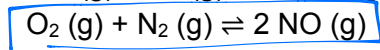
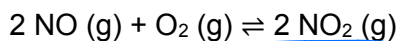


## Equilibrium Take-home Quiz

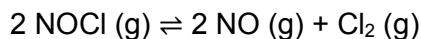
(Due Nov 9<sup>th</sup> by 8:00 AM)

- In your own words, what is meant by "dynamic equilibrium" and how does it relate to chemical reactions?  
*the state where the concentration of reactants and products has stopped changing*
- Determine which of the following reactions have  $K_p = K_c$ . Clearly explain your choice.



$$\Delta n_{\text{gas}} = 0 \quad \text{so} \\ K_p = K_c (RT)^0 = K_c$$

- Calculate  $K_c$  for the following reactions given the equilibrium concentrations listed.

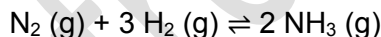


$$[\text{NOCl}] = 9.64 \text{ mM} \quad [\text{Cl}_2] = 4.83 \text{ mM} \quad [\text{NO}] = 2.88 \text{ mM}$$

- Using what you learned in Problem 3, determine  $K_c$  for the following reaction:



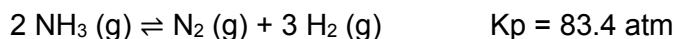
- Calculate  $K_p$  for the reaction in problem 3 if the temperature is 250 °C.
- Determine the vapor pressure of water (in atm.) at 75 °C is  $K_p = 38.5630 \text{ kPa}$
- Consider the following reaction. 1 atm of each reactant is mixed together in a 1 L reaction vessel at 500 °C. At equilibrium the final pressure is found to be 1.924 atm. Determine  $K_p$ .



- Determine the total pressure at equilibrium if 0.20 atm  $\text{H}_2$  and 3.0 atm  $\text{CH}_4$  (g) are mixed in the presence of 4 grams of carbon at 900 °C.



- Calculate the concentration of  $\text{H}_3\text{O}^+$  that will form if 0.5 M  $\text{H}_2\text{CO}_3$  (aq) reacts with liquid water to form  $\text{H}_3\text{O}^+$  and  $\text{HCO}_3^-$ .  $K_c = 4.3 \times 10^{-7} \text{ M}^{-1}$  at 25 °C
- If 25.45 atm of  $\text{N}_2$ , 10.42 atm. of  $\text{H}_2$ , and 23.55 atm of  $\text{NH}_3$  are present in a reaction vessel, determine if ammonia will decompose or be synthesized.



$$3. \quad [\text{NOCl}] = \frac{9.64 \text{ mPa} \cdot 10^{-3} \text{ M}}{1 \text{ mPa}} = 0.00964 \text{ M} \quad [\text{Cl}_2] = 0.00482 \text{ M}$$

$$[\text{NO}] = 0.00288 \text{ M}$$

$$K_c = \frac{[\text{NO}]^2 [\text{Cl}_2]}{[\text{NOCl}]^2} = \frac{(0.00288 \text{ M})^2 (0.00482 \text{ M})}{(0.00964 \text{ M})^2} = 4.311 \times 10^{-4} \text{ M}$$



This is  $\frac{1}{2}$  the equilibrium in problem 3

$$K = (4.311 \times 10^{-4} \text{ M})^{1/2} = 0.0208 \text{ M}^{1/2}$$

$$5. \quad T = 250 + 273.15 = 523.15 \text{ K} \quad \Delta n_{\text{gas}} = 1$$

$$K_P = 4.311 \times 10^{-4} [(0.08206)(523.15)]^1 = 0.0195 \text{ atm}$$

$$6. \quad K_P = P_{\text{H}_2\text{O}} = \frac{38.5630 \text{ kPa}}{101.325 \text{ kPa}} \cdot 1 \text{ atm} = 0.381 \text{ atm}$$



I	1.00	1.00	0
C	-x	-3x	+2x
E	1.0-x	1-3x	2x

$$P_{\text{tot}} = 1.924 = 1-x + 1-3x + 2x$$

$$1.924 = 2 - 2x$$

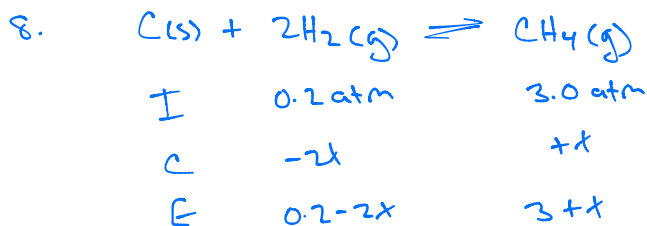
$$x = 0.038 \text{ atm}$$

$$P_{\text{N}_2} = 1 - 0.038 = 0.962 \text{ atm}$$

$$P_{\text{H}_2} = 1 - 3(0.038) = 0.886 \text{ atm}$$

$$P_{\text{NH}_3} = 2(0.038) = 0.076 \text{ atm}$$

$$K_P = \frac{(0.962)(0.886)^3}{(0.076)^2} = 8.63 \times 10^{-3} \text{ atm}^2$$



$$K_P = 0.4725 = \frac{3+x}{(0.2-2x)^2} = \frac{3+x}{0.04 - 0.8x + 4x^2}$$

$$3+x = 0.0189 - 0.378x + 1.89x^2$$

$$0 = 1.89x^2 - 1.378x - 2.9811$$

$$x = \frac{1.378 \pm \sqrt{(1.378)^2 - 4(1.89)(-2.9811)}}{2(1.89)}$$

$$x = -0.9432$$

$$x = 1.6723 \leftarrow \text{not possible}$$

$$(0.2 - 2(x)) = \text{negative}$$

$$P_{H_2} = 0.2 - 2(-0.9432) = 2.0864 \text{ atm}$$

$$P_{CH_4} = 3 + (-0.9432) = 2.0568 \text{ atm}$$

$$P_{\text{tot}} = 2.0864 + 2.0568 = 4.1432 \text{ atm}$$



$$K_c = 4.3 \times 10^{-7} = \frac{x^2}{\frac{0.5-x}{0.5}}$$

use shortcut

$$4.3 \times 10^{-7} = \frac{x^2}{0.5}$$

$$x^2 = 2.15 \times 10^{-7}$$

$$x = 4.64 \times 10^{-4} \text{ M}$$

$$[H_3O^+] = 4.64 \times 10^{-4} \text{ M}$$

$$10. \quad Q = \frac{(24.45)(10.42)^3}{(23.55)^2} = 49.88$$

$K > Q$

Products form