

# Equil Notes: Practice Problems (Solutions)

1. a. Concentration of products + reactants are constant
- b. products
- c. solids & liquids

2. a.  $K = \frac{[\text{NO}_2]^2}{[\text{NO}]^2[\text{O}_2]}$     b.  $K = \frac{[\text{Zn}^{2+}]}{[\text{Ag}^+]^2}$     c.  $K = \frac{[\text{OH}^-]^2}{[\text{CO}_3^{2-}]}$

3. a.  $K > 1$  product favored     $K < 1$  reactant favored     $K = 1$  neither favored

b. Coefficient are exponents

c.  $\Delta n = (n_{\text{products}} - n_{\text{reactants}})$  \* gases only!

d.  $M = \frac{\text{mol}}{L} \Rightarrow \text{mol} = M \times L$

4. a.  $K = \frac{[C]^2}{[A]^2[B]} = \frac{[0.43]^2}{[0.55]^2[0.33]} = 1.9$

$K > 1$  product favored

assume std cond  $\Delta n = 0$  no gases

$K_p = K_c (RT)^{\Delta n} = 1.9 (0.0821 \cdot 298)^0 = 1.9$  same

b.  $K = \frac{[\text{CO}][\text{H}_2\text{O}]}{[\text{CO}_2][\text{H}_2]} = \frac{(0.0046)^2}{(0.0954)(0.0454)} = 0.0049$

$K < 1$  reactant favored

get M first  
 $[\text{CO}] = \frac{0.0092 \text{ mol}}{2 \text{ L}} = 0.0046 \text{ M}$   
 $[\text{H}_2\text{O}]$

$[\text{CO}_2] = \frac{0.1908 \text{ mol}}{2 \text{ L}} = 0.0954 \text{ M}$

$[\text{H}_2] = \frac{0.0908 \text{ mol}}{2 \text{ L}} = 0.0454 \text{ M}$

$\Delta n = 0$   
 $K_c = K_p = 0.0049$

5.a. nothing,  $K$  does not say anything about how fast (rate) a reaction goes only the conditions at equilibrium

b. Yes greatly  $K$  very large so highly product favored.

c.  $K_p = K_c (RT)^{\Delta n} = 7.3 \times 10^{34} (0.0821 \cdot 298)^{(3-2)} = 1.8 \times 10^{36}$

d.  $K_p = \frac{(P_{N_2})^2 (P_{O_2})}{(P_{N_2O})^2} \Rightarrow x^2 \cdot 1.8 \times 10^{36} = \frac{(3.4 \times 10^8)^2 (2.4 \times 10^7)}{x^2}$

$P_{N_2O} = 1.2 \times 10^{-6} \text{ atm}$

$$\frac{1.8 \times 10^{36} x^2}{1.8 \times 10^{36}} = \frac{2.8 \times 10^{24}}{1.8 \times 10^{36}}$$

$$\sqrt{x^2} = \sqrt{1.6 \times 10^{-12}}$$

$$x = 1.2 \times 10^{-6}$$

e. Yes,  $P_{N_2O}$  should be a very small amount

since the reaction is so much product favored there should be very little reactant @ equilibrium.

6. a.  $K$  is cubed ( $K^3$ )

b. Take the reciprocal ( $\frac{1}{K}$ )

c.  $K_{\text{overall}} = K_1 \times K_2 \times \dots$  multiply the  $K$ 's of each step

7. Original eqn +  $K$   $2\text{N}_2\text{O} \rightleftharpoons 2\text{N}_2 + \text{O}_2$   $K = 7.3 \times 10^3$

a. Coeff of rxn are doubled so new  $K = K^2$   
 $K = 5.3 \times 10^{69}$

b. Rxn is flipped so new  $K = \frac{1}{K}$   
 $K = 1.4 \times 10^{-35}$

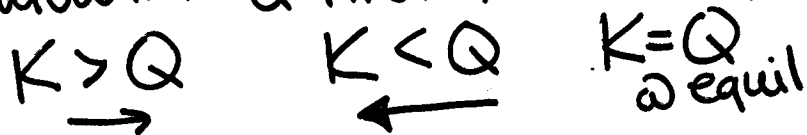
8. Reaction Quotient ( $Q$ ) - may or may not be  
Equilibrium Constant ( $K$ ) -  $\text{at equil}$

9.  $Q = \frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]} = \frac{(3.21 \times 10^{-3})^2}{(3.21 \times 10^{-3})(3.21 \times 10^{-3})} = 1$

$12.3$   
 $K > Q$   
 $\longrightarrow$   
reaction proceeds to the right  
since  $Q$  is less needs to make more products to increase to reach  $K$

