"Recitation" CHMG 142 Group names:______________________

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R=0.082058 $\frac{L\,atm}{mol\ \ K}$

$$\ln\left(\frac{k_2}{k_1}\right) = -\frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

R=8.314 $\frac{J}{mol\ \ K}$

$$k = Ae^{-\frac{E_a}{R\,T}}$$

Piece #1 (1/2 pt). Nitrogen gas and chlorine gas will react to form nitrogen monochloride gas. Write a balanced equation for this reaction.

$$N_2(g) + Cl_2(g) \leftrightarrow 2\ NCl\ (g)$$

Piece #2 (1/2 pt) Nitrogen gas and chlorine gas will react to form nitrogen monochloride gas. This reaction is an equilibrium reaction. Write the equilibrium constant expression (K_c) for this reaction.

$$K_c = \frac{[NCl]^2}{[N_2][Cl_2]}$$

Piece #3 (1/2 pt) Nitrogen gas and chlorine gas will react to form nitrogen monochloride gas. This reaction is an equilibrium reaction. Write the equilibrium constant expression (K_p) for this reaction.

$$K_p = \frac{P_{NCl}^2}{P_{N_2} P_{Cl_2}}$$

Piece #4 (1/2 pt) Nitrogen gas and chlorine gas will react to form nitrogen monochloride gas. 2 moles of nitrogen and 2 moles of chlorine are mixed in a 2 L flask at 350 K. After equilibrium has been established, there is 0.50 moles of nitrogen monochloride, 1.75 moles of nitrogen gas and 1.75 moles of chlorine gas. Construct the ICE chart for this reaction.

	N_2 (g)	+ Cl_2(g)	↔	2 NCl (g)
I	2 mol	2 mol		0 mol
C	-x	-x		+2x
E	1.75 mol	1.75 mol		0.50 mol

OR

	N_2 (g)	+ Cl_2(g)	↔	2 NCl (g)
I	1 M	1 M		1 M
C	-x	-x		+2x
E	0.875 M	0.875 M		0.25 M

Piece #5 (1/2 pt) Nitrogen gas and chlorine gas will react to form nitrogen monochloride gas. 2 moles of nitrogen and 2 moles of chlorine are mixed in a 2 L flask at 350 K. After equilibrium has been established, there is 0.50 moles of nitrogen monochloride, 1.75 moles of nitrogen gas and 1.75 moles of chlorine gas. Calculate the equilibrium constant (K_c) for this reaction.

$$K_c = \frac{[NCl]^2}{[N_2][Cl_2]} = \frac{(0.25\ M)^2}{(0.875\ M)(0.875\ M)} = 0.0816$$

Piece #6 (1/2 pt) Nitrogen gas and chlorine gas will react to form nitrogen monochloride gas. 2 moles of nitrogen and 2 moles of chlorine are mixed in a 2 L flask at 350 K. After equilibrium has been established, there is 0.50 moles of nitrogen monochloride, 1.75 moles of nitrogen gas and 1.75 moles of chlorine gas. Calculate the equilibrium constant (K_p) for this reaction.

$$PV = nRT$$

$$P = \frac{nRT}{V}$$

$$P_{NCl} = \frac{nRT}{V} = \frac{0.50\ mol\ (0.082058\frac{Latm}{molK})(350\ K)}{2\ L} = 7.18\ atm$$

$$P_{N_2} = \frac{nRT}{V} = \frac{1.75\ mol\ (0.082058\frac{Latm}{molK})(350\ K)}{2\ L} = 25.13\ atm$$

$$P_{Cl_2} = \frac{nRT}{V} = \frac{1.75\ mol\ (0.082058\frac{Latm}{molK})(350\ K)}{2\ L} = 25.13\ atm$$

$$K_p = \frac{P_{NCl}^2}{P_{N_2}P_{Cl_2}} = \frac{(7.18\ atm)^2}{(25.13\ atm)(25.13\ atm)} = 0.0816$$

Piece #7 (1/2 pt) Nitrogen gas and chlorine gas will react to form nitrogen monochloride gas. 5 moles of nitrogen and 10 moles of chlorine are mixed in a 2 L flask at 500 K. Construct the ICE chart for this reaction.

