ANSWER KEY.

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7.7 Calculating Equilibrium Concentrations

AP Chemistry | ANSWER KEY

Compare Q with K to find the direction. Set up an ICE table in molarity. Check the small-x shortcut: (x ÷ starting concentration) × 100 should be less than 5%.

1. For $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$, $K_c = 0.0400$. A flask holds 0.200 M PCl_5, 0.100 M PCl_3, and 0.100 M Cl_2. Which way will it shift?

Q = (0.100)(0.100) / 0.200 = 0.0500. Q > K, so it shifts left (reverse): PCl_5 increases.

2. 0.300 M CO and 0.300 M H_2O are mixed for $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$, $K_c = 4.00$. Fill in the ICE table and find all equilibrium concentrations.

	CO	**H_2O**	**CO_2**	**H_2**
I	**0.300**	**0.300**	**0**	**0**
C	**−x**	**−x**	**+x**	**+x**
E	**0.300 − x**	**0.300 − x**	**x**	**x**

$4.00 = x^2 / (0.300 - x)^2$. Square root: $2.00 = x / (0.300 - x)$, so $0.600 = 3.00x$ and $x = 0.200$.
[CO] = [H_2O] = 0.100 M; [CO_2] = [H_2] = 0.200 M

3. 0.25 M PCl_5 is placed in a flask. $K_c = 1.0 \times 10^{-4}$. Use the small-x shortcut to find [PCl_3] and [Cl_2]. Check the shortcut.

$1.0 \times 10^{-4} = x^2 / (0.25 - x) \approx x^2 / 0.25$, so $x^2 = 2.5 \times 10^{-5}$ and $x = 5.0 \times 10^{-3}$ M. [PCl_3] = [Cl_2] = 5.0×10^{-3} M. Check: $(5.0 \times 10^{-3} / 0.25) \times 100 = 2.0\%$, under 5%, so the shortcut works.

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4. A flask starts with only 0.500 M HI for $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$, $K_c = 49.0$. Which way does it shift? Find all equilibrium concentrations.

There is no H_2 or I_2 yet, so the reaction must go in reverse (left). I: 0, 0, 0.500. C: +x, +x, −2x. E: x, x, 0.500 − 2x.
$\sqrt{49.0} = 7.00 = (0.500 - 2x) / x$, so $0.500 = 9.00x$ and $x = 0.0556$.
$[H_2] = [I_2] = 0.0556$ M; $[HI] = 0.389$ M

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5. 1.00 mol N_2O_4 is placed in a 5.00 L flask. $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, $K_c = 4.6 \times 10^{-3}$. Try the small-x shortcut and check it. If it fails, solve with the quadratic formula.

$[N_2O_4]_0 = 0.200$ M. Shortcut: $4x^2 / 0.200 = 4.6 \times 10^{-3}$, so $x = 0.015$. Check: 7.6%, over 5%, so it fails.
Exact: $4x^2 + 0.0046x - 0.00092 = 0$, so $x = 0.0146$.
$[NO_2] = 2x = 0.0292$ M; $[N_2O_4] = 0.200 - x = 0.185$ M

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