ExamFitter

examfitter.com · Free AP Chemistry quizzes, revision notes and worksheets

Topic 7.6: Properties of the Equilibrium Constant

Revision Notes · AP Chemistry

UNIT 7 · EQUILIBRIUM

On ExamFitter.com: Topic 7.6 Quiz · Topic 7.6 Worksheet · Unit 7: All Topics · AP Chemistry Home

K Belongs to the Equation as Written

Every equilibrium constant is tied to one exact way of writing the reaction, at one stated temperature. Change the writing and the constant changes, even though the chemistry in the flask is untouched.

Each rule follows directly from the shape of the K expression: products over reactants, every concentration raised to its coefficient.

Reversing the Equation Inverts K

Reversing a reaction swaps the numerator and denominator of its expression. Products become reactants and reactants become products, so the new constant is the reciprocal of the old one:

K reverse = 1 / K forward

For $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, $K = 6.0 \times 10^5$ at the stated temperature. Written in reverse, $2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$ has $K = 1 / (6.0 \times 10^5) = 1.7 \times 10^{-6}$.

A forward reaction that strongly favours products has a reverse reaction that favours reactants by the same measure, because it is the same mixture read from the other side.

Multiplying the Coefficients Raises K to a Power

Multiplying every coefficient by a number n raises every concentration in the expression to n times its former power. The whole expression is therefore raised to the power n: the new constant is K^n.

© 2026 ExamFitter.com · Free AP Chemistry revision notes

Doubling $A(g) \rightleftharpoons B(g)$ with $K = 3.0$ gives $2A(g) \rightleftharpoons 2B(g)$ with $K = 3.0^2 = 9.0$. Tripling gives K^3. The constant is never multiplied by n itself: scaling the equation and scaling the constant are different operations. For $\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons NO(g)$, $K = 2.1 \times 10^{-16}$, doubling gives $K = (2.1 \times 10^{-16})^2 = 4.4 \times 10^{-32}$ for $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$.

Dividing the Coefficients Takes the Root

Dividing is the same rule with a fraction for n. Halving every coefficient raises K to the one half power, which is taking the square root.

For $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, $K = 2.5 \times 10^2$. The halved equation, $SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$, has $K = \sqrt{(2.5 \times 10^2)} = 15.8$, about 16.

An equation written per mole of one chosen species is often the most useful form, and its K is simply the corresponding root of the original.

Adding Reactions Multiplies Their K Values

When two reactions are added and a species appearing on both sides cancels, that species is an intermediate, and the overall constant is the product of the step constants:

$K_{overall} = K_1 \times K_2$

Multiplying the two step expressions puts the intermediate once in a numerator and once in a denominator, so it cancels, leaving exactly the expression of the overall reaction.

Steps can be prepared before adding. A step used twice enters with its K squared; a step used in reverse enters with its reciprocal. Each manipulation is applied to the step's K in the same way it is applied to the step's equation, and only then are the prepared constants multiplied. Doubling a step squares its K before adding: $A(g) \rightleftharpoons B(g)$ with $K_1 = 2.0$ doubled gives 4.0, and with $2B(g) \rightleftharpoons C(g)$, $K_2 = 9.0$, the overall K is 36. Reversing a step inverts its K first: $K_1 = 5.0$ with $K_2 = 0.10$ reversed to 10 gives an overall K of 50 for $A(g) \rightleftharpoons C(g)$.

Combining Manipulations in the Right Order

Many questions apply two manipulations to one reaction: reverse it and halve it, or double one step and then add it to another. The safe method is to transform the constant step by step, in the same order the equation is transformed, writing the new K after each single change.

Order between reversing and scaling does not alter the final result, because a reciprocal and a power commute. What matters is that every manipulation applied to the equation is applied once,

© 2026 ExamFitter.com · Free AP Chemistry revision notes

and only once, to the constant. For A(g) + B(g) ⇌ C(g), K = 12, the reversed and doubled 2C(g) ⇌ 2A(g) + 2B(g) has K = $(1 / 12)^2 = 6.9 \times 10^{-3}$.

Only Temperature Gives a Different K for the Same Equation

For one fixed way of writing the equation, K is set by temperature alone. Changing concentrations, changing the pressure or volume, or adding a catalyst changes the mixture or the timing, and the mixture then satisfies the same K as before.

Rewriting the equation produces a different constant for the same mixture, while changing the temperature produces a different constant because the mixture settles somewhere new.

