Name _____ Date _____ Period _____

ZornScience
zornscience.org

Equilibrium Constant Virtual Lab

Chemistry and AP Chemistry

Open activities.zornscience.org/equilibrium-k-lab/ and follow each step. Record values as the lab shows them. Chemistry students: your lab may say RICE table and K instead of ICE table and K_c.

Objective

Use the Equilibrium Constant Lab to write K expressions, watch a reaction reach equilibrium, compare Q with K to predict a shift, solve ICE tables, apply the K rules, and find molar solubility from K_{sp}, with and without a common ion.

NGSS alignment

HS-PS1-6 (changes to a system at equilibrium). Practices: using mathematics and computational thinking, analyzing and interpreting data, constructing explanations. Crosscutting concept: stability and change.

AP alignment

Topics 7.1 to 7.8, 7.10, 7.11, and 7.12.

Meet the simulation

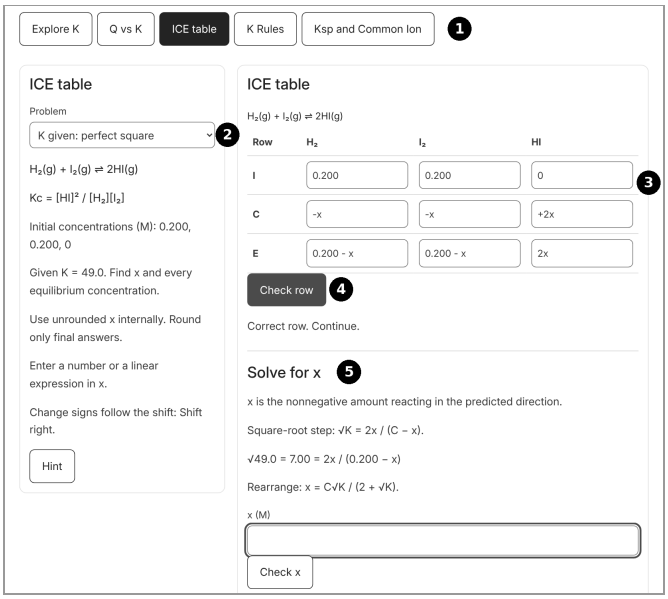


Figure 1. The ICE table mode. (1) Mode tabs: Explore K, Q vs K, ICE table, K Rules, Ksp and Common Ion. (2) Problem type. (3) The table. Type numbers or expressions in x, such as −x, +2x, or 0.200 − x. (4) Check row checks one row at a time. (5) Solve for x appears after the table is correct, followed by the equilibrium values and K.

Pre-lab

1. Write K_c for $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ and K_p for $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$.

2. A mixture has Q < K. Which way will the reaction shift? What if Q > K?

CC BY-NC-SA 4.0 | zornscience.org

Part A. Explore K

3. Choose Explore K and $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ with $K_c = 49.0$. Start with 0.200 M H_2, 0.200 M I_2, and 0 M HI, then press Run. Record the final concentrations, Q, and the forward and reverse rates. What two things are true at equilibrium?

4. Choose $A(aq) \rightleftharpoons B(aq)$. Start with 1.00 M A and 0 M B. Run it with each K and record the equilibrium concentrations. Which K favors products? Is [B] ever exactly zero?

K	[A] at equilibrium (M)	[B] at equilibrium (M)
0.010		
1.0		
100		

5. Choose $X_2 + Y_2 \rightleftharpoons 2XY$, $K_c = 9.0$, Particle view. Start with 0.50 M X_2, 0.50 M Y_2, 0 M XY and Run. Count the particles at equilibrium (each is 0.10 mol in 1.0 L) and use them to calculate K_c.

CC BY-NC-SA 4.0 | zornscience.org

Part B. Q vs K

6. Choose Q vs K. Enter each K_c and mixture, predict the shift, then press Reveal. Record Q and the shift.

Reaction	K_c	Mixture (M)	Q	Shift
$N_2O_4(g) \rightleftharpoons 2NO_2(g)$	4.6×10^{-3}	$[N_2O_4] = 0.200$, $[NO_2] = 0.0500$		
$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$	50.0	$[H_2] = 0.200$, $[I_2] = 0.100$, $[HI] = 0.707$		
$N_2O_4(g) \rightleftharpoons 2NO_2(g)$	0.00800	$[N_2O_4] = 0.400$, $[NO_2] = 0.0800$		

7. Set $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ with $K_c = 0.00800$, $[N_2O_4] = 0.200$ M and $[NO_2] = 0.0400$ M (at equilibrium). Press Halve volume and record Q. Repeat with $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$, $K_c = 50.0$, 0.100 M H_2, 0.100 M I_2, 0.707 M HI. Explain the difference.

Part C. ICE table

8. Choose ICE table and One equilibrium value: find K ($N_2O_4(g) \rightleftharpoons 2NO_2(g)$, 0.100 M N_2O_4 to start, $[NO_2] = 0.0400$ M at equilibrium). Fill in the table as you complete it in the lab, then record x and K.

	N_2O_4	$2NO_2$
I		
C		
E		

CC BY-NC-SA 4.0 | zornscience.org

9. Choose K given: perfect square ($H_2(g)$ + $I_2(g) \rightleftharpoons 2HI(g)$, 0.200 M H_2 and I_2, $K_c = 49.0$). Solve for x and record all equilibrium concentrations.

10. Choose K given: small-x shortcut ($N_2 + O_2 \rightleftharpoons 2NO$, 0.800 M N_2, 0.200 M O_2, $K_c = 1.00 \times 10^{-5}$). Record the shortcut x, the 5% check, and [NO].

Part D. K Rules

11. Choose K Rules. $N_2 + 3H_2 \rightleftharpoons 2NH_3$ has $K = 6.00 \times 10^{-2}$. Find and check K for the reverse reaction, for the reaction doubled, and for the reaction halved.

Part E. Ksp and Common Ion

12. Choose Ksp and Common Ion. For Ag_2CrO_4 ($K_{sp} = 1.1 \times 10^{-12}$) and AgCl ($K_{sp} = 1.8 \times 10^{-10}$), record s in pure water. Which is more soluble? Why can't you just compare K_{sp}?

13. Record the molar solubility of each salt in pure water and with the common ion. What does the common ion do, and why?

Salt	K_{sp}	Common ion	s in pure water (M)	s with common ion (M)
AgCl	1.8×10^{-10}	0.10 M NaCl		
PbI_2	9.8×10^{-9}	0.050 M NaI		
CaF_2	3.7×10^{-11}	0.020 M $Ca(NO_3)_2$		

Analysis and conclusion

14. For CaF_2 in 0.020 M $Ca(NO_3)_2$, the lab shows a shortcut answer of 2.2×10^{-5} M and an exact answer of 2.1×10^{-5} M. Is the shortcut acceptable? Why do they differ?

15. Claim, evidence, reasoning: how do Q and K tell you which way a reaction will shift, and how does an ICE table find the equilibrium amounts?

CC BY-NC-SA 4.0 | zornscience.org