TEAM PROBLEM

CHAPTER 13

The reaction: $AB_{(aq)} \rightarrow A_{(g)} + B_{(g)}$ is second-order in AB and has a rate constant of 0.0118 M^{-1} s^{-1} at 25.0⁰C. A reaction vessel initially contains 250.0mL of 0.100M AB which is allowed to react to form gaseous product. The product is collected over water at 25⁰C. How much time is required to produce 200.0mL of the products at a pressure of 755.1mmHg?

ANSWER:

Plan for solving:
- Imagine what is happening so you can understand it
- Think about what you know – information, equations etc.
  - plan your calculations

What is going on?
- From the chemical reaction, there is a solution ($AB_{(aq)}$) that is decomposing into two gasses ($A_{(g)}$ & $B_{(g)}$) At the end of the time, there should be 200.0mL of gas above the surface of the solution.
- So imagine a syringe with 250.0mL of solution and no gas. As the reaction takes place the gasses exert pressure on the plunger pushing it back. When it reached 200.0mL we have the time asked for – this all assumes that the outside pressure is 755.1mmHg (which means the pressure inside the syringe is 755.1mmHg as well)

What is known?
- Second-order reaction – the integrated rate law (which tells us about how the concentration varies over time) is:
  $1/[AB]_t = kt + 1/[AB]_0$
- Gasses collected over water are involved:
  PV=nRT, subtracting the water vapor pressure from the total pressure
  Vapor Pressure of water at 25⁰C = 24mmHg (had to look that up)
- $[AB]_0 = 0.100M$
- $k = 0.0118$ $M^{-1}s^{-1}$

Plan the calculations:
Step 1: Ultimately, need to find "t" in the integrated rate law – the only part missing is $[AB]_t$
Step 2: Find the moles of gas needed to have 200.0mL at 755.1mmHg
Step 3: Find the moles of AB that was used making that amount of gas
Step 4: Find the [AB] left after that amount is used – this is $[AB]_t$
Step 5: Put it into the integrated rate law & solve for time

Step 1:

$1/[AB]_t = (0.0118M^{-1}s^{-1})(t) + 1/[0.100M]$

Step 2:
- The total pressure is due to the pressure of $A_{(g)}$ & $B_{(g)}$ & H_2O (remember you are collecting a gas over water)
- $P_{tot} = P_A + P_B + P_{H2O}$
  $P_{tot} = 755.1mmHg$
  $P_{H2O} = 24mmHg$ (looked up on Internet)
- $(755.1mmHg) - (24mmHg) = 731.1mmHg = P_A + P_B$
- $P_A = P_B$ b/c the moles of A = B b/c for every A you make a B (look at coefficients)
  so $P_A = 365.55mmHg$ (1/760mmHg) = 0.480atm
- $25^0C = 298K$
- $PV = nRT$
  $(0.480atm)(0.200L) = n (0.0821 \ Latm \ mol^{-1}K^{-1}) (298K)$
  $n = 0.00393mol$ of gas A, and of gas B

Step 3:
- if 0.00393mol of A is made then 0.00393mol of AB has been used (see coefficients)

Step 4:
- Initially there was
  250.0mL (1L/1000mL)(0.100mol/1L) = 0.0250mol AB
- 0.0250molAB initial – 0.00393mol AB used = 0.02102mol AB left in the 250.0ml solution
- 0.02102mol AB/0.250L = 0.0843M = $[AB]_t$

Step 5:
- Plug & chug!
- $1/[0.0843M] = (0.0118M^{-1}s^{-1}) \ t + 1/[0.100M]$
- 157.8 s = t

So after ==157.8 seconds==, there should be 200.0mL of gas above a 0.0843M AB solution