Worked Examples

Example 1: Reversing, checked against a real mixture. For $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$, Kc = 54, and Topic 7.5 used the equilibrium row $[H_2] = [I_2] = 0.214$ and $[HI] = 1.57$ mol L^{-1}. The reverse reaction, $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$, has $K = 1 / 54 = 0.019$. Check with the same mixture: $(0.214 \times 0.214) / (1.57)^2 = 0.019$. One mixture, two constants, each correct for its own direction.

Example 2: Halving, checked against a real mixture. For $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, the mixture $[SO_2] = 0.20$, $[O_2] = 0.10$ and $[SO_3] = 1.0$ mol L^{-1} gives $K = (1.0)^2 / ((0.20)^2 \times 0.10) = 2.5 \times 10^2$. The halved equation $SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$ applied to the same mixture gives $1.0 / (0.20 \times \sqrt{0.10}) = 15.8$, which is $\sqrt{(2.5 \times 10^2)}$, as the rule requires.

Example 3: Adding two steps. Step 1: A(g) ⇌ B(g), $K_1 = 2.0$. Step 2: B(g) ⇌ C(g), $K_2 = 5.0$. Adding cancels B, giving A(g) ⇌ C(g) with $K = 2.0 \times 5.0 = 10$. A single mixture confirms it: $[A] = 0.30$, $[B] = 0.60$ and $[C] = 3.0$ mol L^{-1} gives $0.60 / 0.30 = 2.0$ for step 1, $3.0 / 0.60 = 5.0$ for step 2, and $3.0 / 0.30 = 10$ for the overall reaction.

Example 4: Two manipulations combined. For 2A(g) ⇌ B(g), K = 36; the mixture $[A] = 0.10$ and $[B] = 0.36$ mol L^{-1} confirms it, since $0.36 / (0.10)^2 = 36$. Write the reaction in reverse with all coefficients halved: $\frac{1}{2}B(g) \rightleftharpoons A(g)$. Reverse first: K becomes $1 / 36$. Then halve: take the square root. $K = \sqrt{(1 / 36)} = 1 / 6 = 0.17$. The same mixture agrees: $0.10 / \sqrt{0.36} = 0.10 / 0.60 = 0.17$.

© 2026 ExamFitter.com · Free AP Chemistry revision notes

Traps That Cost Marks in Topic 7.6

"Doubling the equation doubles K." Doubling raises K to the second power. K = 3.0 becomes 9.0, not 6.0.

"The reverse reaction has K equal to negative K." K is a ratio of concentrations and is never negative. Reversing gives the reciprocal: K = 0.25 forward means K = 4.0 in reverse.

"Adding two reactions adds their constants." Adding reactions multiplies the constants, because the expressions themselves multiply and the intermediate cancels. Steps with K_1 = 2.0 and K_2 = 5.0 combine to 10, never to 7.0.

"Halving the equation halves K." Halving takes the square root. K = 2.5×10^2 becomes about 16, not 1.25×10^2.

"The manipulated K can be used with the original equation." Each constant belongs to its own written form. Using √(K) in a calculation set up with the doubled equation mixes two different constants and gives a wrong answer, even though both values describe the same flask.

"A bigger K after rewriting means the reaction now favours products more." Rewriting changes nothing in the flask. K = 36 for 2A(g) ⇌ B(g) and K = 6.0 for A(g) ⇌ ½B(g) describe the identical equilibrium mixture.

Key Relationships to Remember

- Reversing a reaction gives the reciprocal constant: K reverse = 1 / K forward
- Multiplying every coefficient by n raises the constant to the power n: K new = $(\text{K old})^n$
- Halving every coefficient takes the square root: K new = √(K old)
- Adding reactions multiplies their constants, and any species that cancels is an intermediate
- A step must be prepared before adding: reversed steps contribute their reciprocal, and steps used n times contribute K^n
- Combined manipulations apply in sequence: reverse then halve K = 36 gives √(1 / 36) = 0.17
- K is never negative, and a manipulated K is valid only for the equation in its manipulated form
- For a fixed written equation, only temperature changes K; concentration, pressure, volume and catalysts do not

© 2026 ExamFitter.com · Free AP Chemistry revision notes

Continue Revising

Topic 7.6 Quiz: Properties of the Equilibrium Constant

Topic 7.6 Worksheet

Unit 7: All Topics

© 2026 ExamFitter.com · Free AP Chemistry revision notes