"Recitation" CHMG 142 Group names:_____

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The following data was collected for the reaction of nitrogen gas and chlorine gas to form nitrogen trichloride gas.

Expt #	Initial Nitrogen (atm)	Initial Chlorine (atm)	Initial Rate (atm/min)	Temp (K)
1	0.250	0.250	0.0115	300 K
2	0.500	0.500	0.045	300 K
3	0.500	0.250	0.011	300 K
4	0.250	0.500	0.072	500 K

Piece #1 (1/2 pt.)Write a balanced equation for the reaction of nitrogen gas and chlorine gas to form nitrogen trichloride gas.

$N_2\,(g) + 3\,Cl_2\,(g) \rightarrow 2\,NCl_3\,(g)$

Piece #2 (1/4 pt) If 1 mole of nitrogen gas reacted (see 1), how many moles of chlorine gas would react?

$$1\ mol\ N_2 \frac{3\ mol\ Cl_2}{1\ mol\ N_2} = 3\ mol\ Cl_2$$

Piece #3 (1/4 pt) If 1 mole of nitrogen gas reacted (see 1), how many moles of nitrogen trichloride gas would be formed?

$$1\ mol\ N_2 \frac{2\ mol\ NCl_3}{1\ mol\ N_2} = 2\ mol\ NCl_3$$

Piece #4 (1 pt) Looking at Experiment #2 and #3 in the data table, answer the following questions:

A. What is the ratio of the initial concentration of nitrogen in Experiment #2 relative to Experiment #3?

$$\frac{0.500\ M}{0.500\ M} = 1$$

B. What is the ratio of the intial concentration of chlorine in Experiment #2 relative to Experiment #3?

$$\frac{0.500\ M}{0.250\ M} = 2$$

C. What is the ratio of the rate of the reaction in Experiment #2 relative to Experiment #3?

$$\frac{0.045}{0.011} = 4.09$$

Piece #5 (1/2 pt) Look back at your answers to Piece #4. Based on your answers to Part C and Part B, what is the order of the reaction with respect to chlorine?

When I doubled the concentration of chlorine, the rate quadrupled (approx.), so it is SECOND ORDER.

Or, you can do the algebra!

$$\frac{Rate_{expt2}}{Rate_{expt3}} = \frac{k[Cl_2]_2{}^x[N_2]_2{}^y}{k[Cl_2]_1{}^x[N_2]_1{}^y} = \frac{[Cl_2]_2{}^x[N_2]_2{}^y}{[Cl_2]_1{}^x[N_2]_1{}^y} = \frac{[Cl_2]_2{}^x[N_2]_2{}^y}{[Cl_2]_1{}^x[N_2]_1{}^y}$$

$$\frac{0.045\frac{atm}{min}}{0.011\frac{atm}{min}} = \frac{[Cl_2]_2{}^x[N_2]_2{}^y}{[Cl_2]_1{}^x[N_2]_1{}^y} = \frac{(0.500)^x(0.500)^y}{(0.500)^x(0.250)^y} = \left(\frac{0.500}{0.250}\right)^y = 2^y$$

$4.09 = 2^y$

$$ln4.09 = \ln(2^y) = yln2$$

$$y = \frac{\ln 4.09}{\ln 2} = 2.03 \approx 2$$

Either way – 2nd order!

Piece #6 (1/2 pt) What is the order of the reaction with respect to nitrogen?

Same game, only using Expt 1 and Expt 3. Now, the Nitrogen has doubled, but the rate hasn't changed. So, zeroth order!

Piece #7 (1/2 pt) Write the rate law for the reaction.

$$Rate = k[Cl_2]^2$$

Piece #8 (1/2 pt) What is the rate constant (k) for the reaction at 300 K, with appropriate units?

Really should take an average of all 3:

$$Rate = k[Cl_2]^2$$

$$0.0115\frac{atm}{min} = k[0.250\ atm]^2$$

$$k = 0.184\ atm^{-1}min^{-1}$$

$$0.045\frac{atm}{min} = k[0.500\ atm]^2$$

$$k = 0.180\ atm^{-1}min^{-1}$$

$$0.011\frac{atm}{min} = k[0.250\ atm]^2$$

$$k = 0.176\ atm^{-1}min^{-1}$$

$$k_{avg} = 0.180\ atm^{-1}min^{-1}$$

Piece #9 (1/2 pt) What is the rate constant (k) for the reaction at 500 K, with appropriate units?

The orders should stay the same, only k changes with the temperature.

$$Rate = k[Cl_2]^2$$

$$0.072\frac{atm}{min} = k[0.500\ atm]^2$$

$$k = 0.288\ atm^{-1}min^{-1}$$

Piece #10 (1/2 pt) 1 atm of nitrogen and 1 atm of chlorine are mixed in a 2 L flask at 500 K. What is the initial rate of the reaction?

$$Rate = 0.288\ atm^{-1}min^{-1}[Cl_2]^2$$

$$Rate = 0.288\ atm^{-1}min^{-1}[1\ atm]^2 = 0.288\frac{atm}{min}$$

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