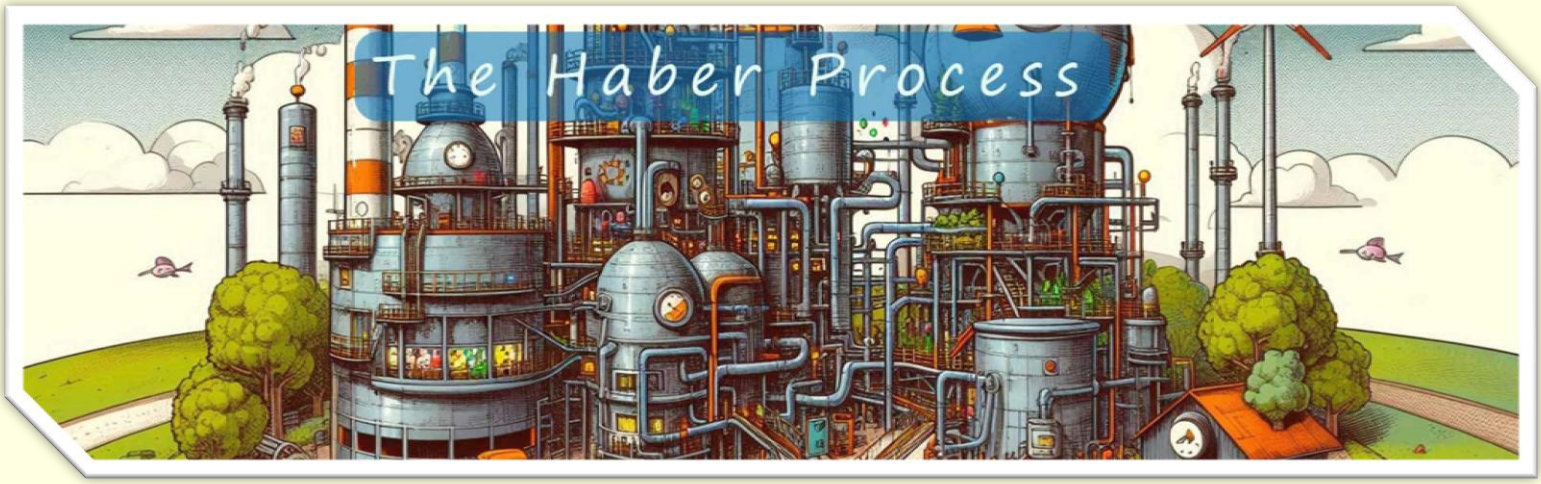
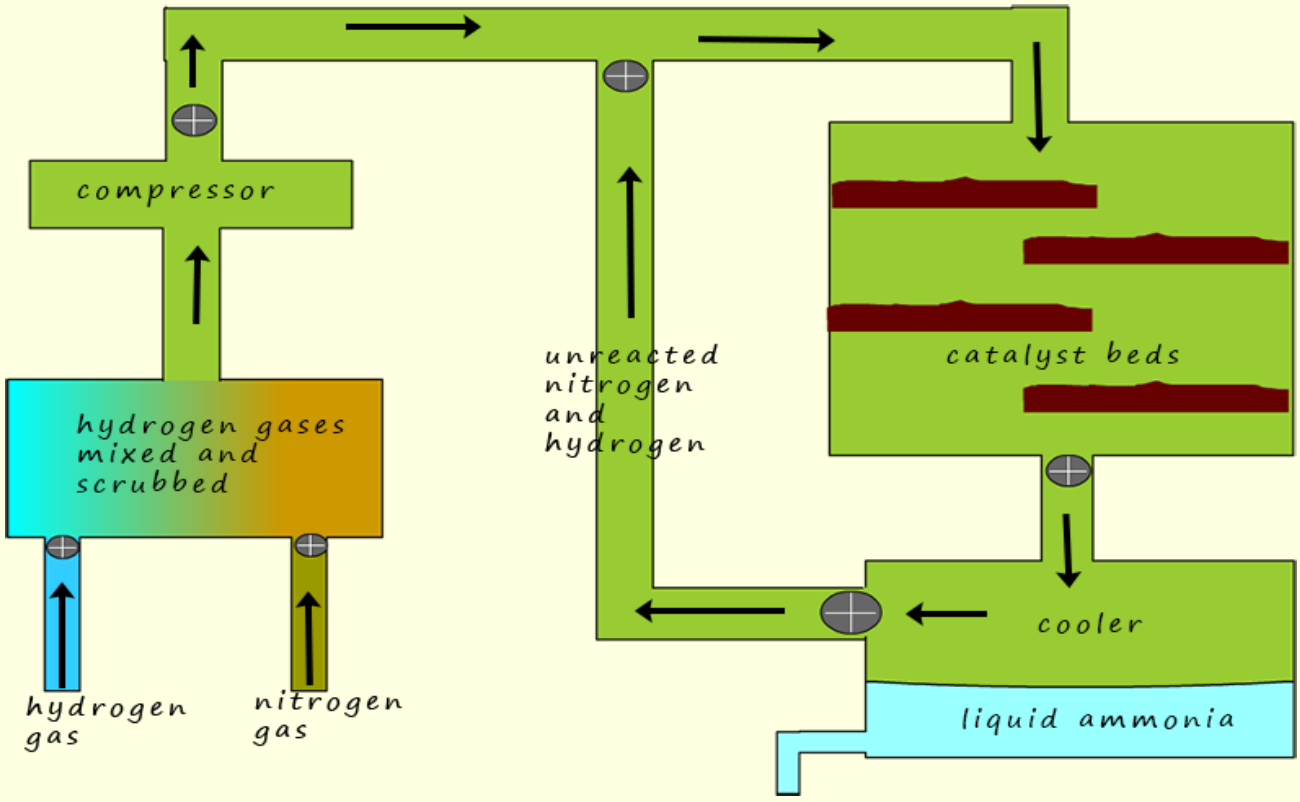