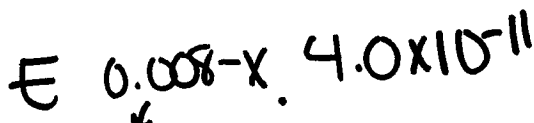
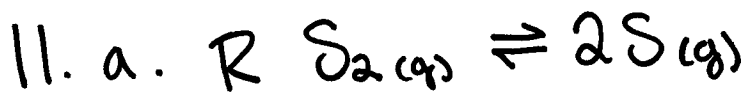
10. a. The question gives/asks information about both initial + equilibrium conditions

b. Calculate Q first then compare Q to K



c. If you end up w/ an expression of  $ax^2 + bx + c = 0$

d. If K is very small i.e.  $\times 10^{-5}$  magnitude



$$[\text{S}_2] = 0.008 - 2.0 \times 10^{-11} = 0.008$$

$\leftarrow$  x is very small so [S<sub>2</sub>] doesn't change

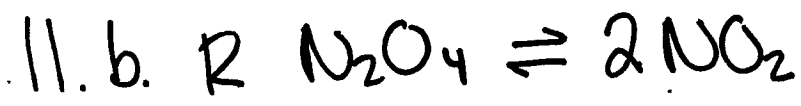
$$K = \frac{[\text{S}]^2}{[\text{S}_2]} = \frac{(0.008)^2}{(2.0 \times 10^{-11})} = 4.0 \times 10^8$$

$$\text{initial } [\text{S}_2] = \frac{0.0040 \text{ mol}}{0.500 \text{ L}} = 0.008 \text{ M}$$

$$\text{equil } [\text{S}] = \frac{2.0 \times 10^{-11} \text{ mol}}{0.500 \text{ L}} = 4.0 \times 10^{-11} \text{ M}$$

$$\frac{2x}{2} = \frac{4.0 \times 10^{-11}}{2}$$

$$x = 2.0 \times 10^{-11}$$



$[N_2O_4]_{\text{initial}} = \frac{0.50 \text{ mol}}{0.750 \text{ L}} = 0.67 \text{ M}$

I 0.67                      0

$[N_2O_4]_{\text{equil}} = \frac{0.42 \text{ mol}}{0.750 \text{ L}} = 0.56 \text{ M}$

C -x                              +2x

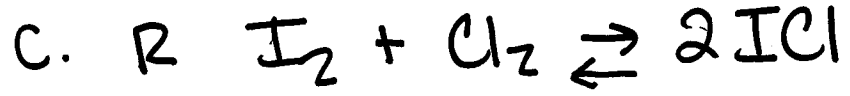
E 0.56                              2x

$0.67 - x = 0.56$   
 $x = 0.11$

$[NO_2] = 2x = 2(0.11) = 0.22 \text{ M}$

$K = \frac{[NO_2]^2}{[N_2O_4]} = \frac{(0.22)^2}{(0.56)} = 0.086$

← since you have amounts for each



I 0.100    0.100                      0.100

Check Q first

$Q = \frac{[ICl]^2}{[I_2][Cl_2]} = \frac{0.100^2}{0.100^2} = 1$

C -x                      -x                              +x

$K > Q$   
 $81.9 > 1$   
 → forward

E 0.100-x    0.100-x    0.100+x

$K = \frac{[ICl]^2}{[I_2][Cl_2]} \Rightarrow \sqrt{81.9} = \frac{(0.100+x)^2}{(0.100-x)^2}$

$[I_2] + [Cl_2] = 0.100 - x = 0.020 \text{ M}$   
 $\swarrow 0.0801$

$(0.100-x) 9.05 = \frac{0.100+x}{0.100-x} (0.100-x)$

$0.905 - 9.05x = 0.100 + x$

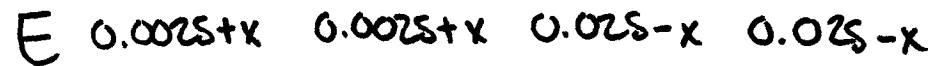
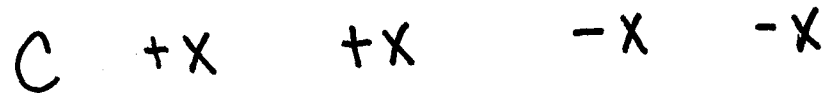
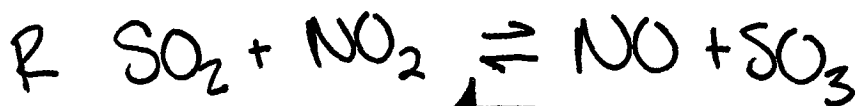
$-0.100 + 9.05x = 0.100 + x$

$[ICl] = 0.100 + x = 0.180 \text{ M}$   
 $\swarrow 0.0801$

$\frac{0.805}{10.05} = \frac{10.05x}{10.05}$

$0.0801 = x$

11.d.



