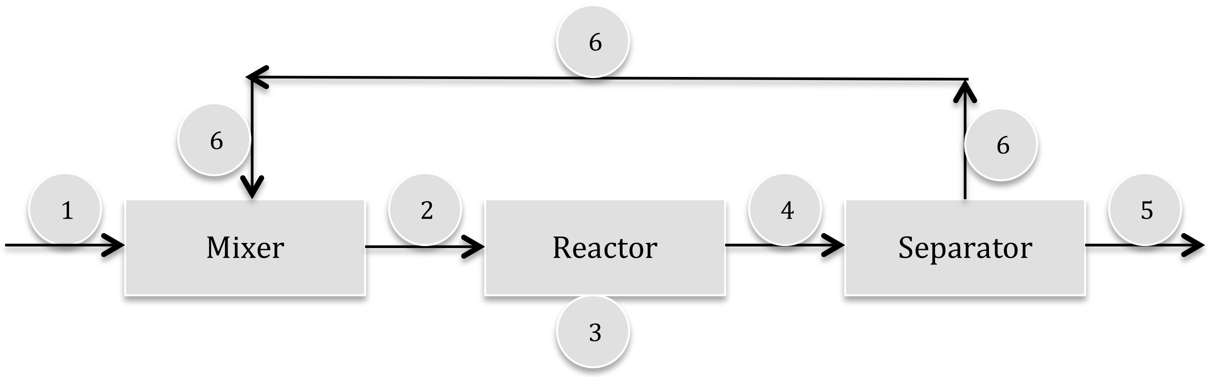
Objective

The use of Microsoft Excel Spread Sheet™ to solve material balance for the given feed stream

Theory

The use of Excel to solve mass balances for a process consisting of a feed stream, a mixer in which the feed stream is mixed with the recycle stream, and a reactor, followed by a separator where the product is removed and the reactants are recycled. **The reactor is limited by chemical equilibrium consideration.** The process takes hydrogen and nitrogen (in a 3:1 ratio) to make ammonia. The reactor is limited by equilibrium; you will prepare the spreadsheet in stages to aid troubleshooting. Thus, prepare a spreadsheet as shown in Figure using 25 percent conversion per pass in the reactor.

Process Diagram



Reaction involved

$$N_2 + 3H_2 \rightarrow 2NH_3$$

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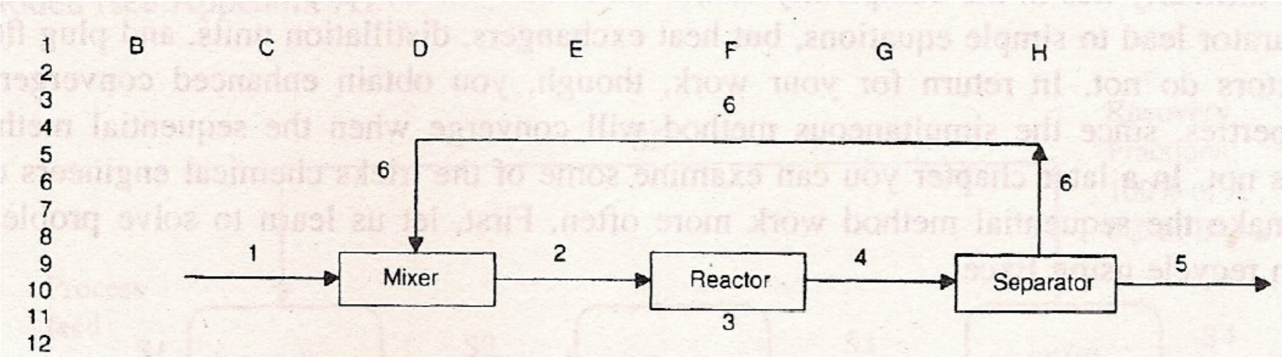
Simulation Diagram



	B	C	D	E	F	G	H
13		1	2	3	4	5	6
14	Nitrogen	100.00	394.09	−98.52	295.57	1.48	294.09
15	Hydrogen	300.00	1182.27	−295.57	886.70	4.43	882.27
16	Ammonia	0.00	4.02	197.04	201.07	197.04	4.02
17	Total	400.00	1580.38	−197.04	1383.33	202.96	1180.38
18							
19			Conversion	0.25			

Algorithm

Step 1 The mixer takes streams 1 and 6, adds them, and puts them into stream 2.