Answer the questions below then check your answers

1. Which 2 gases are used to make ammonia?
2. What is the chemical formula for ammonia?
3. Write a word equation to show how nitrogen and hydrogen react to make ammonia.
4. Where are the nitrogen and hydrogen needed to make ammonia obtained from?
5. The reaction to make ammonia is reversible. What does this mean?
6. The diagram below shows an outline of the Haber process.



a. What catalyst is used in the Haber process?

b. What gases will leave the reaction chamber and enter in cooler in the diagram of the Haber process?

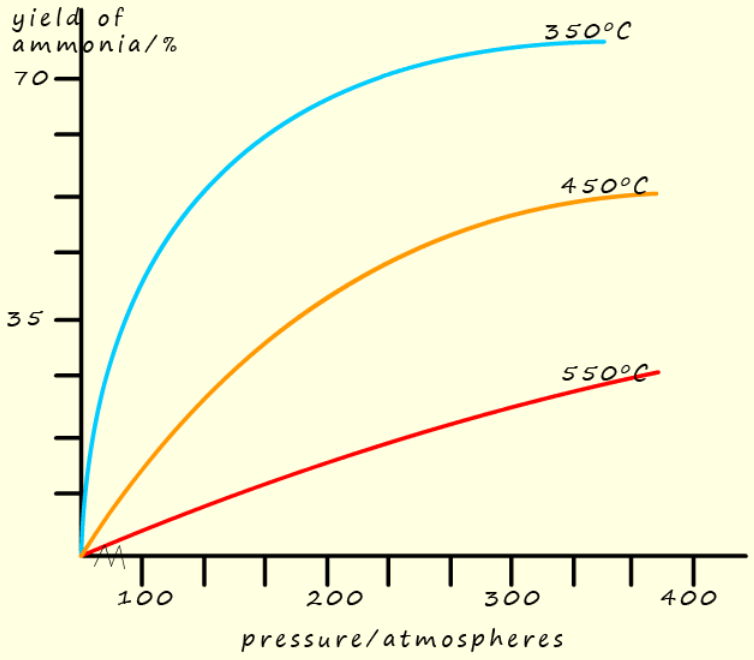
c. What happens to the unreacted nitrogen and hydrogen in the cooler?

7. The graphs below show the yield of ammonia at various temperatures and pressures.

a. What happens to the yield of ammonia as the pressure increases?

b. What happens to the yield of ammonia as the temperature increases?

c. From the graphs shown what temperature and pressure will give the largest yield of ammonia?



d. A Haber plant which manufactures ammonia operates at temperature of around 450°C and a pressure of 200 atmospheres. However from the graph these conditions do not give the maximum yield of ammonia, so why are these conditions used?

