

10

ACIDS

WHAT WE HAVE LEARNT

- **Acids are chemicals which produce hydronium ion when dissolved in water.**
- **Neutralisation is the reaction where acids react with alkalies producing salt and water.**
- **Losing of electrons is oxidation. Gaining of electrons is reduction.**
- **Dibasic acids give two kinds of salts.**
- **Temperature, pressure, concentration and catalysts are factors influencing the speed of chemical reactions.**

ACIDS

The quantity of industrially produced acids is said to be an indicator of the industrial advancement of a country. Acids are industrially important substances. They are essential for small and large industries. In chemical laboratories they have a variety of uses. Concentrated sulphuric acid and nitric acid can dissolve even hard metals. Almost all the elements and compounds are reacted upon by concentrated acids. What are acids in chemical terms? Basically all acids are electrolytes. You know that electrolytes are substances which produce ions when they dissolve in solvents. Acids show the common characteristics of electrolytes. Because of their high reactivity and wide use they have an important place in chemistry. With sulphuric acid and nitric acid as examples, let us examine the chemical nature of acids and their reactions.

Acids are chemicals with which you are quite familiar. You have conducted many experiments using sulphuric acid, nitric acid and hydrochloric acid. You have also studied about organic acids found in bio-materials. Some of the acids are industrially important.

You know that acids have some common properties. Prepare a list of these properties.

What is the common factor in acids? Complete the equations given below showing the ionisation of acids.



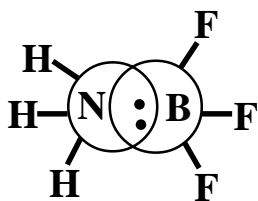
When acids dissolve in water, the hydrogen ions in them combine with water molecules forming hydronium ion (H_3O^+). The reason for common properties of acids is the presence of hydronium ions. Do you know the name of this theory?

Another theory about acids is Lowry Bronsted theory. How is an acid defined in this theory? Write down.

Lewis acids

Certain compounds with out hydrogen ions also show acidic property. These compounds are known as Lewis acids.

In the diagram below, the reaction between boron trifluoride and ammonia is given.



Can you find out the Lewis acid and base? How many more electrons do boron need to complete its octet? Which atom gives these electrons?

Why do we consider boron trifluoride as a Lewis acid? Compare NH_3 and BF_3 and find out the answer.

Record the three definitions of acids in the table given below.

Arrhenius theory	
Lowry - Bronsted theory	
Lewis theory	

Table 10.1

pH scale

You have learnt that acids react with bases and neutralise each other. The H^+ ions in acids and OH^- ions in bases combine together to form water.



Can you name real life situations where neutralisation is used?

Some times acidity of the soil is increased as a result of decayed bio-materials or some other reasons. What is added to the soil to neutralise the acidity? What about excess

alkalinity? Acidity or alkalinity is determined by testing the soil. Have you thought of a method like this to find out the acidity or alkalinity of a solution?

We know that pure water is a neutral solvent. It is either acidic or basic. Write down the chemical equation showing the ionisation of water.



We get H^+ ions and OH^- ions when water ionises. At ordinary temperatures water ionises only to a small extent. That is, it is calculated that 10^{-7} moles H^+ ions and an equal amount of OH^- ions are produced when 1 litre of water ionises. So we can say that the concentration of H^+ ions in water is 10^{-7} mole/litre. How is this expressed decimal form?

0.0000001 mole/litre.

What does the concentration of H^+ ions in water change when a small quantity of acid is added?

If the concentration of H^+ ions increases 10 times, what will be the concentration of H^+ ions in the solution?

0.0000001 10 = mole/litre

pH scale is used to express the concentration of H^+ ions. This method was proposed by the scientist Sorensen. The pH of a solution means the logarithm of the reciprocal of the concentration of H^+ ions.

$$\text{pH} = \log$$

Accordingly, the pH of pure water is 7. For all neutral solutions the pH is 7.

Concentration of H^+ ions in moles/litre	pH value
10^{-7}	$\log \quad = 7$
10^{-6}	$\log \frac{1}{10^{-6}} = 6$
10^{-8}	$\log \frac{1}{10^{-8}} = 8$

Table 10.2

You have seen that the pH values of acidic solutions are less than that of water. That is, the concentration of H^+ ions will be greater than 10^{-7} mole/litre. For example, if the concentration of H^+ ions is 10^{-6} mole/litre, it will be acidic. What about the concentration of OH^- ions? Similarly what about basic solutions? Concentration of which ion is greater? Which is less?

If the H^+ ion concentration is 10^{-8} mole/litre the solution will be basic.

The diagram showing the pH value of acidic solutions and basic solutions is given below.

