Limiting Reactants

Purpose:

To investigate the mathematics of chemical reactions under conditions in which there is a limiting and an excess reactant.

Getting Ready:

Visit the **Limiting Reactants** simulation at The Physics Classroom website:

https://www.physicsclassroom.com/Physics-Interactives/Chemistry/Limiting-Reactants

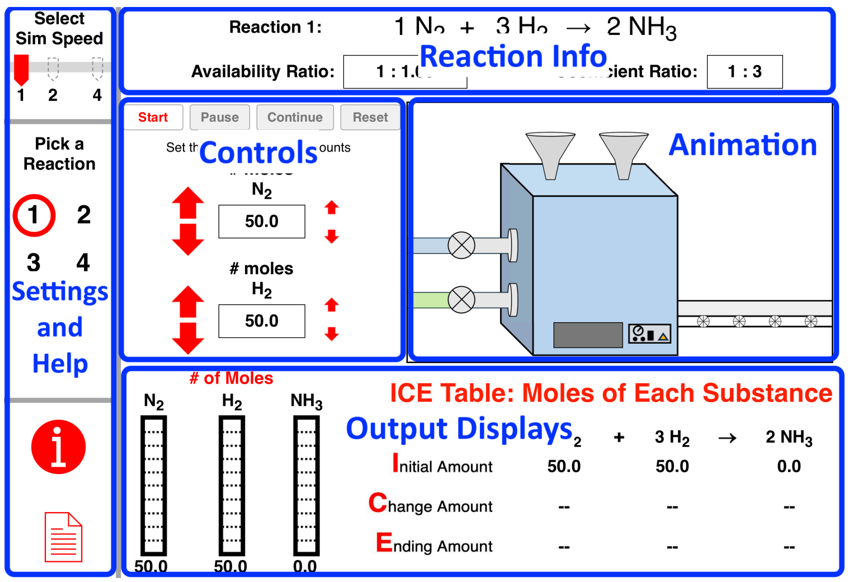
Navigational Path:

www.physicsclassroom.com ➔ Physics Interactives ➔ Chemistry ➔ Limiting Reactants

Getting Acquainted:

The interface is shown at the right. There are five main sections that we will reference in this activity:

- Settings and Help
- Reaction Information
- Controls
- Animation
- Output Display



Observe each section and become acquainted with the interface. Before starting, experiment with the Controls, adjust some settings and observe the results, tap Start and watch an animation and the Output displays. It's not too complicated; but get acquainted with the buttons and the output displays before we begin.

Part 1: Stoichiometric Conditions

1. Adjust the Sim Speed to level 1. Pick Reaction 1 to study. Observe the balanced chemical equation in the Reaction Information section. The Coefficient Ratio is 1:3 for the two reactants. Run the following trials. They should all have the same **Availability Ratio**. Record the results in the table. Pick your own reactant amounts for Trials 3 and 4.

Trial	Init. Moles of N_2	Init. Moles of H_2	Avail. Ratio	Ending Moles NH_3
1	10	30	1: 3.00	
2	20	60	1 : 3.00	
3			1 : 3.00	
4			1 : 3.00	

2. Observe the **ICE Table**.
What is the **Ending Amount** of reactants when the Availability Ratio matches the Coefficient Ratio?

3. Rerun a trial if you must to answer this question. Observe the bar charts on the left side of the Output Displays section. How would you describe the final bar height of the reactants in these trials?

4. The reaction conditions in **Question 1** are referred to as **Stoichiometric Conditions**. The reactants are initially present in the reactor at the same ratio at which the reactants are consumed. In this case, it was 1 part N_2 to 3 parts H_2. Under such conditions, all the reactants are used up. For reaction 1, the mole ratio is 1:3. But it is different for different reactions. Pick one of the other reactions (but not #5 or #6) and repeat the study. Adjust the # of moles so that the **availability ratio** matches the **coefficient ratio**. Complete the table below, including the balanced chemical equation:

Reaction #____: ____________________ (Reactants) → ___________ (Product) Coeff. Ratio = ______

Trial	Init. Moles of _____ (Rxt 1)	Init. Moles of _____ (Rxt 2)	Availability Ratio*	Ending Moles of _____ (Product)
1				
2				
3				

* Must match the Coeff. Ratio

5. For the reaction you have chosen, describe how the mole amounts must be initially set in order for all the reactants to be used up.

