

Special K traits:

1. K is a unitless constant

2. K is generated from equilibrium concentrations in MOLARITY units.

If other units are used, a special subscript is applied to K to note that change.

eg. if kPa units are used, the value would be K_p

3. K is a fixed constant for a given equilibrium system at a FIXED TEMP.

Only a change in temperature can change K.

Recall that entropy is favoured at high temp and enthalpy is favoured at low temp.

Changes in Conc, Pressure, Volume, etc. may alter the concentration of each individual species, **but this will not change K.**

$K_{RTP} \neq K_{STP}$ (not equal!)

4. Species in the solid or liquid states are included in K expressions only if the equilibrium system is HOMOGENEOUS.

In heterogeneous systems, they are excluded because their concentrations are invariable at a fixed temperature. (i.e. density is constant at a fixed temperature)
SEE GIVEN EXAMPLES.

5. K values indicate whether REACTANTS OR PRODUCTS are favoured at a particular temperature.

Products are ***favoured*** when $K \gg 1$ and reactants are ***favoured*** when $K \ll 1$

6. K is independent of reaction mechanism, so catalysis does not change K.

(Catalysts only alter how fast we arrive at equilibrium, or the pathway taken to "complete" the reaction).

7. K assumes **IDEAL behaviour.**

-perfect elastic spheres (no energy loss)

-perfect spherical particles

-no intermolecular attraction

-particles occupy zero volume

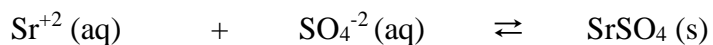
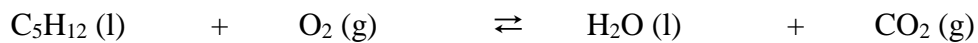
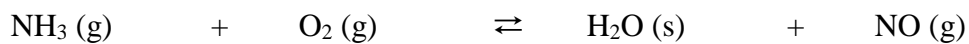
K is a good approximation of the real behaviour in an equilibrium system.

#4. examples

“Keq” expressions

Write the K expressions for the following.

BE SURE TO CHECK if the reaction is BALANCED, *everytime!*



HOW TO WRITE EQUILIBRIUM CONSTANT EXPRESSIONS
AND
SOLVE FOR THE EQUILIBRIUM CONSTANT,
and/or solve for equilibrium molar concentrations

1. BALANCE THE EQUATION for the CHEMICAL REACTION.

2. DETERMINE:
 - The initial concentrations of each species,
 - The concentration (moles per litre) of each species *that reacted*
- **ACCORDING TO THE MOLAR RATIO**
 - The equilibrium concentration of each species.
 (you will not necessarily be able to determine these values in this particular order).

3. Write the **equilibrium constant expression EVERYTIME**.
THEN...show the numbers (and/or variables) that you are substituting into the K expression.

4. Solve for K and/or the variables in your K expression.

Use: (i) GRAPHICAL means

(ii) GUESSING - **Trial and error** - MOST USEFUL!
Will need to do (and show) "K trials"

(iii) QUADRATIC FORMULA – if necessary / applicable

Quadratic Formula	Example Equation
$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$	$\begin{array}{ccccccc} x^2 & + & 2x & + & 1 & = & 0 \\ \uparrow & & \uparrow & & \uparrow & & \\ a & & b & & c & & \end{array}$

(iv) FACTORING

- a little cumbersome and sometimes not even achievable, for our Chem 12 questions.

Be sure to **ALWAYS ESTABLISH AND STATE** your **LIMITS**

“Keq” calculations – Unit 2 Quiz Practice

1. Determine Keq at RTP for:

	C ₃ H ₈ (g)	+	O ₂ (g)	⇌	CO ₂ (g)	+	H ₂ O (l)
I	4.0 M		3.0 M		-----		-----
R							
E					1.5 M		

2a. Determine Keq at 300°C for:

	NH ₃ (g)	+	O ₂ (g)	⇌	H ₂ O (g)	+	NO (g)
I	6.00 M		8.00 M		-----		-----
R							
E							1.60 M

2b. Find [NH₃]eq at 300°C if [O₂]eq = 2.00 M and [H₂O]eq = 1.00 M = [NO]eq

3. Determine K_{eq} at 150 K for:

	NH_3 (g)	\rightleftharpoons	H_2 (g)	+	N_2 (g)
I	0.200 M		-----		0.080 M
R					
E	0.156 M				1.60 M

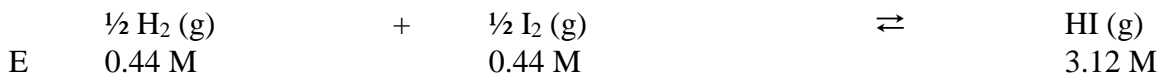
4a.

