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Q and le châtelier's principle

Practice #1

$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ $K_c = 1.00 \cdot 10^{-8}$ at 1000 C

If .100 moles of N_2 and O_2 are added to 5.00L reaction vessel, what are equilibrium concentrations of N_2, O_2, and NO?

	$N_2(g)$	+ $O_2(g)$	$\rightleftharpoons$	$2NO(g)$
I	0.100 mol	0.100 mol		0
C	$-x$	$-x$		$+2x$
E	$0.100 - x$ $\frac{0.1\ mol}{5L}$ = 0.02M	$0.100 - x$ $\frac{0.1\ mol}{5L}$ = 0.02M		$2x = \frac{1.0 \cdot 10^{-5}}{5L}$ = $1 \cdot 10^{-6}$ M

(based on stoich. coefficient)

② $K_c = \frac{[NO]^2}{[N_2][O_2]}$

③ $K_c = \frac{\left(\frac{2x}{5.0}\right)^2}{\left(\frac{0.100 - x}{5.0}\right)\left(\frac{0.100 - x}{5.0}\right)}$

④ $K_c = \frac{(2x)^2}{(0.100 - x)^2} = 1.00 \cdot 10^{-8}$

(Ignore 'x' in this term b/c we know it's small. (x is less than 5% of 0.100))

⑤ $K_c = \frac{4x^2}{(0.100)^2} = 1.00 \cdot 10^{-8}$

$4x^2 = (1.00 \cdot 10^{-8})(1.00 \cdot 10^{-2})$

$4x^2 = 1.00 \cdot 10^{-10}$

$x^2 = \frac{1.00 \cdot 10^{-10}}{4}$

$x = 5.0 \cdot 10^{-6}$

∴ Dropping (x) was a reasonable assumption. $(.100 - 5 \cdot 10^{-6}) \approx .100$

Practice #2 — Q (RXN quotient)

$CH_4 + H_2O \rightleftharpoons CO + 3H_2$ $K_c = 5.6$

0.100 M 0.200M 0.500M 0.800M

GENERAL: $Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$ (equilibrium tions too)

$Q = \frac{[CO][H_2]^3}{[CH_4][H_2O]} = \frac{(.500)(.800)^3}{(.100)(.200)} = 12.8$

∴ $Q \neq K_c$

- If $Q = K_c$, RXN @ equilibrium, no change
- If $Q > K_c$, there is too much product. RXN will go to left
- If $Q < K_c$, too much reactant, RXN goes to right.

Practice #3

$CO_{(g)} + H_2O_{(g)} \rightleftharpoons CO_{2(g)} + H_{2(g)}$ $K_c = 1.00$ @ 1100 K

1 mol 1 mol 2 mol 2 mol in 1L

- This system will shift towards reactants until equilibrium reached.

— class demo —

$H_2CO_{3(aq)} \rightleftharpoons H_2O_{(l)} + CO_{2(g)}$

Initial: (Soda at P = 4 atm)

MENTOS:
- putting mentos in soda, sped up RXN. CO_2 placed back into gas phase.

Le Châtelier's Principle - system @ equilibrium disturbed (temp., pressure, entration) the system will shift its equilibrium in order to counteract the effect of disturbance (away)

Ex/ $H_2O + CO_2 \rightleftharpoons H_2 + CO_2$ $K = 1$

Initially: 1.0 M 1.0 M 1.0 M 1.0 M

↓

2.0 M

$Q = \frac{(1)(1)}{(1)(2)} = \frac{1}{2}$ ∴ $Q < K$, so the RXN goes to the right in order to make more product.

x/ $H_2O + CO \rightleftharpoons H_2 + CO_2$ $Q = \frac{1}{2}$ ∴ $Q < K$, RXN shifts to product.

1.0 1.0 1.0 0.5 M

x/ 1.0 M 1.0 M 2.0 M 1.0 M $Q = 2$ ∴ $Q > K$, RXN shifts to reactions.

x/ .5 M 1.0 M 1.0 M 1.0 M $Q = 2$ $Q > K$,