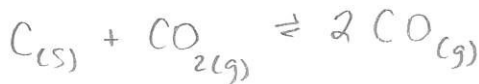
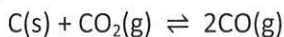


Now you try!

1. If the K_p for the following reaction is 2.4×10^{-9} and the initial concentration of CO_2 is 2.00 atm, what are the partial pressures of the substances at equilibrium?



}	2.00	ϕ
}	-x	+2x
}	2.00-x	2x

$$K_p = \frac{(P_{\text{CO}})^2}{P_{\text{CO}_2}} = \frac{(2x)^2}{2.00-x} \approx \frac{4x^2}{2.00} = 2.4 \times 10^{-9}$$

x negligible,
b/c $2.0 > 1000(2.4 \times 10^{-9})$] $(P_{\text{CO}_2})_i$ and K_p
differ by factor $\uparrow 1000!$

$$\Rightarrow x = \sqrt{\frac{(2.00)(2.4 \times 10^{-9})}{4}} = \underline{3.46 \times 10^{-5}} \text{ 2 s.f.}$$

$$P_{\text{CO}} = 2x = 2(3.46 \times 10^{-5}) = \underline{6.9 \times 10^{-5} \text{ atm}}$$

$$P_{\text{CO}_2} = 2.00 - x = \underline{2.00 \text{ atm}}$$

Check K :

$$K_p = \frac{(6.9 \times 10^{-5})^2}{2.00} = 2.4 \times 10^{-9} \checkmark$$

Check approximation:

$$\left(\frac{3.46 \times 10^{-5}}{2.0} \right) \times 100 = 0.0029\% < 5\% \checkmark$$

2. A gas, $\text{XY}(\text{g})$, decomposes according to the following reaction: $2\text{XY}(\text{g}) \rightleftharpoons \text{X}_2(\text{g}) + \text{Y}_2(\text{g})$, $K_p = 230$. A sample of each of the gases is placed in a previously evacuated container, and the initial partial pressures of the gases are shown in the table below:

Gas	Initial Partial Pressure (atm)
XY	0.010
X ₂	0.20
Y ₂	2.0

If the temperature of the reaction mixture is held constant, in which direction will the reaction proceed? Explain.

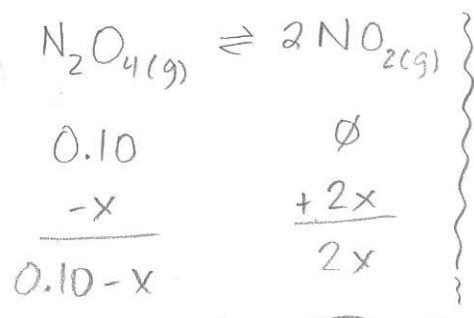
$$Q_p = \frac{P_{\text{X}_2} P_{\text{Y}_2}}{(P_{\text{XY}})^2} = \frac{(0.20)(2.0)}{(0.010)^2} = 4000 > 230$$

$Q > K$

$K < Q$, so the rxn will proceed to the left: decreasing P_{products} + increasing $P_{\text{reactants}}$ to achieve equilibrium.

$$\Rightarrow [N_2O_4] = \frac{1.0 \text{ mol}}{10.0 \text{ L}} = 0.10 \text{ M}$$

3. For the reaction $N_2O_4(g) \rightleftharpoons 2 NO_2(g)$, 1.0 mol of $N_2O_4(g)$ is placed in a 10.0 L reaction vessel at a constant temperature. $K_c = 4.0 \times 10^{-7}$ for this temperature. Find the equilibrium concentrations.



$$K_c = \frac{[NO_2]^2}{[N_2O_4]} = \frac{(2x)^2}{0.10-x} \approx \frac{4x^2}{0.10} = 4.0 \times 10^{-7}$$