	N_2 (g)	+ Cl_2 (g)	↔	2NCl (g)
I	2.5 M	5 M		0 M
C	-x	-x		+2x
E	2.5M-x	5 M-x		2x

Piece #8 (1/2 pt) Nitrogen gas and chlorine gas will react to form nitrogen monochloride gas. 5 moles of nitrogen and 10 moles of chlorine are mixed in a 2 L flask at 500 K. After equilibrium has been established, there are 3 moles of NCl (g) present. Construct the ICE chart for this reaction.

	N_2 (g)	+ Cl_2 (g)	↔	2NCl (g)
I	2.5 M	5 M		0 M
C	-x	-x		+2x
E	2.5M-x	5 M-x		2x=1.5M

Piece #9 (1 pt) Nitrogen gas and chlorine gas will react to form nitrogen monochloride gas. 5 moles of nitrogen and 10 moles of chlorine are mixed in a 2 L flask at 500 K. After equilibrium has been established, there are 3 moles of NCl (g) present. What is the equilibrium constant (K_c) for this reaction at 500 K?

	N_2 (g)	+ Cl_2 (g)	↔	2NCl (g)
I	2.5 M	5 M		0 M
C	-x	-x		+2x
E	2.5M-x	5 M-x		2x=1.5M

2x=1.5 M

X=0.75 M

	N_2 (g)	+ Cl_2 (g)	↔	2NCl (g)
I	2.5 M	5 M		0 M
C	-(0.75 M)	-(0.75 M)		+2(0.75 M)
E	2.5M-0.75 M=1.75 M	5 M – 0.75 M = 4.25 M		2x=1.5M

$$K_c = \frac{[NCl]^2}{[N_2][Cl_2]} = \frac{(1.5\ M)^2}{(1.75\ M)(4.25\ M)} = 0.303$$

BONUS Question (2 pts) Nitrogen gas and chlorine gas will react to form nitrogen monochloride gas. 10 moles of nitrogen and 25 moles of chlorine are mixed in a 2 L flask at 500 K. After equilibrium has been established, how many moles of NCl (g) will be present?

All equilibrium problems have THREE PARTS!

1. Balanced equation:

$$N_2(g) + Cl_2(g) \leftrightarrow 2\ NCl\ (g)$$

2. Equilibrium constant expression:

$$K_c = \frac{[NCl]^2}{[N_2][Cl_2]} = 0.303$$

3. ICE chart

	N_2 (g)	+ Cl_2 (g)	↔	2NCl (g)
I	5 M	12.5 M		0 M
C	-x	-x		+2x
E	5M-x	12.5 M-x		2x

$$K_c = \frac{[NCl]^2}{[N_2][Cl_2]} = \frac{(2x)^2}{(5-x)(12.5-x)} = 0.303$$

You can try assuming x<<5, but it won't work!

$$\frac{(2x)^2}{(5-x)(12.5-x)} = \frac{4x^2}{62.5 - 17.5x + x^2} = 0.303$$

$$\frac{4x^2}{62.5 - 17.5x + x^2} = 0.303$$

$$4x^2 = 0.303(62.5 - 17.5x + x^2)$$

$$4x^2 = 18.94 - 5.31x + 0.303x^2$$

$$0 = 18.94 - 5.31x - 3.697x^2$$

I'm too poor to own a graphing calculator, so I'll go Old School with the quadratic formula!

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-5.31) \pm \sqrt{(-5.31)^2 - 4(-3.697)(18.94)}}{2(-3.697)}$$

$$x = \frac{-(-5.31) \pm \sqrt{(-5.31)^2 - 4(-3.697)(18.94)}}{2(-3.697)} = \frac{5.31 \pm 17.56}{-7.394} = -3.093\ or\ 1.66$$

Only x=1.66 M makes sense. You can tell from the ICE chart

If x=-3.09 then

	N_2 (g)	+ Cl_2 (g)	↔	2NCl (g)
I	5 M	12.5 M		0 M
C	-(-3.09)	-(-3.09)		+2(-3.09)
E	8.09	15.59		-6.18

You can't have a negative M, so -6.18 M makes no sense.

But, if x=1.66, it all makes sense!

	N_2 (g)	+ Cl_2 (g)	↔	2NCl (g)
I	5 M	12.5 M		0 M
C	-1.66 M	-1.66 M		+2(1.66 M)
E	3.34 M	10.84 M		3.32 M

$$3.32 \frac{mol}{L} 2\ L = 6.64\ mol$$