8. The equation below shows how the Haber process produces ammonia from nitrogen and hydrogen. The forward reaction is exothermic.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92KJ\ mol^{-1}$$

a. If the forward reaction is exothermic then what can you say about the back reaction?

b. What is Le Chatelier's principle?

c. According to Le Chatelier's principle what will happen to the yield of ammonia as:

i. The temperature is increased?

ii The temperature is reduced?

iii The pressure is increased?

9. What will happen to the yield of ammonia if the catalyst was suddenly removed?

10. Calculate the maximum mass of ammonia that can be made from 280Kg of nitrogen gas.

11. In one day the Haber plant expected to make 1500Kg of ammonia. However they only managed to make 650Kg. Calculate the % yield.

12. Why does it not matter so much that the % yield was low?

13. The reaction used to make ammonia is a reversible reaction. Explain why the engineers operating the plant will not allow the reaction to achieve equilibrium.

14. Suggest a reason why people in a village might not be very happy at plans to build a Haber plant manufacturing ammonia close to their village.

a. Suggest a reason why some people might welcome plans to build this factory.

Answers

1. Which 2 gases are used to make ammonia?

Nitrogen and hydrogen

2. What is the chemical formula for ammonia? NH_3

3. Write a word equation to show how nitrogen and hydrogen react to make ammonia.

Nitrogen(g) + hydrogen(g) ⇌ ammonia(g)

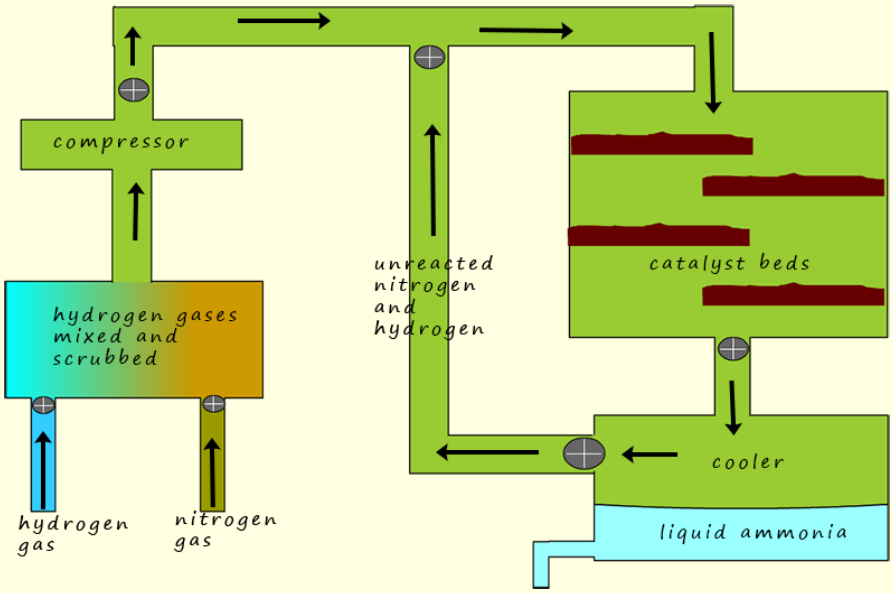
4. Where are the nitrogen and hydrogen needed to make ammonia obtained from?

Nitrogen from the air, hydrogen from methane gas by reaction with steam.

5. The reaction to make ammonia is reversible. What does this mean?

Reversible reactions are ones where the reactants can form products and the products can turn back into reactants again.

6. The diagram below shows an outline of the Haber process.



a. What catalyst is used in the Haber process?

