

The Ammonia Factory

Introduction:

You have been hired by Haber Manufacturing, an ammonia production company, to conduct a 180-day pilot study. They will provide you with total control of one of their many production lines. Your assignment is to determine what conditions will maximize the amount of ammonia produced on a daily basis. During your pilot study, you will modify four different parameters - Temperature, Pressure, N₂ Flow Rate, and H₂ Flow Rate. You will observe the effect these variables have upon daily yield and profit. Keep careful records. At the end of 180 days, you will file a report of your findings. The report will describe the conditions that maximize ammonia production and present the evidence and reasoning that support such claims.

Getting Ready:

Visit **The Ammonia Factory** simulation at The Physics Classroom website:

<https://www.physicsclassroom.com/Physics-Interactives/Chemistry/Ammonia-Factory>

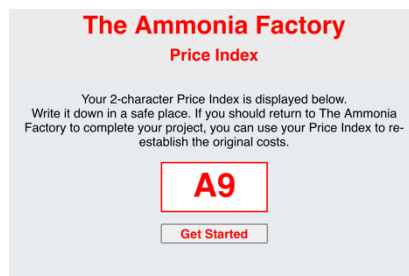
Navigational Path:

www.physicsclassroom.com → Physics Interactives → Chemistry → The Ammonia Factory

Getting Acquainted:

Once you arrive, tap the **Launch Interactive** button to start the simulation. Navigate through the initial screens. On the third screen, you will be issued a **Price Index Code**. It is used to fix the costs of raw materials (N₂ and H₂) and the sale price of ammonia. Record the 2-character Price Index Code:

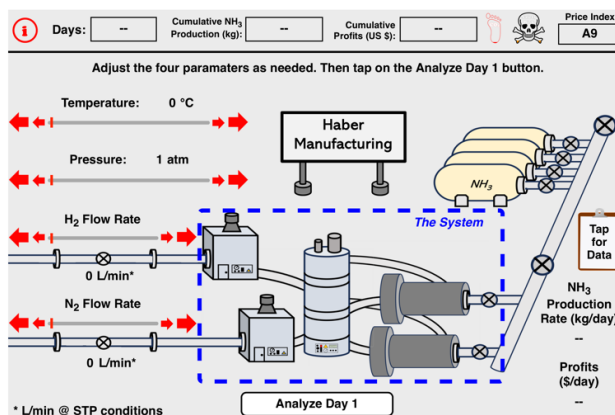
Price Index Code = _____



If you return to the page for a second visit, enter this **Price Index Code** to obtain the same prices as on the first visit. This insures consistency from visit to visit.

The user interface for the simulation page is shown at the right. There are three important elements:

- There are four parameters that you can change. Tapping on the arrows changes the values.
- The **Analyze** button at the bottom will run the simulation with the parameter values you have chosen. A daily report will be displayed
- The **Tap for Data** clipboard can be used to access all data.



Experiment with the interface until you feel comfortable with using it.

Procedural Suggestions:

1. **Be Mindful of Your Goal!**

Your assigned task should drive your activity. You are wanting to determine what set of parameter values (Temperature, Pressure, H₂ Flow Rate, and N₂ Flow Rate) produce the best performance. The best performance is measured in terms of two **output parameters** - daily NH₃ production and the Daily Profits. These values will be re-calculated and reported each time you tap on the **Analyze Day #** button.

2. **Be systematic!!**

As you modify parameter values to accomplish your assigned task, consider changing one variable at a time and observing its effect upon the two major output parameters. The Daily Report will list these output parameters. They are also tabulated in a data table that can be accessed by tapping on the Clipboard. (Tapping on the column headings of the data table provides additional info ... and some subtle hints.)

3. **Keep Good Records!!!**

As part of your goal, you will have to make a claim as to what conditions result in the highest yield of ammonia and the most profits. AND you will have to provide evidence and reasoning that support the claim. Evidence is data. You need to collect some data. Use the provided data tables to record data (or take screenshots of the provided data tables). You will reference this data as evidence and supply reasoning to convince Haber Manufacturing of why your claims are believable.

You should also be aware that all data stored in the program will be lost if you exit the page. It is OK to exit if you have a written (or screened) copy of the data. When you return, you should re-enter the Price Index Code so as to have the same pricing as in any previous visits.

Your Final Product:

(Your teacher may provide some modified instructions to the following.)

Create a written report to the Board of Directors of Haber Manufacturing in which you present the findings of your study. Make a claim as to the conditions that maximize daily NH₃ production and daily profits. Present evidence and reasoning for each of the four parameter values that you have listed in your claim. Explain the reasoning for why the Temperature should be T and not T+10 or T-10 or Your reasoning should *point* to evidence (data) that you have collected. You can reference the data by a Day number. Repeat this process for the other three variables. Also discuss the carbon footprint and the safety risk. Explain the source of these ratings and what can be done (if anything) to lower them.

As part of your discussion, introduce some Chemistry that explains the application of LeChatelier's principle, kinetics and reaction rates, and stoichiometry. Explain to the Board how these big ideas relate to your pilot study at The Ammonia Factory.

