Equilibrium Practice Problems

1. The following reaction reaches equilibrium at 600 C

$$MgCO_3(s) \rightleftharpoons MgO(s) + CO_2(g)$$

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?

$$K_p = P_{CO_2} = 23.5 \text{ atm}$$

b. What mass of Magnesium Carbonate remains at equilibrium?

$$n_{CO_2} = \frac{PV}{RT} = \frac{(23.5 \text{ atm})(2.50 \text{ L})}{(0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1})(873 \text{ K})} = 0.82\underline{0}09113 \text{ mol } CO_2$$

$$\text{g } MgCO_3 = 0.82\underline{0}09113 \text{ mol } CO_2 \times \frac{1 \text{ mol } MgCO_3}{1 \text{ mol } CO_2} \times \frac{84.3139 \text{ g } MgCO_3}{1 \text{ mol } MgCO_3} = 69.1 \text{ g } MgCO_3 \text{ decomposed}$$

$$\text{g } MgCO_3 \text{ left} = 100.0 \text{ g } MgCO_3 - 69.1 \text{ g } MgCO_3 = 30.9 \text{ g } MgCO_3$$

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

A Ý + B Ý + C Ý ¾ 3D Ý

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

$$Q_c = \frac{[D]^3}{[A][B][C]} = \frac{(0.0012)^3}{(0.100)^3} = 1.728\times10^{-6} < K_c$$ reaction shifts right

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

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

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

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

$$x = \frac{0.0012 - 0.100\left(\sqrt[3]{K_c}\right)}{-3-\sqrt[3]{K_c}} = 0.021\underline{2}396$$

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:

2 A ¾ B + C

If the reaction begins with [A] = 2.50 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

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

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

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

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

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

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