	H_2 (g)	+	I_2 (g)	\rightleftharpoons	2HI (g)
I	2.00 M		2.00 M		-----
R					
E					

$K_{eq} = 5.00 \times 10^1$ at 110°C . How much of the hydrogen gas reacted?

4b. Calculate the equilibrium concentrations of all reactants and products.

4c. Consider:

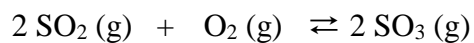


Find the relationship between this K_{eq} and your answer from 4a.

4d. Given $K_{eq} = 6.6 \equiv \frac{[SO_3]}{[SO_2] [O_2]^{1/2}}$

(1) write a balanced equation for all gases involved

(2) what is the numerical value of K_{eq} for:



(3) what is the numerical value of K_{eq} for:



5.

	H ₂ (g)	+	I ₂ (g)	\rightleftharpoons	2HI (g)
I	4.00 M		2.00 M		-----
R					
E					

If $K_{eq} = 5.00 \times 10^1$ at 110°C, find equilibrium concentrations of hydrogen and iodine gas.

6. At a certain temperature, 0.040 M of phosphorus pentachloride was placed in a flask and allowed to come to equilibrium in a closed system. The concentration of each of the products at equilibrium was 0.025 M. Calculate K_{eq} .

	PCl ₅ (g)	\rightleftharpoons	PCl ₃ (g)	+	Cl ₂ (g)
I	0.040 M		-----		-----
R					
E			0.025 M		0.025 M

7. The same reaction was carried out at the same temperature (as in question # 6), but a different starting concentration of reactants was used. Calculate $[PCl_5]_I$ and $[PCl_5]_{eq}$.

	PCl ₅ (g)	\rightleftharpoons	PCl ₃ (g)	+	Cl ₂ (g)
I	X		-----		-----
R					
E			0.10 M		

8. The reaction: $2XY_{(g)} \rightleftharpoons X_{2(g)} + Y_{2(g)}$ has a $K_{eq} = 35$ at 25°C.

If 3.0 moles of XY are injected into a 1.0 L container at 25°C, find the equilibrium $[X_2]$ and $[Y_2]$.

9. Given the equilibrium equation: $3A_{(g)} + B_{(g)} \rightleftharpoons 2C_{(g)}$
If 2.50 moles of A and 0.500 moles of B are added to a 2.00 L container, an equilibrium is established in which the [C] is found to be 0.250 M.
a) Find [A] and [B] at equilibrium.

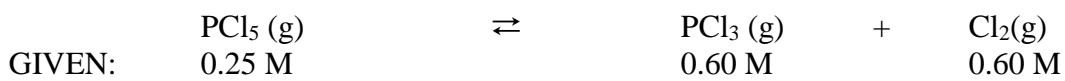
b) Calculate the value of the equilibrium constant K_{eq} .

10. At a certain temperature the reaction: $CO_{(g)} + H_2O_{(g)} \rightleftharpoons CO_{2(g)} + H_2_{(g)}$
has a $K_{eq} = 0.400$. Exactly 1.00 mol of each gas was placed in a 100.0 L vessel and the mixture was allowed to react in a closed system. Find the **equilibrium concentration** of each gas.

11. At 800°C, for the reaction: $CO_{2(g)} + H_{2(g)} \rightleftharpoons CO_{(g)} + H_2O_{(g)}$
the equilibrium constant K_{eq} , is 0.279
If 1.50 moles of CO_2 and 1.50 moles of H_2 are added to a 1.00 L container, what would the [CO] be at equilibrium?

12. Given this equilibrium reaction: $\text{COCl}_2 \rightleftharpoons \text{CO} + \text{Cl}_2$
Calculate all three equilibrium concentrations when $K_{\text{eq}} = 0.680$
with $[\text{CO}]_{\text{I}} = 0.500$ and $[\text{Cl}_2]_{\text{I}} = 1.00$ M.

13. The same reaction (as in question # 6) was carried out (at the same temperature) and the following information was noted:



Is this given data at equilibrium?
How do you know?

If the answer is no:

- 1) what must happen for this system to reach equilibrium?
- 2) calculate the new equilibrium concentrations and show numerical proof that these concentrations do in fact reflect a system at equilibrium.

#12 answer:

Both roots yield positive values, so how do we pick the correct one?

The answer lies in the fact that x is not the final answer, whereas $(0.5 - x)$ is.

It is the term $(0.5 - x)$ which must be positive.

So the root of 1.92 is rejected in favor of the 0.26 value to achieve a positive value for concentration.