Equilibrium #6

Key

A. Reactant/Product Concentration Graph

The decomposition of phosphorus pentachloride, PCl_5, into phosphorus trichloride and chlorine gas is a reversible reaction that reaches a state of chemical equilibrium.

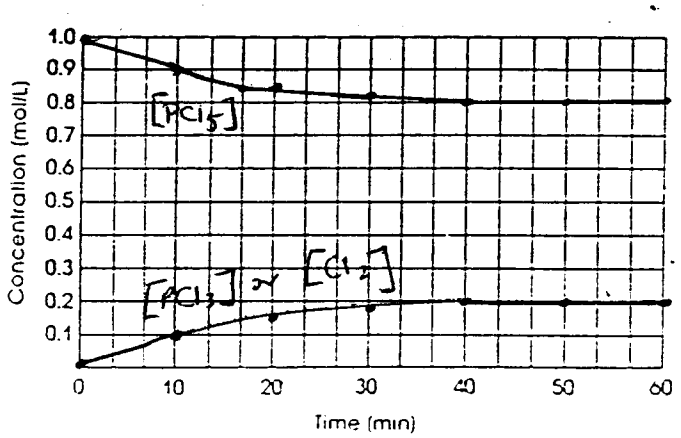
The equilibrium reaction is

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

One mole of PCl_5 is placed in a sealed one-liter container and heated to 250°C. The concentrations of reactant and products are measured at ten-minute intervals. The following data are collected.

TIME (MINUTES)	CONCENTRATIONS (MOLES PER LITER)		
	$[PCl_5]$	$[PCl_3]$	$[Cl_2]$
0	1.00	0.00	0.00
10	0.90	0.10	0.10
20	0.85	0.15	0.15
30	0.82	0.18	0.18
40	0.80	0.20	0.20
50	0.80	0.20	0.20
60	0.80	0.20	0.20

Plot this data on the grid provided. Answer the questions that follow.



1. How long did it take for the reaction to reach equilibrium?

40 minutes

2. What is the equilibrium concentration of each reaction component?

$[PCl_5] = 0.80\ M$ $[PCl_3] = [Cl_2] = 0.20\ M$

As each PCl_5 particle reacts it forms 1 PCl_3 and 1 Cl_2 particle

4. Predict the concentration of each component at 70 minutes.

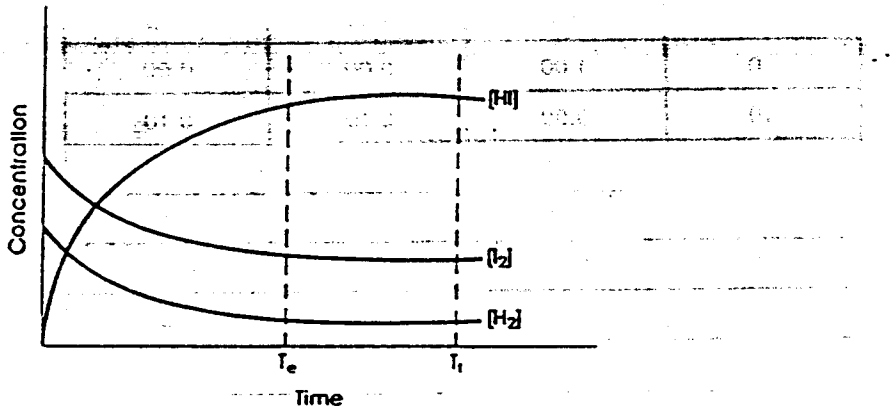
If conditions are unchanged $[PCl_5] = 0.80M$ $[PCl_3] = [Cl_2] = 0.20M$

B. Predicting Reactant/Product Concentrations

The synthesis of hydrogen iodide is a reversible exothermic reaction that proceeds as follows.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

In a laboratory experiment, hydrogen gas and iodine gas are placed in a sealed reaction flask. The gases react to produce hydrogen iodide until equilibrium is established. The concentrations of reactants and product are plotted in the graph that follows. Assume equilibrium is reached at point T_e.



The following changes are introduced at time T_f. Determine which situation best describes how the graph would be changed to the right of T_f. Write your answer in the space provided.

1. Concentration of I_2 is increased the HI curve rises, the I_2 curve rises, the H_2 curve drops
   a. The HI curve rises, the I_2 curve drops, the H_2 curve remains the same.
   b. The HI curve drops, the I_2 curve rises, the H_2 curve drops.
   c. The HI curve rises, the I_2 curve rises, the H_2 curve drops.

2. Temperature of the system is increased the H_2 and I_2 curves rise, the HI curve drops
   a. The curves for all three components rise.
   b. The H_2 and I_2 curves rise, the HI curve drops.
   c. The H_2 and I_2 curves drop, the HI curve rises.

3. Pressure of the system is increased All curves rise (depends on method used to increase pressure)
   a. All curves rise
   b. The H_2 and I_2 curves drop, the HI curve rises.
   c. All curves remain the same.

4. If a catalyst is present at the initial introduction of reactants, how would the graph differ from the one shown?

the time taken to reach equilibrium would be less

C. Applying Le Chatelier's Principle

The oxidation of ammonia is a reversible exothermic reaction that proceeds as follows:

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

Le Chatelier's principle allows us to predict the changes that occur in an equilibrium reaction to compensate for any stress that is placed upon the system. For each situation described in the table, use the symbol ↑ to show an increase in concentration or the symbol ↓ to show that a decrease in concentration is expected.

COMPONENT	STRESS	EQUILIBRIUM CONCENTRATIONS			
		$[NH_3]$	$[O_2]$	$[NO]$	$[H_2O]$
NH_3	addition	1 ↑	↓	↑	↑
	removal	2 ↓	↑	↓	↓
O_2	addition	3 ↓	↑	↑	↑
	removal	4 ↑	↓	↓	↓
NO	addition	5 ↑	↑	↑	↓
	removal	6 ↓	↓	↓	↑
H_2O	addition	7 ↑	↑	↓	↑
	removal	8 ↓	↓	↑	↓
Increase in temperature		9 ↑	↑	↓	↓
Decrease in temperature		10 ↓	↓	↑	↑
Increase in pressure		11 ↑	↑	↓	↓
Decrease in pressure		12 ↓	↓	↑	↑
Addition of a catalyst		13 —	—	—	—