LESSON MAKER PRO

Equilibrium in Action

Calculate K_c from equilibrium concentrations. Show your substitutions.

HIGH SCHOOL · CHE.11.3

CHE.11.3 "Enrichment: Use mathematical and computational thinking to calculate an equilibrium constant expression for a reaction."

NAME _____ DATE _____

BUILD THE EXPRESSION

Use concentrations measured at equilibrium to calculate K_c. Multiply the product concentrations, each raised to its coefficient in the balanced equation, then divide by the reactant concentrations treated the same way. Leave pure solids and pure liquids out of the expression.

WORKED EXAMPLE

For $2NO_2(g) \rightleftharpoons N_2O_4(g)$, the equilibrium concentrations are $[NO_2] = 4$ mol/L and $[N_2O_4] = 8$ mol/L. Find K_c.

1. Write $K_c = [N_2O_4]/[NO_2]^2$.
2. Substitute: $K_c = 8/4^2$.
3. Calculate: $K_c = 8/16$.

Answer: $K_c = 1/2$

PRACTICE 6 problems

1 Find K_c for $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$. At equilibrium, $[H_2] = 1/2$ mol/L, $[Cl_2] = 1/2$ mol/L, and $[HCl] = 1$ mol/L.

ANSWER _____

2 Find K_c for $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$. At equilibrium, $[CO] = 1/2$ mol/L, $[H_2O] = 1/5$ mol/L, $[CO_2] = 1/5$ mol/L, and $[H_2] = 1$ mol/L.

ANSWER _____

3 Find K_c for $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$. At equilibrium, $[N_2] = 1/2$ mol/L, $[H_2] = 1$ mol/L, and $[NH_3] = 1/2$ mol/L.

ANSWER _____

4 Find K_c for $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$. At equilibrium, $[CO_2] = 1/5$ mol/L.

ANSWER _____

5 Find K_c for $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$. At equilibrium, $[SO_2] = 1/2$ mol/L, $[O_2] = 1/2$ mol/L, and $[SO_3] = 1$ mol/L.

ANSWER _____

6 Find K_c for $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$. At equilibrium, $[H_2] = 1/5$ mol/L, $[I_2] = 1/5$ mol/L, and $[HI] = 1/2$ mol/L.

ANSWER _____

APPLY IT Show your work

1 A lab studies how a car's catalytic converter can reduce harmful exhaust gases. For $2CO(g) + 2NO(g) \rightleftharpoons 2CO_2(g) + N_2(g)$, the equilibrium concentrations are [CO] = 1/5 mol/L, [NO] = 1/5 mol/L, $[CO_2]$ = 2/5 mol/L, and $[N_2]$ = 1/10 mol/L. Find K_c.

WORK SPACE

ANSWER _____

2 Ammonia is used to make fertilizer for growing food. A plant uses $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$. At equilibrium, $[N_2]$ = 1/4 mol/L, $[H_2]$ = 1/2 mol/L, and $[NH_3]$ = 1/2 mol/L. Find K_c.

WORK SPACE

ANSWER _____

CHALLENGE One step up

A sealed container starts with [HI] = 1 mol/L and no H_2 or I_2. The reaction is $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$. At equilibrium, $[H_2]$ = 1/4 mol/L. Find the equilibrium concentrations of HI and I_2, then calculate K_c. Show how the coefficients help you find the missing concentrations.

WORK SPACE AND ANSWER

Equilibrium in Action

PART 1 · PRACTICE

#	PROBLEM	ANSWER
1	Find K_c for $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$. At equilibrium, $[H_2] = 1/2$ mol/L, $[Cl_2] = 1/2$ mol/L, and $[HCl] = 1$ mol/L.	**$K_c = 4$**
2	Find K_c for $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$. At equilibrium, $[CO] = 1/2$ mol/L, $[H_2O] = 1/5$ mol/L, $[CO_2] = 1/5$ mol/L, and $[H_2] = 1$ mol/L.	**$K_c = 2$**
3	Find K_c for $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$. At equilibrium, $[N_2] = 1/2$ mol/L, $[H_2] = 1$ mol/L, and $[NH_3] = 1/2$ mol/L.	**$K_c = 1/2$**
4	Find K_c for $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$. At equilibrium, $[CO_2] = 1/5$ mol/L.	**$K_c = 1/5$**
5	Find K_c for $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$. At equilibrium, $[SO_2] = 1/2$ mol/L, $[O_2] = 1/2$ mol/L, and $[SO_3] = 1$ mol/L.	**$K_c = 8$**
6	Find K_c for $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$. At equilibrium, $[H_2] = 1/5$ mol/L, $[I_2] = 1/5$ mol/L, and $[HI] = 1/2$ mol/L.	**$K_c = 25/4$**

PART 2 · APPLY IT

1. **$K_c = 10$** Use $K_c = [CO_2]^2[N_2]/([CO]^2[NO]^2)$. Substitution gives $((2/5)^2(1/10))/((1/5)^2(1/5)^2) = 10$.
2. **$K_c = 8$** Use $K_c = [NH_3]^2/([N_2][H_2]^3)$. Substitution gives $(1/2)^2/((1/4)(1/2)^3) = (1/4)/(1/32) = 8$.

CHALLENGE

For every 1/4 mol/L of H_2 formed, 1/4 mol/L of I_2 forms and 1/2 mol/L of HI reacts. Thus $[I_2] = 1/4$ mol/L and $[HI] = 1/2$ mol/L. $K_c = ([H_2][I_2])/[HI]^2 = ((1/4)(1/4))/(1/2)^2 = 1/4$.

Accept equivalent fractions or decimals. K_c calculations must use equilibrium concentrations, not starting concentrations.