Part 2: Non-Stoichiometric Conditions

6. Select **Reaction #1** again. Keep the **Sim Speed** set to level 1. If you must, use the simulation to answer these two questions:
   - How many mol of H_2 react with 10.0 mol of N_2? __________
   - How many mole of NH_3 are produced by the reaction of 10.0 mol of N_2? __________

7. Now run the following trials. Record all data.

Trial	Initial Moles N_2	Initial Moles H_2	Avail. Ratio	Ending Moles N_2	Ending Moles H_2	Ending Moles NH_3
1	10.0	40.0				
2	10.0	50.0				
3	10.0	24.0				
4	10.0	18.0				

8. The reaction conditions in **Question 7** are referred to as **Non-Stoichiometric Conditions**. The availability ratio is not matched to the coefficient ratio. One of the reactant bars depletes to 0 height; the other bar is greater than 0. One of the reactants is used up; there is an excess or left overs of the other reactant. The reactant that is used up is referred to as the **limiting reactant**. When it becomes used up, the reaction stops. The reactant that is left over at that point is the **excess reactant**. Complete the table at the right, identifying the formula (N_2 or H_2) of the limiting and the excess reactant for each trial from **Question 7**.

Trial	Coeff. Ratio	Avail. Ratio	Limiting Reactant	Excess Reactant
1	1 : 3			
2	1 : 3			
3	1 : 3			
4	1 : 3			

9. For Reaction 1, the coefficients indicate that there must be 3 times as much H_2 as N_2 (in terms of moles). Based on the above data, complete the following statements.

If there is more than 3X as much H_2 as N_2, then the limiting reactant is _________ (N_2, H_2) and the excess reactant is _________ (N_2, H_2).

If there is less than 3X as much H_2 as N_2, then the limiting reactant is _________ (N_2, H_2) and the excess reactant is _________ (N_2, H_2).

10. Run the following three trials for Reaction 1. Then answer the follow-up questions.

Trial	Initial Moles N_2	Initial Moles H_2	Avail. Ratio	Ending Moles N_2	Ending Moles H_2	Ending Moles NH_3
1	15.0	30.0				
2	20.0	30.0				
3	30.0	30.0				

11. For the above table (**Question 10**), H_2 is the limiting reactant and N_2 is the excess reactant. Identify the following statements as being True (**T**) or False (**F**).

T or F?	Statement
________	a. The reactant with the least number of moles is the limiting reactant.
________	b. The reaction ends when the limiting reactant is used up.
________	c. If the amount of excess reactant is increased, more product is made.
________	d. The excess reactant is the reactant that is partly left over at the end.
________	e. The limiting reactant is the reactant that is used up first.

12. Predict:
   a. If 14.0 mol N_2 and 30.0 mol H_2 are present, then ________ is the limiting reactant and there will be ________ mol of the excess reactant and ________ mol NH_3 at the end.

   b. If 10.0 mol N_2 and 34.0 mol H_2 are present, then ________ is the limiting reactant and there will be ________ mol of the excess reactant and ________ mol NH_3 at the end.

Part 3: Predicting the Amount of Product and Excess Reactant

13. An ICE Table is a tool for keeping track of the amount of reactants and products that are **I**nitially present, the amount of **C**hange that occurs as the result of the reaction, and the **E**nding amount of reactants and product. Complete the following ICE Tables. Use coefficient ratios and availability ratios to think through what is limiting and excess and to complete the math on your own. But if needed, use the simulation to complete or to check answers for the tables. The tables apply to reactions 1, 4, and 8.

Rxn #1:	N_2	+	$3\ H_2$	→	$2\ NH_3$
I	20.0		70.0		0.0
C					
E					

Rxn #1:	N_2	+	$3\ H_2$	→	$2\ NH_3$
I	40.0		90.0		0.0
C					
E					

Rxn #4:	$3\ Ti$	+	$2\ N_2$	→	Ti_3N_4
I	30.0		30.0		0.0
C					
E					

Rxn #4:	$3\ Ti$	+	$2\ N_2$	→	Ti_3N_4
I	40.0		20.0		0.0
C					
E					

Rxn #8:	$4\ Li$	+	O_2	→	$2\ Li_2O$
I	40.0		20.0		0.0
C					
E					

Rxn #8:	$4\ Li$	+	O_2	→	$2\ Li_2O$
I	50.0		10.0		0.0
C					
E					

14. If you can accurately complete these statements, then you've earned the Dataway! Statements are based on Reaction #1.

Dataway!!

   a. There are initially 15 mol N_2 and 60 mol H_2. The _____ is the limiting reactant. All of the _____ will react and there will be _____ mol of _____ remaining. _____ mol NH_3 are produced.

   b. There are initially 25 mol N_2 and 60 mol H_2. The _____ is the limiting reactant. All of the _____ will react and there will be _____ mol of _____ remaining. _____ mol NH_3 are produced.

   c. There are initially 12 mol N_2 and 40 mol H_2. The _____ is the limiting reactant. All of the _____ will react and there will be _____ mol of _____ remaining. _____ mol NH_3 are produced.

   d. There are initially 20 mol N_2 and 45 mol H_2. The _____ is the limiting reactant. All of the _____ will react and there will be _____ mol of _____ remaining. _____ mol NH_3 are produced.