Unit 4, Lesson 01: Introduction to Reaction Rates, Answers to Homework

Page 272

1. Reaction: cyclopropane (C_3H_6) $\rightarrow$ propene (C_3H_6)

   Propene is produced at the same rate that cyclopropane is consumed. If cyclopropane is consumed at a rate of 0.25 mol/s, then propene is produced at 0.25 mol/s.

2. Reaction: $\underline{4\ NH_3\ (g)}$ + $5\ O_2\ (g)$ $\rightarrow$ $4\ NO\ (g)$ + $\underline{6\ H_2O\ (g)}$

   $$\frac{4}{0.068\ \text{mol/L/s}} = \frac{6}{x}$$

   Cross multiply: $4x = 6 \times 0.068$ mol/L/s

   $x = 0.10$ mol/L/s (2 sig digs)

   Therefore, water is produced at a rate of 0.10 mol/L/s

3. Reaction: $4\ HBr\ (g) + O_2\ (g) \rightarrow 2\ Br_2\ (g) + 2\ H_2O\ (g)$

   HBr is consumed two times faster than Br_2 is formed, so;

   rate of change in HBr = 2 x rate of change in Br_2

   or rate of change in Br_2 = ½ rate of change of HBr

Answers to Homework on Handout:

a) Completed data table for the reaction:

$N_2O_4\ (g) \rightarrow 2\ NO_2\ (g)$

To calculate the pressure of N_2O_4:

N_2O_4 is used up at half the rate that NO_2 is produced.

If 4.2 atm of NO_2 is produced, then 2.1 atm of N_2O_4 is consumed, leaving (20.0 atm – 2.1 atm) = 17.9 atm N_2O_4

To calculate the pressure of N_2O_4, you can use the equation:

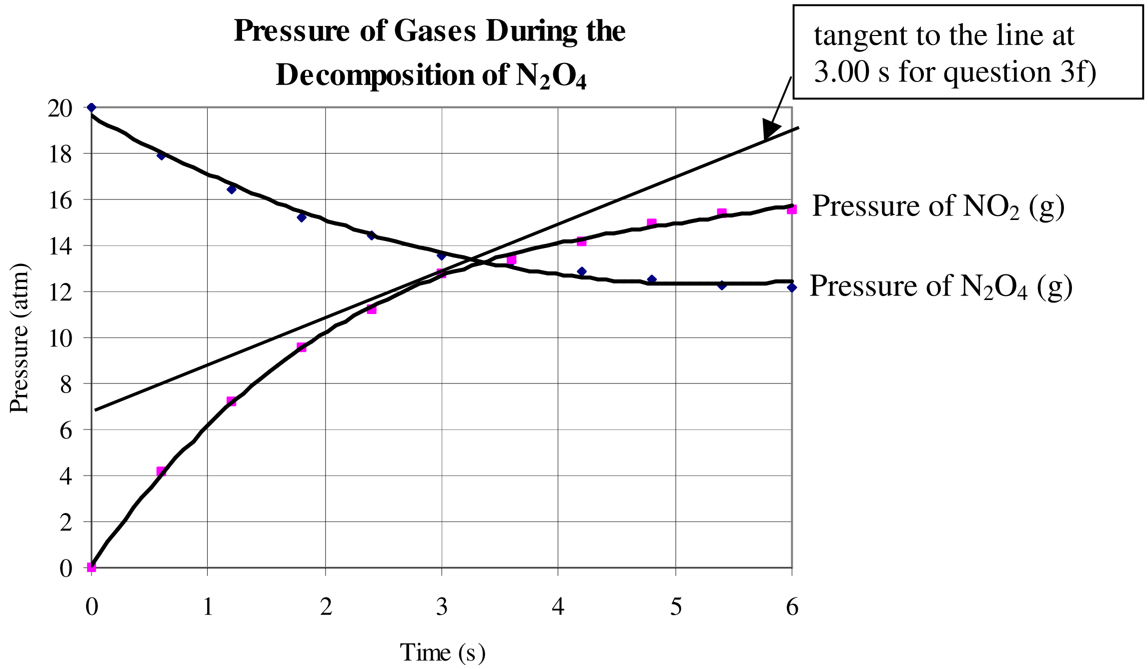
P_{N2O4} = 20.0 atm – ½ P_{NO2}

(You do not need to show your work. I included it so you could see where the numbers came from.)

Pressures of Gases Measured for the Decomposition of $N_2O_4(g)$

Time (s)	**Pressure N_2O_4 (atm)**	**Pressure NO_2 (atm)**
0.00	20.0	0.0
0.60	20.0 – ½(4.2) = 17.9	4.2
1.20	20.0 – ½(7.2) = 16.4	7.2
1.80	20.0 – ½(9.6) = 15.2	9.6
2.40	20.0 – ½(11.2) = 14.4	11.2
3.00	20.0 – ½(12.8) = 13.6	12.8
3.60	20.0 – ½(13.4) = 13.3	13.4
4.20	20.0 – ½(14.2) = 12.9	14.2
4.80	20.0 – ½(15.0) = 12.5	15.0
5.40	20.0 – ½(15.4) = 12.3	15.4
6.00	20.0 – ½(15.6) = 12.2	15.6

b) See graph below. Be sure that you include a detailed title, labelled both axes with units. Time must be on the x-axis.



b) Describe the reaction rate in the first 0.60 s of the reaction. Explain why it is like this.

In the first 0.60 s, the reaction rate is very fast. This is because the concentration of N_2O_4 is very high, so the reaction is progressing at its maximum rate.

c) Describe the reaction rate in the last 0.60 s of the reaction. Explain why it is like this.

In the last 0.60 s, the reaction rate is very slow, approximately zero. This is because the concentration of N_2O_4 is extremely small, so there is very little of it present to react and the reaction essentially stops.

d) Calculate the rate of the reaction for both species during the first 1.80 s (ie. between 0.0 and 1.80 s). Is this the average rate, instantaneous rate or initial rate for the reaction?

$$\text{reaction rate } N_2O_4 = \frac{\text{final pressure } N_2O_4 - \text{initial pressure } N_2O_4}{\text{final time} - \text{initial time}}$$

$$= \frac{15.2\text{ atm} - 20.0\text{ atm}}{1.80\text{ s} - 0.00\text{ s}}$$

= - 2.67 atm/s, but the " – " sign is ignored (take the absolute value)
= 2.67 atm/s for N_2O_4

Similarly, the reaction rate for NO_2 in the first 1.80 s is 9.6 atm / 1.80 s = 5.3 atm / s

These rates are the average reaction rate for the first 1.80 s of the reaction, and they are approximately equal to the initial rate for the reaction (either of these answers is acceptable because it is the rate so early in the reaction). They are NOT the instantaneous rate for the reaction at 1.80 s.

e) To find the instantaneous rate of reaction for NO_2 at 3.00 s, draw a tangent to the line at 3.00 s (a line that it perpendicular to the curve at 3.00 s and touches the curve in only one spot). See graph. Calculate the slope of the tangent. This is equal to the rate of the reaction at that point in time.

$$\text{reaction rate } NO_2 = \frac{\text{final pressure } NO_2 - \text{initial pressure } NO_2}{\text{final time} - \text{initial time}}$$ (pick any 2 points on the tangent)

$$= \frac{19 \text{ atm} - 6.8 \text{ atm}}{6.0 \text{ s} - 0.0 \text{ s}}$$

$$= 2.0 \text{ atm/s} \quad \text{at } 3.00 \text{ s}$$ (you can only read 2 sig digs from this graph)

therefore, NO_2 is being produced at a rate of 2.0 atm/s at 3.00 s