$0.1 > 1000(4E-7)$
so x is negligible!
 $[N_2O_4]_i$ and K_c differ by a factor $\uparrow 1000!$

$$[N_2O_4] = 0.10 - x = 0.10 - 1.0E-4 = \boxed{0.10 \text{ M}}$$

$$[NO_2] = 2x = 2(1.0E-4) = \boxed{2.0 \times 10^{-4} \text{ M}}$$

$$x = \sqrt{\frac{(0.10)(4.0E-7)}{4}} = 1.0 \times 10^{-4}$$

Check K:

$$K = \frac{(2.0E-4)^2}{0.10} = 4.0E-7 \checkmark$$

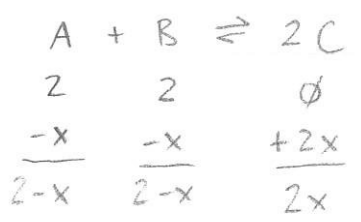
Check approx:

$$\frac{1.0E-4}{0.10} \times 100 = 0.10\% < 5\% \checkmark$$

Multiple Choice Practice!

4. Here is a general reaction with a K value of 16: $A(aq) + B(aq) \rightleftharpoons 2 C(aq)$. Initially, $[A] = [B] = 2.0 \text{ M}$. Solve for the equilibrium concentration of each substance.

- a. $[A] = [B] = 0.67 \text{ M}$, $[C] = 1.3 \text{ M}$
- b. $[A] = [B] = 1.6 \text{ M}$, $[C] = 0.88 \text{ M}$
- c. $[A] = [B] = 0.67 \text{ M}$, $[C] = 2.7 \text{ M}$
- d. $[A] = [B] = 0.50 \text{ M}$, $[C] = 3.0 \text{ M}$



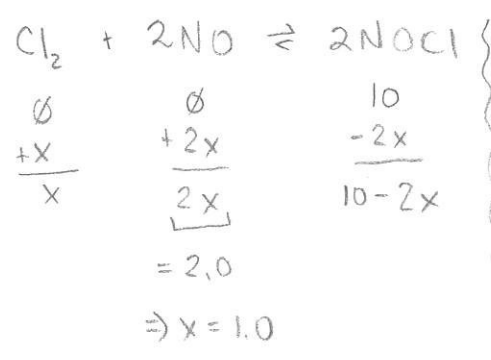
$$K = \frac{[C]^2}{[A][B]} = \frac{(2x)^2}{(2-x)^2} = 16$$

$$\begin{aligned}
 [A] &= [B] = 2 - x \\
 &= 2 - 1.33 = 0.67 \\
 [C] &= 2x = 2(1.33) = 2.67
 \end{aligned}$$

$$\Rightarrow 4 = \frac{2x}{2-x} \Rightarrow 8 - 4x = 2x \Rightarrow 8 = 6x \Rightarrow x = 1.33$$

5. Consider the following equilibrium: $Cl_2(g) + 2 NO(g) \rightleftharpoons 2 NOCl(g)$. Initially, the reaction was started by adding 10.0 M NOCl gas to a reaction vessel. At equilibrium, $[NO] = 2.0 \text{ M}$. What is the value of K_c ?

- a. 0.63
- b. 2.3
- c. 4.0
- d. 16



$$\begin{aligned}
 [Cl_2] &= x = 1.0 \\
 [NO] &= 2.0 \\
 [NOCl] &= 10 - 2x \\
 &= 10 - 2 \\
 &= 8
 \end{aligned}$$

$$K = \frac{[NOCl]^2}{[Cl_2][NO]^2} = \frac{8^2}{(1)(2)^2} = \frac{8 \cdot 8}{4} = 16$$

6. The reaction below came to equilibrium at a temperature of 100°C . At equilibrium the partial pressure due to NOBr was 4 atm, the partial pressure due to NO was 4 atm, and the partial pressure due to Br_2 was 2 atm. What is the equilibrium constant, K_p , for this reaction at 100°C ?