Amounts for each  
So check Q 1st

$$Q = \frac{[NO][SO_3]}{[SO_2][NO_2]} = 100$$

$K < Q$  rxn goes left  
85.0    100

$$K = \frac{[NO][SO_3]}{[SO_2][NO_2]}$$

$$[SO_2] + [NO_2] = 0.0025 + 0.000196 = 0.0027$$

$$\sqrt{85.0} = \sqrt{\frac{(0.025-x)^2}{(0.0025+x)^2}}$$

$$(0.0025+x) 9.22 = \frac{0.025-x}{0.0025+x} (0.0025+x)$$

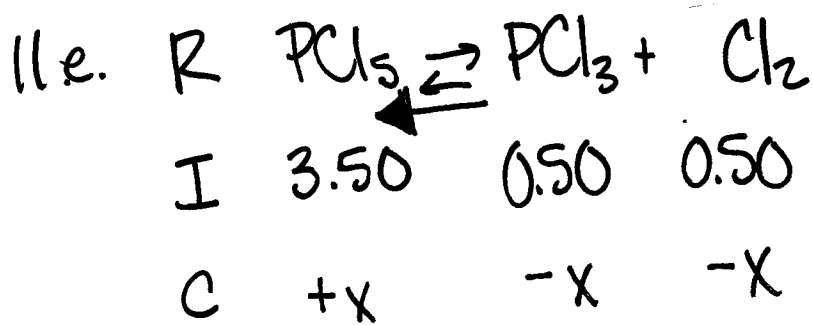
$$\frac{[NO]}{[SO_3]} = \frac{0.025 - 0.000196}{0.000196} = 0.025M$$

$$\cancel{0.0230} + 9.22x = 0.025 - \cancel{x}$$

$$\cancel{-0.0230} + x = \cancel{-0.0230} + x$$

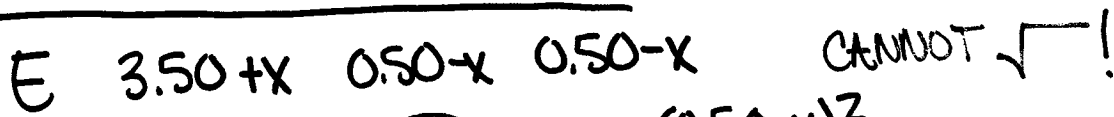
$$\frac{10.22x}{10.22} = \frac{0.002}{10.22}$$

$$x = 0.000196$$



$$Q = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]} = \frac{(0.50)^2}{3.50} = 0.0714$$

$K < Q$  goes to the left  
 0.0454    0.0714



$$K = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]} = \frac{(0.50-x)^2}{3.50+x} = 0.0454$$

$$0.159 + 0.0454x = (0.50-x)(0.50-x) \quad \text{FOIL}$$

$$0.159 + 0.0454x = 0.25 - x + x^2 \quad \text{get } = 0$$

$$-0.159 - 0.0454x - 0.159 - 0.0454x$$

must use quadratic formula

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2}$$

$$0 = 0.091 - 1.0454x + x^2$$

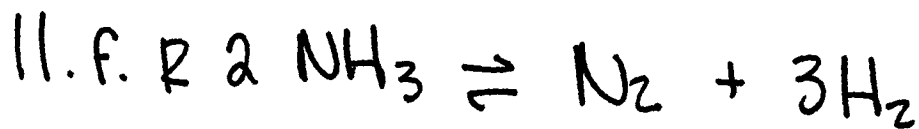
a                  b                  c

You get two x's (x=0.10)  
 pick the x that gives you a positive [ ] for equil b/c a neg [ ] isn't possible

$$[\text{PCl}_3] = 0.50 - 0.10 = 0.40 \text{ M}$$

$$[\text{Cl}_2] = 0.50 - 0.10 = 0.40 \text{ M}$$

$$[\text{PCl}_5] = 3.50 + 0.10 = 3.60 \text{ M}$$



$$\text{I} \quad [\text{NH}_3] \quad 0 \quad 0$$

$$\text{C} \quad -2x \quad +x \quad +3x$$

$$\text{E} \quad [\text{NH}_3] - 2x \quad x \quad 0.342$$

$$[\text{NH}_3] - 2(0.114) \quad 0.114$$

← given

$$\frac{3x}{3} = \frac{0.342}{3}$$

$$x = 0.114$$

$$K = \frac{[\text{N}_2][\text{H}_2]^3}{[\text{NH}_3]^2}$$

$$6.30 = \frac{(0.114)(0.342)^3}{([\text{NH}_3] - 0.228)^2}$$

↳ change to  $y$  to make it easier to solve

$$(y - 0.228)^2 \quad 6.30 = \frac{0.00456}{(y - 0.228)^2} \quad (y - 0.228)^2$$

↑ get this on top

$$\frac{(y - 0.228)^2}{6.30} \cdot 6.30 = \frac{0.00456}{6.30}$$

$$\sqrt{(y - 0.228)^2} = \sqrt{0.000724}$$

$$y - 0.228 = 0.0269$$

$$\begin{array}{r} +0.228 \\ \hline \end{array} \quad \begin{array}{r} +0.228 \\ \hline \end{array}$$

$$y = 0.255$$

$$[\text{NH}_3] = 0.255 \text{ M}$$