

ACIDS

	Hydrochloric acid	Sulfuric acid
Preparation		
Physical properties		
Chemical properties		
Uses		

BASES

	Sodium hydroxide	Ammonia
Preparation		
Physical properties		
Chemical properties		
Uses		

Important Acids

Read text book: 16.4 - Important Acids , pages 343 - 349

(Only Tables 16.4, 16.6 and perhaps 16.7 are relevant to the TEE syllabus)

Read notes: Hydrochloric acid, Sulfuric acid pages 4 - 6

SUMMARY

Answer the following questions.

Chemical properties of hydrochloric acid, sulfuric acid and nitric acid.

1. These three acids react in similar ways with many substances. Complete the following general equations which illustrate these similarities:

acid + carbonate \rightarrow + + salt solution

acid + hydrogencarbonate \rightarrow + + salt solution

acid + metal oxide \rightarrow + salt solution

acid + metal hydroxide \rightarrow + salt solution

acid + sulfite (SO_3^{2-}) \rightarrow + + salt solution

acid + sulfide (S^{2-}) \rightarrow + salt solution

2. The products formed in the reactions of acids with metals can vary depending on the acid and its concentration. Complete the following general equations to summarise the products formed for the different acids and concentrations:

hydrochloric acid + metal \rightarrow + salt solution

dilute sulfuric acid + metal \rightarrow + salt solution

concentrated sulfuric acid + metal \rightarrow + H_2O + salt solution

dilute nitric acid + metal \rightarrow + H_2O + salt solution

concentrated nitric acid + metal \rightarrow + H_2O + salt solution

Industrial Manufacture of Sulfuric Acid

The manufacture of sulfuric acid involves three stages:

1. Production of SO_2
2. Production of SO_3
3. Production of H_2SO_4 .

1. Production of SO_2 .

a) What are the starting materials for this stage?

b) To form SO_2 , the sulfur is burnt in air. Write the equation for this reaction.

(Note - the SO_2 is sometimes obtained from other industries where it is an unwanted, polluting by-product e.g. in the extraction of metals such as copper)

2. Production of SO₃

- a) Give the balanced equation for the formation of SO₃ from SO₂.
- b) This reaction is exothermic. Using Le Chatelier's Principle, decide if a high temperature or a low temperature would give you a high yield of SO₃.
- c) What conditions, high or low temperature, would allow the reaction to proceed (or the equilibrium position to be reached) at the fastest rate?
- d) As you "discovered" in questions b) and c), a high temperature would give you a fast rate but a low equilibrium yield, and a low temperature would give you a high equilibrium yield but at a slow rate. An intermediate temperature of 400°C - 600°C is chosen for the reaction temperature.
At this temperature the reaction is still not 100 % nor does it occur at a very fast rate.
 - i) What is used to speed up the reaction at this temperature?
 - ii) How is the yield improved?
- e) Considering Le Chatelier's Principle, you would predict that the reaction would be more complete if a high pressure was used. Why is a high pressure not used?
- f) Why is it necessary to cool the reaction mixture as it passes from one catalyst bed to another?
- g) What precautions are necessary to ensure that the catalyst of V₂O₅ continues to work efficiently?

3. Production of concentrated H₂SO₄

- a) Describe how concentrated sulfuric acid is formed from sulfur trioxide.
- b) Give equations for the formation of concentrated H₂SO₄ from SO₃.
- c) Why is the sulfur trioxide not just dissolved in water in the industrial production of sulfuric acid?

Important bases

Read text book: 16.5 Important Bases, pages 352 - 357

Read notes: Sodium hydroxide, Ammonia, pages 6 - 7

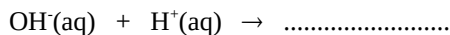
SUMMARY

Answer the following questions.

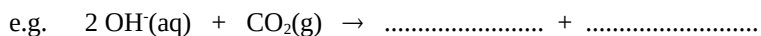
Chemical properties of sodium hydroxide.

Complete the following equations, and balance them:

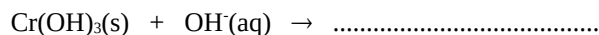
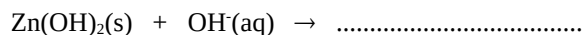
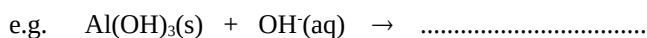
- a) reaction of a solution of sodium hydroxide with an acid:



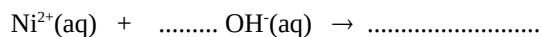
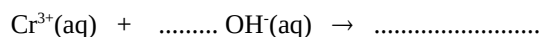
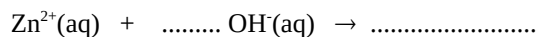
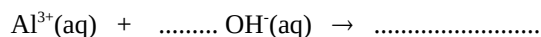
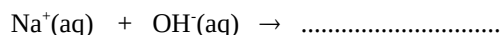
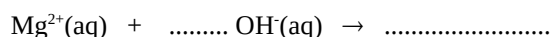
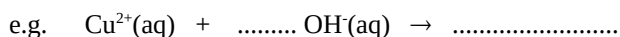
- b) reaction of a solution of sodium hydroxide with an acidic oxide



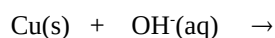
- c) reaction of a solution of sodium hydroxide with amphoteric hydroxides



- d) reaction of solution of sodium hydroxide (in excess) with a solution containing a metal ion

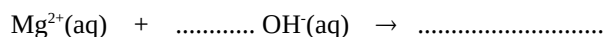


- e) reaction of a solution of sodium hydroxide with amphoteric metals

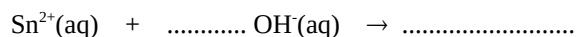
Chemical properties of ammonia - Reaction of a solution of ammonia with a solution containing metal ions

- a) when a solution of ammonia is added to most metal ions in solution, the metal ions react with the OH^- ions present in the ammonia solution, to form an insoluble metal hydroxide :

e.g ammonia solution is added to a solution of magnesium chloride

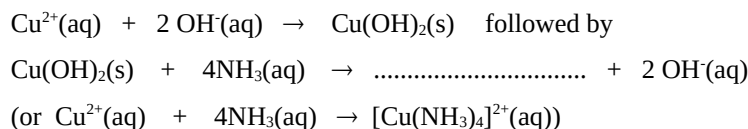


ammonia solution is added to a solution of tin nitrate

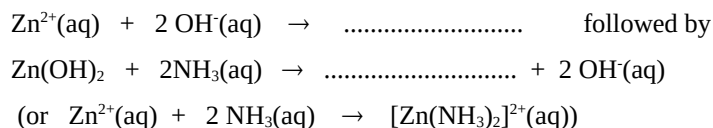


- b) when a solution of ammonia is added to a solution containing Cu^{2+} , Zn^{2+} , or Ag^+ , the product formed depends on the amount of ammonia present. First the insoluble metal hydroxide forms, then if more ammonia is present, soluble complex ions containing ammonia molecules form:

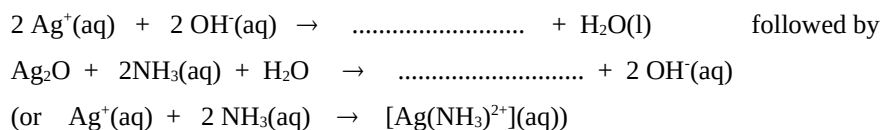
e.g. - when ammonia solution is added to a solution of copper sulfate, the following occurs:



- when ammonia solution is added to a solution of zinc nitrate, the following occurs:



- when ammonia solution is added to a solution of silver nitrate, and precipitate of Ag_2O first forms, and this then dissolves to form $[\text{Ag}(\text{NH}_3)_2]^{+}$



Industrial Manufacture of Ammonia

(For your exam you must be able to describe in detail the industrial manufacture of ammonia, giving equations, conditions used and reasons for using these conditions, in terms of equilibrium and rates principles. The following questions will help you focus on these ideas.)

The manufacture of ammonia involves only one stage.

- What are the starting materials for the industrial manufacture of ammonia?
- From where are these starting materials obtained?
- Give the balanced equation for the industrial manufacture of ammonia.
- This reaction is exothermic. Using Le Chatelier's Principle, decide if a high temperature or a low temperature would give you a high yield of ammonia.
- What conditions, high or low temperature, would allow the reaction to proceed (or the equilibrium position to be reached) at the fastest rate?
- As was the case in the production of sulfuric acid, a compromise between the use of a low temperature for a maximum yield and a high temperature for faster rate, must be made. An intermediate temperature of about 500°C is chosen for the reaction temperature. At this temperature the equilibrium yield is still quite low, and the reaction is rather slow.

What is used to speed up the reaction?

- A high pressure of about 350 atm is also used. Used Le Chatelier's Principle to explain why an increase in pressure would improve the yield of ammonia.

- h) Using a high pressure and an intermediate temperature, the reaction is only 30 - 40 % complete. As a result the gases emerging from the catalyst/reaction chamber is a mixture of ammonia, hydrogen and nitrogen gases.
- i) How is the ammonia separated from the other two gases?
- ii) What happens to the unreacted hydrogen and nitrogen gases after the ammonia has been separated from them?