

Chemistry 30

**Unit 3: Chemical Equilibrium**

Assignment 4

Applications of Chemical Equilibrium

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For this assignment you will research the Haber Process, an important industrial application of equilibrium.

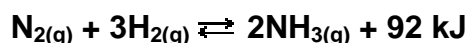
Begin by finding at least five different sources of information about this process. You may use textbooks, the Internet, other library books. List these references on your assignment.

You will not be writing a formal report; instead answer the following questions regarding the Haber Process.

1. Who developed the Haber Process? When? What country was he from?

**German chemist Fritz Haber, 1909/1910**

2. Write a balanced chemical equation for this reaction, including the energy term. Is it an endothermic or exothermic reaction?



3. Use Le Châtelier's Principle to explain the conditions that favor the forward reaction.
  - a) lower temperature. Favors the forward exothermic reaction.
  - b) increasing the pressure to favor the product side of the equation (2 moles on product side versus 4 moles on the reactant side)
  - c) remove  $\text{NH}_3$  as it forms
4. Temperature is important in regulating this reaction. Is the reaction carried out at high or low temperatures? How does this relate to part of your answer for Question 3?

**The forward reaction is exothermic, meaning it produces heat and is favored at low temperatures. Increasing the temperature tends to drive the reaction in the reverse direction, which is undesirable if the goal is to produce ammonia. However, reducing the temperature reduces the rate of the reaction, which is also undesirable. Therefore, an intermediate temperature high enough to allow the reaction to proceed at a reasonable rate, yet not so high as to drive the reaction in the reverse direction, is required.**

5. Under what temperature and pressure conditions is this reaction typically carried out?

**The reaction is usually carried out under high temperatures (400 - 500°C) and high pressures (300 – 1000 atm) (answers may vary with references used).**

6. What catalyst is used for this reaction?

**The first Haber-Bosch reaction chambers used [osmium](#) and [uranium](#) catalysts. Today a mixture of iron, potassium oxide, and aluminum oxide are used.**

7. Provide a short paragraph providing some historical background. Why was this an important chemical reaction?

**It was first used on an industrial scale by the Germans during [World War I](#): Germany had previously imported [nitrates](#) from [Chile](#), but the demand for munitions and the uncertainty of this supply in the war prompted the adoption of the process. The ammonia produced was oxidised for the production of [nitric acid](#) in the [Ostwald process](#), and the [nitric acid](#) for the production of various explosive nitro compounds used in munitions.**

7. Is the Haber Process still important today? Explain.

**Yes. The Haber process now produces about half of all the nitrogen used in agriculture: billions of people are alive and fed from its use.**

**Resources should be cited; encourage proper bibliographic format.**