a. $\frac{1}{4}$ b. $\frac{1}{2}$

c. 1

d. 2

$$K_p = \frac{(P_{\text{NO}})^2 (P_{\text{Br}_2})}{(P_{\text{NOBr}})^2} = \frac{(4)^2 (2)}{(4)^2} = 2$$

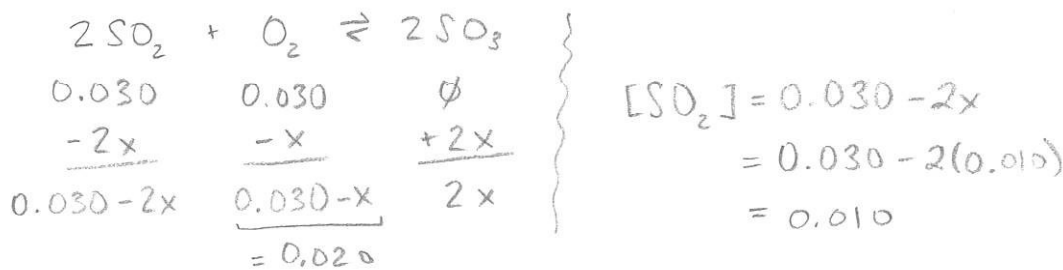
7. Consider the following: $2 \text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2 \text{SO}_3(\text{g})$. Initially, 0.030 mol SO_2 and 0.030 mol O_2 are placed into a 1.0 L container. At equilibrium, there is 0.020 mol O_2 present. What is the $[\text{SO}_2]$ at equilibrium?

a. 0.010 mol/L

b. 0.020 mol/L

c. 0.030 mol/L

d. 0.040 mol/L



$\Rightarrow x = 0.010$ Use the information below to answer #8-10.

Reaction 1:	$\text{NOBr}(\text{g}) \rightleftharpoons \text{NO}(\text{g}) + \frac{1}{2} \text{Br}_2(\text{g})$	$K_c = 3.4 \times 10^{-2}$	$K < Q$
Reaction 2:	$2 \text{NOCl}(\text{g}) \rightleftharpoons 2 \text{NO}(\text{g}) + \text{Cl}_2(\text{g})$	$K_c = 1.6 \times 10^{-5}$	$K < Q$
Reaction 3:	$2 \text{NO}(\text{g}) + 2 \text{H}_2(\text{g}) \rightleftharpoons \text{N}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{g})$	$K_c = 4.0 \times 10^6$	$K > Q$
Reaction 4:	$\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2 \text{NO}(\text{g})$	$K_c = 4.2 \times 10^2$	$K > Q$

8. For a reaction involving nitrogen monoxide inside a sealed flask, the value for the reaction quotient (Q) was found to be 1.1×10^2 at a given point. If, after this point, the amount of NO gas in the flask increased, which reaction is most likely taking place in the flask?

a. reaction 1

b. reaction 2

c. reaction 3

d. reaction 4

9. Which of these reactions proceeds at the slowest rate?

a. reaction 1

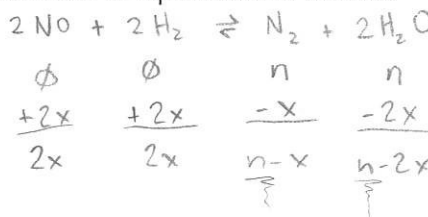
b. reaction 2

c. reaction 3

d. cannot be determined

10. For reaction #3, equimolar amounts of N_2 gas and H_2O gas are allowed to come to equilibrium in a sealed reaction vessel. Which of the following must be true at equilibrium?

- I. $[\text{N}_2]$ must be less than $[\text{H}_2\text{O}]$. \times
 II. $[\text{N}_2]$ must be greater than $[\text{H}_2\text{O}]$. \checkmark
 III. $[\text{NO}]$ must be greater than $[\text{H}_2]$. \times



a. I only

b. II only

c. I and III

d. II and III