

“Recitation”

CHMG 142

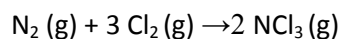
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The following data was collected for the reaction of nitrogen gas and chlorine gas to form nitrogen trichloride gas.

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

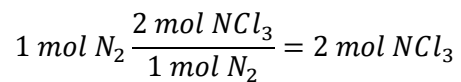
Piece #1 (1/2 pt.) Write a balanced equation for the reaction of nitrogen gas and chlorine gas to form nitrogen trichloride gas.



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

$$1 \text{ mol N}_2 \frac{3 \text{ mol Cl}_2}{1 \text{ mol N}_2} = 3 \text{ mol Cl}_2$$

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



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?

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

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

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

- 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!

$$\frac{Rate_{expt2}}{Rate_{expt3}} = \frac{k[Cl_2]_2^x [N_2]_2^y}{k[Cl_2]_1^x [N_2]_1^y} = \frac{[Cl_2]_2^x [N_2]_2^y}{[Cl_2]_1^x [N_2]_1^y} = \frac{[Cl_2]_2^x [N_2]_2^y}{[Cl_2]_1^x [N_2]_1^y}$$
$$\frac{0.045 \frac{atm}{min}}{0.011 \frac{atm}{min}} = \frac{[Cl_2]_2^x [N_2]_2^y}{[Cl_2]_1^x [N_2]_1^y} = \frac{(0.500)^x (0.500)^y}{(0.500)^x (0.250)^y} = \left(\frac{0.500}{0.250}\right)^y = 2^y$$

$$4.09 = 2^y$$

$$\ln 4.09 = \ln(2^y) = y \ln 2$$

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

Either way – 2<sup>nd</sup> 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.

$$\text{Rate} = k[\text{Cl}_2]^2$$

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:

$$\text{Rate} = k[\text{Cl}_2]^2$$

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

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

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

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

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

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

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

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.

$$\text{Rate} = k[\text{Cl}_2]^2$$

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

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

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?

$$\text{Rate} = 0.288 \text{ atm}^{-1} \text{ min}^{-1} [\text{Cl}_2]^2$$

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