Step 2 Stream 3 is not really a stream but it is the moles reacting so the reaction stoichiometry is clearly displayed.

Step 3 Cell EI4 is set to the negative (for reactants) of nitrogen in stream 2 times the conversion (in cell E 19).

Step 4 Cell E 15 is set to three times cell E 14 (hydrogen uses three times the nitrogen reacting), and cell EI6 is set to twice the nitrogen in cell E14. In this column, the signs are negative for reactants and positive for products. The spreadsheet clearly shows that the stoichiometry is correct.

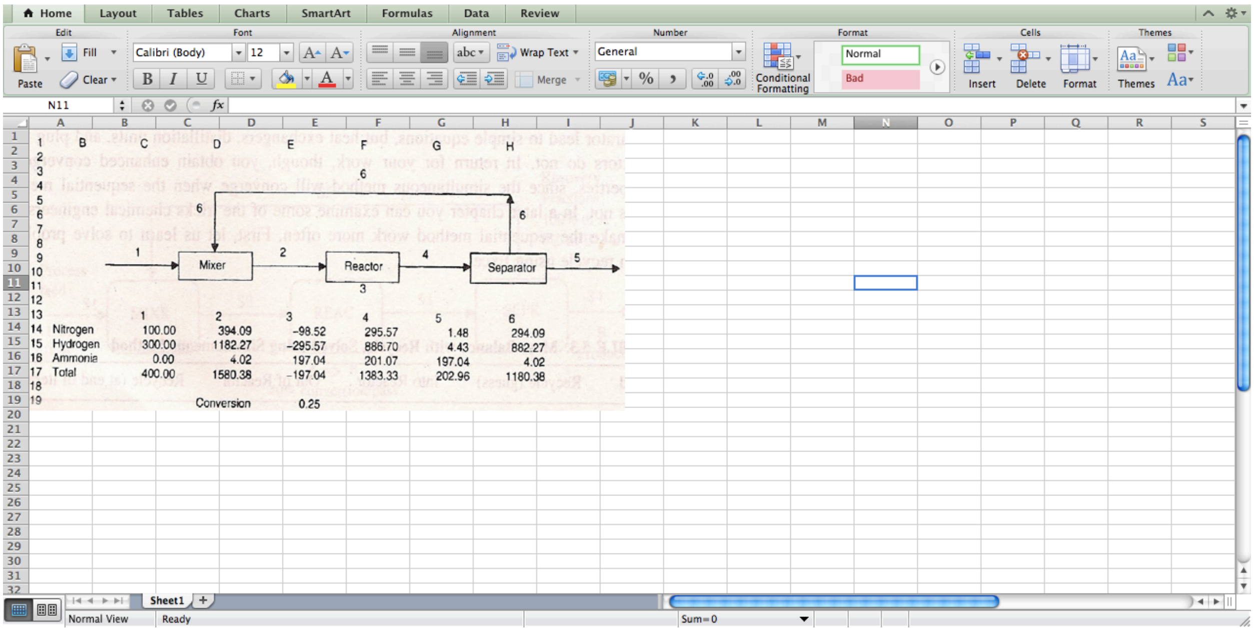
Step 5 Stream 4 is the sum of streams 2 and 3.

Step 6 Stream 5 takes 98 percent of the ammonia and 0.5 percent of the nitrogen and hydrogen.

Step 7 The rest goes out in stream 6. You can easily check the mole balance around the separator.

Step 8 Turn on the iteration feature for the circular reference and the problem is solved.

Result Output



	1	2	3	4	5	6
Nitrogen	100.00	394.09	-98.52	295.57	1.48	294.09
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Reference:

Bruce A. Finlayson, *Introduction to Chemical Engineering Computing*, John Wiley and Sons, 2006 Edition, pp 62-63.