

Equilibrium Practice Problems

1. The following reaction reaches equilibrium at 600 C



The equilibrium constant, K_p , for the reaction is 23.5. If 100.0 g of Magnesium Carbonate is placed into a 2.50 L container at 600 C and allowed to come to equilibrium:

- a. What is the partial pressure of carbon dioxide at equilibrium?

$$K_p = P_{\text{CO}_2} = 23.5 \text{ atm}$$

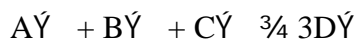
- b. What mass of Magnesium Carbonate remains at equilibrium?

$$n_{\text{CO}_2} = \frac{PV}{RT} = \frac{(23.5 \text{ atm})(2.50 \text{ L})}{(0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1})(873 \text{ K})} = 0.82009113 \text{ mol CO}_2$$

$$\text{g MgCO}_3 = 0.82009113 \text{ mol CO}_2 \times \frac{1 \text{ mol MgCO}_3}{1 \text{ mol CO}_2} \times \frac{84.3139 \text{ g MgCO}_3}{1 \text{ mol MgCO}_3} = 69.1 \text{ g MgCO}_3 \text{ decomposed}$$

$$\text{g MgCO}_3 \text{ left} = 100.0 \text{ g MgCO}_3 - 69.1 \text{ g MgCO}_3 = 30.9 \text{ g MgCO}_3$$

2. The following reaction has an equilibrium constant, K_c , of 0.56:



If the reaction starts with $[A] = [B] = [C] = 0.100$ M and $[D] = 0.0012$ M, what are the equilibrium concentrations of all substances?

$$Q_c = \frac{[D]^3}{[A][B][C]} = \frac{(0.0012)^3}{(0.100)^3} = 1.728 \times 10^{-6} < K_c \quad \text{reaction shifts right}$$

	A	B	C	D
I	0.100	0.100	0.100	0.0012
Δ	-x	-x	-x	+3x
E	0.100 - x	0.100 - x	0.100 - x	0.0012 + 3x

$$K_c = \frac{(0.0012 + 3x)^3}{(0.100 - x)^3} \Rightarrow \sqrt[3]{K_c} = \frac{(0.0012 + 3x)}{(0.100 - x)}$$

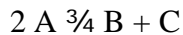
$$\sqrt[3]{K_c} (0.100 - x) = 0.0012 + 3x$$

$$(-3 - \sqrt[3]{K_c})x = 0.0012 - 0.100(\sqrt[3]{K_c})$$

$$x = \frac{0.0012 - 0.100(\sqrt[3]{K_c})}{-3 - \sqrt[3]{K_c}} = 0.0212396$$

At equilibrium $[A] = [B] = [C] = 0.100 - 0.021 = 0.079$ M and
 $[D] = 0.0012 + 3(0.021) = 0.0642$ M

3. The following reaction has an equilibrium constant of 647:



If the reaction begins with $[A] = 2.50 \text{ M}$, what are the equilibrium concentrations of all substances?

The reaction shifts to the right.

	A	B	C
I	2.50	0	0
Δ	$-2x$	$+x$	$+x$
E	$2.50 - 2x$	x	x

$$K_c = 647 = \frac{(x)(x)}{(2.50 - 2x)^2} = \frac{x^2}{4x^2 - 10x + 6.25}$$

$$647(4x^2 - 10x + 6.25) = x^2$$

$$2588x^2 - 6470x + 4043.75 = x^2$$

$$2587x^2 - 6470x + 4043.75 = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-6470) \pm \sqrt{(-6470)^2 - 4(2587)(4043.75)}}{2(2587)} = 1.21619 \text{ or } 1.28574$$

Only the first one makes sense, the second value will give a negative concentration for A, so the equilibrium values are $[A] = 0.07 \text{ M}$, $[B] = [C] = 1.22 \text{ M}$.