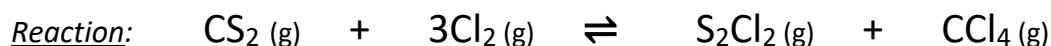


## Equilibrium Concentrations:

name: \_\_\_\_\_

- 1) The given chemical reaction illustrates the synthesis of a chlorofluorocarbon (CCl<sub>4</sub>), which was formerly widely employed in refrigeration and aerosol industries before its detrimental impact on the ozone layer was recognized.



In a 1.5-liter container, 1.35 moles of CS<sub>2</sub> and 2.085 moles of Cl<sub>2</sub> are initially introduced. Upon reaching equilibrium, 0.51 moles of CCl<sub>4</sub> are formed.

What is value of the equilibrium constant.

**Données:**

$n_{\text{CS}_2\text{i}} = 1,35 \text{ mol}$   
 $n_{\text{Cl}_2\text{i}} = 2,085 \text{ mol}$   
 $n_{\text{CCl}_4\text{éq}} = 0,510 \text{ mol}$   
 $V = 1,50 \text{ L}$   
 $K_c = ?$

**Calcul:**

1. Calcul des concentrations:

$$[\text{CS}_2]_i = \frac{1,35 \text{ mol}}{1,50 \text{ L}} = 0,900 \text{ mol/L}$$
$$[\text{Cl}_2]_i = \frac{2,085 \text{ mol}}{1,50 \text{ L}} = 1,39 \text{ mol/L}$$
$$[\text{CCl}_4]_{\text{éq}} = \frac{0,510 \text{ mol}}{1,50 \text{ L}} = 0,340 \text{ mol/L}$$

2. Report des données et utilisation du tableau IVÉ où  $C_{\text{éq}} = C_i + \Delta C$ :

Concentration (mol/L)	CS <sub>2</sub> (g)	+ 3 Cl <sub>2</sub> (g)	⇌	S <sub>2</sub> Cl <sub>2</sub> (g)	+ CCl <sub>4</sub> (g)
Initiale (C <sub>i</sub> )	0,900	1,39		0	0
Variation (ΔC)	-0,340	-1,02		+0,340	+0,340
Équilibre (C <sub>éq</sub> )	0,560	0,37		0,340	0,340

3. Calcul de la constante d'équilibre:

$$K_c = \frac{[\text{S}_2\text{Cl}_2] \cdot [\text{CCl}_4]}{[\text{CS}_2] \cdot [\text{Cl}_2]^3}$$
$$= \frac{0,340 \cdot 0,340}{0,560 \cdot (0,37)^3}$$
$$= 4,1$$

**Réponse:** La valeur de la constante d'équilibre est de 4,1.

- 2) The following synthesis reaction for NOBr takes place in a 2.5L container.



At equilibrium the system contains 1.25 moles of Br<sub>2</sub>, 0.75 moles of NO, and 0.15 moles of NOBr.

What is the value of the equilibrium constant for the above synthesis of NOBr and for the decomposition of NOBr.

**Calcul:**

1. Calcul des concentrations à l'équilibre:

$$C = \frac{n}{V}$$
$$[\text{Br}_2] = \frac{1,250 \text{ mol}}{2,50 \text{ L}} = 0,500 \text{ mol/L}$$
$$[\text{NO}] = \frac{0,750 \text{ mol}}{2,50 \text{ L}} = 0,300 \text{ mol/L}$$
$$[\text{NOBr}] = \frac{0,150 \text{ mol}}{2,50 \text{ L}} = 0,0600 \text{ mol/L}$$

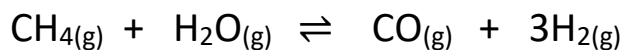
2. Calcul de la constante d'équilibre:

$$K_{c_{\text{syn}}} = \frac{[\text{NOBr}]^2}{[\text{Br}_2] \cdot [\text{NO}]^2} = \frac{(0,0600)^2}{0,500 \cdot (0,300)^2} = 0,0800$$

3. Calcul de la constante d'équilibre de la réaction inverse:

$$K_{c_{\text{déc}}} = \frac{1}{K_{c_{\text{syn}}}} = \frac{1}{0,0800} = 12,5$$

3) Consider the following reaction:



This is known as steam reforming of methane, a key industrial process used for the production of hydrogen gas for human purposes.

A 2.0-liter reaction vessel initially contains:

- 1.00 mole of  $\text{CH}_4$
- 1.50 moles of  $\text{H}_2\text{O}$

At equilibrium, 0.40 moles of  $\text{CO}$  are present.

Calculate the equilibrium constant,  $K_c$ , for the reaction.

Step 1: Calculate concentrations for substances given

Step 2:

	$\text{CH}_4$ (mol/L)	$\text{H}_2\text{O}$ (mol/L)	$\text{CO}$ (mol/L)	$\text{H}_2$ (mol/L)
Theory	1	1	1	3
Initial	0.50	0.75	0	0
Change	-0.20	-0.20	+0.20	+0.60
Equilibrium	0.30	0.55	0.20	0.60

Step 3: 
$$K_c = \frac{[\text{CO}][\text{H}_2]^3}{[\text{CH}_4][\text{H}_2\text{O}]} \quad K_c = \frac{(0.20)(0.60)^3}{(0.30)(0.55)} \approx 0.262$$

- 4) Phosphorus pentachloride ( $\text{PCl}_5$ ) is a volatile compound that decomposes at high temperatures into phosphorus trichloride ( $\text{PCl}_3$ ) and chlorine gas ( $\text{Cl}_2$ ). This reaction is reversible and reaches equilibrium in a closed system. The reaction is shown below:



At 500 K, the equilibrium constant ( $K_c$ ) for the decomposition of phosphorus pentachloride is 15.

A sealed container is initially filled with 2.0 mol/L of  $\text{PCl}_5$ , and no  $\text{PCl}_3$  or  $\text{Cl}_2$  is present at the start.

Calculate the equilibrium concentrations of all substances once equilibrium is established.

	$\text{PCl}_5$ (mol/L)	$\text{PCl}_3$ (mol/L)	$\text{Cl}_2$ (mol/L)
Theory	1	1	1
Initial	2.0	0	0
Change	$-x$	$+x$	$+x$
Equilibrium	$2.0 - x$	$x$	$x$

$$K_c = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]}$$

$$15 = \frac{(x)(x)}{(2.0 - x)}$$

$$15 = \frac{x^2}{2.0 - x}$$

$$15(2.0 - x) = x^2$$

$$30 - 15x = x^2$$

$$x^2 + 15x - 30 = 0$$

Now calculate the two possible values for  $x$ :

$$x = \approx 1.785 \quad \& \quad \approx -16.785$$

Since concentration cannot be negative, we discard the negative root and take  $x \approx 1.785$ .

Plug this value into TICE table for  $x$  to get final equilibrium concentrations

Equilibrium	$2.0 - x$	$x$	$x$
	$2.0 - 1.785$	$1.785$	$1.785$

- $[\text{PCl}_5] = 2.0 - 1.785 = 0.215 \text{ mol/L}$
- $[\text{PCl}_3] = x = 1.785 \text{ mol/L}$
- $[\text{Cl}_2] = x = 1.785 \text{ mol/L}$