

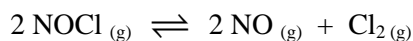
AP CHEMISTRY

TOPIC 6: EQUILIBRIUM, PART E

Day 69:

- Solving Equilibrium Problems

1. At 35 °C, $K = 1.6 \times 10^{-5}$ for the reaction



Calculate the concentrations of all the species at equilibrium for each of the following original mixtures.

a) 2.0 mol pure NOCl in a 2.0 liter flask.

Answers:

	2 [NOCl]	\rightleftharpoons	2 [NO]	+	[Cl ₂]
I	2.0 mol / 2.0 L		0		0
C	- 2x		+ 2x		+ x
E	1.0 - 2x		2x		x

$$K = 1.6 \times 10^{-5} = \frac{[\text{NO}]^2 [\text{Cl}_2]}{[\text{NOCl}]^2} = \frac{(2x)^2 (x)}{(1.0 - 2x)^2} = \frac{(2x)^2 (x)}{(1.0)^2}$$

$$1.6 \times 10^{-5} = \frac{4x^3}{(1.0)^2}, \quad \frac{1.6 \times 10^{-5}}{4} = \frac{4x^3}{4}$$

$$4.0 \times 10^{-6} = x^3 \quad ; \quad \sqrt[3]{4.0 \times 10^{-6}} = x = 0.016$$

$$[\text{NO}] = 2x = (2)(0.016) = 0.032 \text{ M} ; \quad [\text{Cl}_2] = x = 0.016 \text{ M} ; \quad [\text{NOCl}] \approx 1.0 \text{ M}$$

b) 1.0 mol NOCl and 1.0 mol NO in a 1.0 liter flask.

Answers:

	2 [NOCl]	\rightleftharpoons	2 [NO]	+	[Cl ₂]
I	1.0 mol / 1.0 L		1.0 mol / 1.0 L		0
C	- 2x		+ 2x		+ x
E	1.0 - 2x		1.0 + 2x		x

$$K = 1.6 \times 10^{-5} = \frac{[NO]^2 [Cl_2]}{[NOCl]^2} = \frac{(1.0 + 2x)^2 (x)}{(1.0 - 2x)^2} = \frac{(1.0)^2 (x)}{(1.0)^2}$$

$$x = 1.6 \times 10^{-5}$$

$$[NOCl] \approx [NO] \approx 1.0 M ; [Cl_2] = x = 1.6 \times 10^{-5} M$$

c) 2.0 mol NOCl and 1.0 mol Cl₂ in a 1.0 liter flask

Answers:

	2 [NOCl]	\rightleftharpoons	2 [NO]	+	[Cl ₂]
I	2.0 mol / 1.0 L		0		1.0 mol / 1.0 L
C	- 2x		+ 2x		+ x
E	2.0 - 2x		2x		1.0 + x

$$K = 1.6 \times 10^{-5} = \frac{[NO]^2 [Cl_2]}{[NOCl]^2} = \frac{(2x)^2 (1.0 + x)}{(2.0 - 2x)^2} = \frac{(2x)^2 (1.0)}{(2.0)^2} = \frac{4x^2}{4.0}$$

$$1.6 \times 10^{-5} = \frac{4x^2}{4.0} ; 1.6 \times 10^{-5} = x^2$$

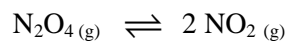
$$\sqrt{1.6 \times 10^{-5}} = x = 4.0 \times 10^{-3}$$

$$[NOCl] = 2.0 M$$

$$[NO] = 2(4.0 \times 10^{-3}) = 8.0 \times 10^{-3} M$$

$$[Cl_2] = 1.0 M$$

2. At a particular temperature, $K = 4.0 \times 10^{-7}$ for the reaction



In an experiment, 1.0 mol N_2O_4 is placed in a 10.0 liter vessel. Calculate the concentrations of N_2O_4 and NO_2 when this reaction reaches equilibrium.

Answers:

	$[\text{N}_2\text{O}_4]$	\rightleftharpoons	$2 [\text{NO}_2]$
I	1.0 mol / 10.0 L		0
C	- x		+ 2x
E	0.1 - x		2x

$$K = 4.0 \times 10^{-7} = \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]} = \frac{(2x)^2}{(0.1 - x)} = \frac{(2x)^2}{(0.1)} = \frac{4x^2}{0.1}$$

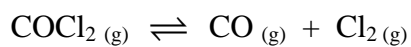
$$4.0 \times 10^{-7} = \frac{4x^2}{0.1}$$

$$4.0 \times 10^{-8} = 4x^2$$

$$1.0 \times 10^{-4} = x$$

$$[\text{N}_2\text{O}_4] \approx 0.1 \text{ M}; \quad [\text{NO}_2] = 2x = 2(1.0 \times 10^{-4}) = 2.0 \times 10^{-4}$$

3. At a particular temperature, $K_p = 6.8 \times 10^{-9}$ for the reaction



If pure COCl_2 at an initial concentration of 1.0 atm decomposes, calculate the equilibrium pressures of all species.

Answers:

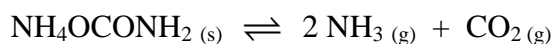
	[COCl_2]	\rightleftharpoons	[CO]	+	[Cl_2]
I	1.0		0		0
C	- x		+ x		+ x
E	1.0 - x		x		x

$$6.8 \times 10^{-9} = \frac{(P_{\text{CO}})(P_{\text{Cl}_2})}{(P_{\text{COCl}_2})} = \frac{x^2}{(1.0 - x)} = \frac{x^2}{(1.0)}$$

$$\sqrt{6.8 \times 10^{-9}} = x = 8.2 \times 10^{-5} \text{ atm}$$

$$P_{\text{COCl}_2} = 1.0 \text{ atm}, \quad P_{\text{CO}} = P_{\text{Cl}_2} = 8.2 \times 10^{-5} \text{ atm}$$

4. At 25 °C, $K_p = 2.9 \times 10^{-3}$ for the reaction



In an experiment carried out at 25 °C, a certain amount of NH_4OCNH_2 is placed in an evacuated rigid container and allowed to come to equilibrium. Calculate the total pressure in the container at equilibrium.

Answers:

	$[\text{NH}_4\text{OCNH}_2]$	\rightleftharpoons	$2 [\text{NH}_3]$	+	$[\text{CO}_2]$
I	-		0		0
C	-		+ 2x		+ x
E	-		2x		x

$$K_p = 2.9 \times 10^{-3} = (P_{\text{NH}_3})^2 (P_{\text{CO}_2})$$

$$2.9 \times 10^{-3} = (2x)^2 (x) = 4x^3$$

$$2.9 \times 10^{-3} = 4x^3$$

$$\frac{2.9 \times 10^{-3}}{4} = \frac{4x^3}{4} \quad ; \quad 7.25 \times 10^{-4} = x^3$$

$$\sqrt[3]{7.25 \times 10^{-4}} = x = 8.98 \times 10^{-2}$$

$$P_T = P_{\text{NH}_3} + P_{\text{CO}_2} = 2x + x$$

$$P_T = P_{\text{NH}_3} + P_{\text{CO}_2} = 2(8.98 \times 10^{-2} \text{ atm}) + (8.98 \times 10^{-2} \text{ atm}) = 0.27 \text{ atm}$$