{NO}_2]$	$[\text{N}_2\text{O}_4]$	Q	
1	1.00	0	0	
2	0.30	0.010	0.11	
3	0.20	0.018	0.45	
4	0.50	0.25	1.0	
5	0	1.0	Very Large	

Example

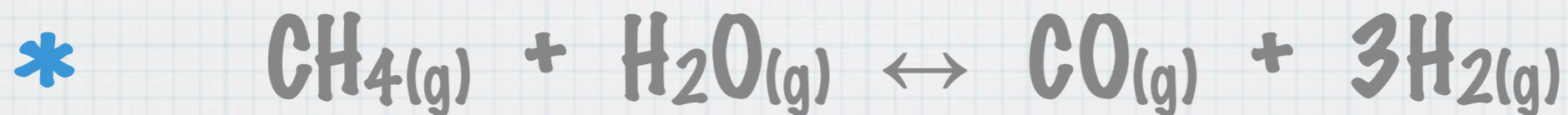
* In the following reaction K was determined to be 0.45



	$[\text{NO}_2]$	$[\text{N}_2\text{O}_4]$	Q	Direction
1	1.00	0	0	Right
2	0.30	0.010	0.11	Right
3	0.20	0.018	0.45	Equilibrium
4	0.50	0.25	1.0	Left
5	0	1.0	Very Large	Left

Example

* Calculate Q to determine the direction of reaction when the concentrations are: $[\text{CH}_4] = 0.100 \text{ M}$, $[\text{CO}] = 0.500 \text{ M}$, $[\text{H}_2\text{O}] = 0.200 \text{ M}$ and $[\text{H}_2] = 0.800 \text{ M}$. The equilibrium constant for the reaction below is 5.67.



Solution

$$Q = \frac{[\text{CO}][\text{H}_2]^3}{[\text{CH}_4][\text{H}_2\text{O}]}$$

$$Q = \frac{[0.500][0.800]^3}{[0.100][0.200]}$$

$$Q = 12.8$$

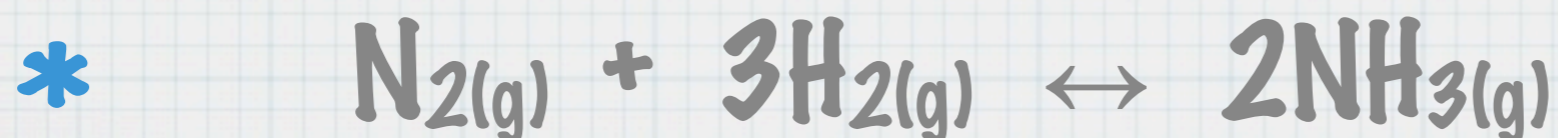
$$12.8 > 5.67$$

$$Q > K$$

Therefore the reaction
moves to the LEFT

Example

* The value of K for the following reaction is 0.40. The concentrations of gases are present in a container are: $[\text{N}_2] = 0.10 \text{ mol/L}$, $[\text{H}_2] = 0.30 \text{ mol/L}$, and $[\text{NH}_3] = 0.20 \text{ mol/L}$. Is this mixture of gases at equilibrium? If not, in which direction will the reaction go to reach equilibrium?



Solution

$$Q = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$$

$$Q = \frac{[0.2]^2}{[0.1][0.3]^3}$$

$$Q = 15$$

$$15 > 0.4$$

$$Q > K$$

Therefore the reaction
moves to the LEFT

Homework

* pg 460 # 81-84