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
  * $2NO_2 \rightleftharpoons N_2O_4$

	$[NO_2]i$	$[N_2O_4]i$	Q	
1	1.00	0		
2	0.30	0.010		
3	0.20	0.018		
4	0.50	0.25		
5	0	1.0		

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Calculate Q $\frac{[N_2O_4]}{[NO_2]^2}$

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5	0	1.0	Very Large	

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* In the following reaction K was determined to be 0.45
  * $2NO_2 \rightleftharpoons N_2O_4$

	$[NO_2]i$	$[N_2O_4]i$	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: $[CH_4]$=0.100 M, [CO] = 0.500 M, [H2O] = 0.200 M and $[H_2]$ = 0.800 M. The equilibrium constant for the reaction below is 5.67.

* $CH_{4(g)} + H_2O_{(g)} \leftrightarrow CO_{(g)} + 3H_{2(g)}$

Solution

$$Q = \frac{[CO][H_2]^3}{[CH_4][H_2O]}$$

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

$$Q = 12.8$$

$$12.8 > 5.67$$

$$Q > K$$

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: $[N_2]$ = 0.10 mol/L, $[H_2]$ = 0.30 mol/L, and $[NH_3]$ = 0.20 mol/L. Is this mixture of gases at equilibrium? If not, in which direction will the reaction go to reach equilibrium?

* $N_{2(g)} + 3H_{2(g)} \leftrightarrow 2NH_{3(g)}$

Solution

$$Q = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

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

$$Q = 15$$

$$15 > 0.4$$

$$Q > K$$

Therefore the reaction moves to the LEFT

Homework

* pg 460 # 81-84