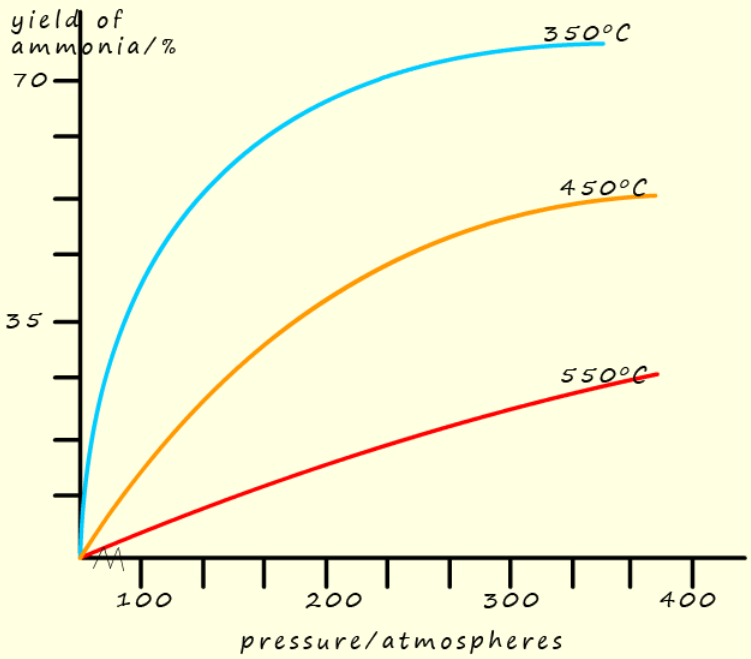
Iron catalyst

b. What gases will leave the reaction chamber and enter in cooler in the diagram of the Haber process? Ammonia, unreacted nitrogen and hydrogen

c. What happens to the unreacted nitrogen and hydrogen in the cooler?

They are re-circulated back through the reaction chamber.

7. The graphs below show the yield of ammonia at various temperatures and pressures.



a. What happens to the yield of ammonia as the pressure increases?

The yields of ammonia increases with pressure

b. What happens to the yield of ammonia as the temperature increases?

The yield of ammonia decreases as the temperature increases.

c. From the graphs shown what temperature and pressure will give the largest yield of ammonia?

Lowest temperature which is 350°C and highest pressure which is 400 atmospheres.

d. A Haber plant which manufacture ammonia operate at temperature of around 450°C and a pressure of 200 atmospheres. However from the graph these conditions do not give the maximum yield of ammonia, so why are these conditions used?

Low temperatures makes the reaction too slow so very little ammonia will be made. High pressure is to dangerous and expensive to operate the plant safely at. Compromise temperature and pressure are used - give reasonable yield of ammonia in a reasonable time.

8. The equation below shows how the Haber process produces ammonia from nitrogen and hydrogen. The forward reaction is exothermic.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = -92KJ\ mol^{-1}$$

a. If the forward reaction is exothermic then what can you say about the back reaction?

It will be endothermic.

b. What is Le Chatelier's principle?

A system (chemicals) at equilibrium will oppose any change made to it. Equilibrium is a low energy state for a reaction and the system will always try to remain there if possible.

c. According to Le Chatelier's principle what will happen to the yield of ammonia as:

i. The temperature is increased? System will try remove applied heat - so force the position of equilibrium to the left (more reactants) as back reaction is endothermic- so the yield of ammonia will decrease.

ii The temperature is reduced?

System will try to increase temperature - so force position of equilibrium towards the products- so yield will increase.

iii The pressure is increased?

Products are low pressure side of reaction, as only 2 moles of gas here. There are 4 moles of gas on the reactants side, so this can be viewed as the high pressure side. So a reaction at equilibrium will oppose any change, so if pressure is increased then system will try to reduce this - position of equilibrium will move to the right - more ammonia will be produced and the yield will increase.

9. What will happen to the yield of ammonia if the catalyst was suddenly removed?

The reaction would slow down but the amount of ammonia produced will not change. Catalyst do no effect the position of equilibrium. It will take longer to produce the same amount of ammonia but given enough time the same amount of ammonia would be produced with/without a catalyst.

10. Calculate the maximum mass of ammonia that can be made from 280Kg of nitrogen gas.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

28g ⟶ 34g

28Kg ⟶ 34Kg

280Kg ⟶ 340Kg

11. In one day the Haber plant expected to make 1500Kg of ammonia. However they only managed to make 650Kg. Calculate the % yield.

(650/1500) x 100% = 43% yield.

12. Why does it not matter so much that the % yield was low?

Unreacted nitrogen and hydrogen are re-circulated through the reactor until they react and form ammonia.

13. The reaction used to make ammonia is a reversible reaction. Explain why the engineers operating the plant will not allow the reaction to achieve equilibrium.

By constantly removing ammonia it will force the position of equilibrium to the right hand side, by Le Chatelier's principle- more ammonia

14. Suggest a reason why people in a village might not be very happy at plans to build a Haber plant manufacturing ammonia close to their village.

They operate 24/7, 365 days a year, noise and disruption will be considerable. Not exactly nice to look at! A complete eyesore.

a. Suggest a reason why some people might welcome plans to build this factory.

Jobs and money! Local business will thrive, bring in more jobs more investment.