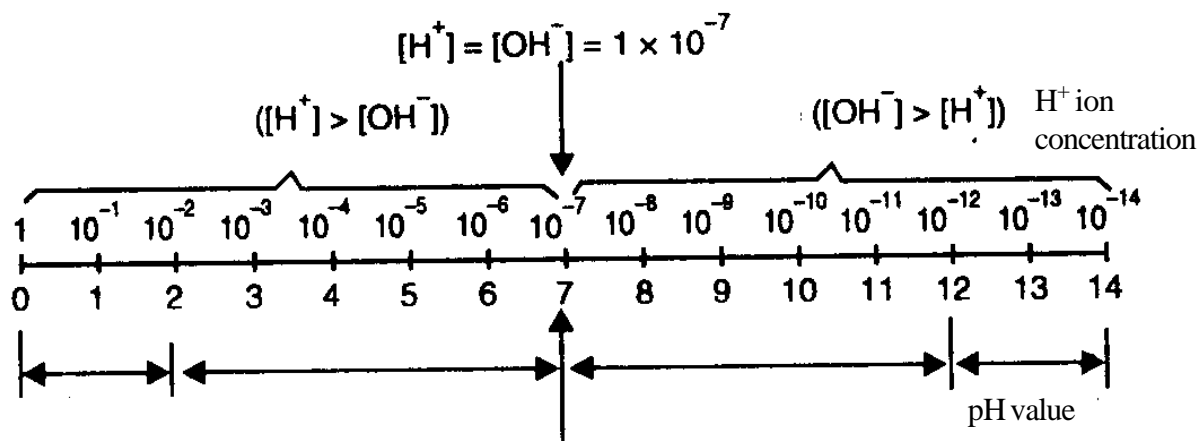


Figure 10.1

Analyse the diagram and record the following.

- Between which numbers is the pH value?
- What is the pH value of a neutral solution?
- What is the nature of the solutions whose pH value lies below 7?
- What is the nature of solutions having pH value above 7?

Using 'indicator paper' and with the help of the instrument 'pH meter' the pH value of a solution can be ascertained.

Take hydrochloric acid, lemon juice, vinegar, soap solution, ammonia solution and sodium hydroxide solution in separate test tubes. Using pH paper find the pH value of each. When you dip the pH paper in each of the solution you see a colour change. Compare this colour with the chart given along with the indicating paper. In the chart a number is given along with each colour. This number shown against the colour which

matches the colour of the paper is the pH value of that particular solution.

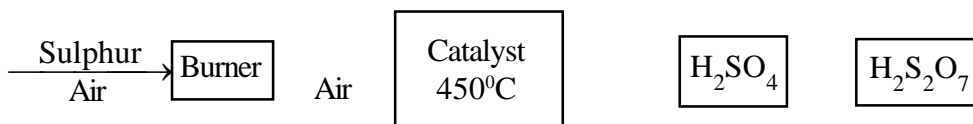
Sample solution	Colour of the pH paper	pH value
HCl		
Lemon juice		
Vinegar		
Soap solution		
Ammonia solution		
NaOH solution		

Table 10.3

Why do we need to determine pH? What is its importance? Discuss and record in your science diary.

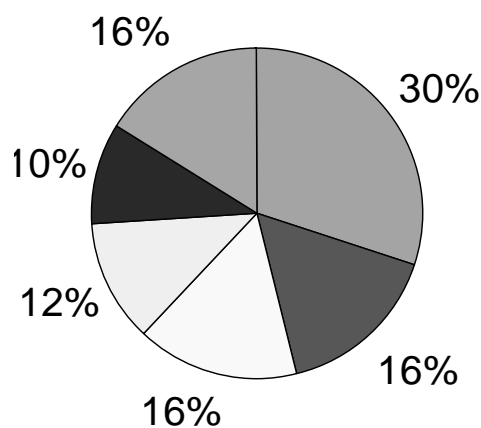
- **Agriculture**
- **Preparation of medicines**
- **Treatment of diseases**
- **Industry**

We saw the use of pH value in determining the acidity of soil. This helps to select chemical manures and other manures for cultivation. Some of the chemical manures are compounds of sulphates and nitrates. You know that these are salts of sulphuric acid and nitric acid. To manufacture these kinds of chemicals, sulphuric acid and nitric acid are highly useful. Let us study such acids of industrial importance.



Sulphuric Acid (H_2SO_4)

Sulphuric acid is an industrially important substance. See how industrially prepared sulphuric acid is used.



30% -chemical fertilisers; 16% - paints; 16% - chemicals; 12% - detergents; 10% -fibres; 16% -others

Figure 10.2

Sulphuric acid is known as the king of chemicals. 150 million tons of sulphuric acid are manufactured in the world every year.

Industrial production

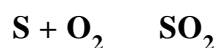
We know that acids are produced when non-metallic oxides dissolve in water. When the oxide of sulphur is dissolved in water, we get sulphuric acid. The raw material used in the industrial manufacture of sulphuric acid is sulphur.

Look at the flow chart given below showing the different stages for the industrial production of sulphuric acid by "contact process".

The equation of the chemical reaction taking place at each stage is given below.

Stage 1

Sulphur dioxide is made by burning sulphur in air.



Stage 2

SO_2 is mixed with air and heated to 450°C in the presence of platinised asbestos or vanadium pentoxide catalyst.



Balance this equation.

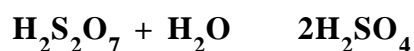
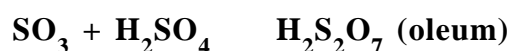
This is a reversible reaction. The forward reaction is exothermic.

- How can we increase the amount of SO_3 ?
- What is the influence of the catalyst on this reaction?
- If pressure is increased, will the production of SO_3 increase? Or will it decrease? Why?

At high pressure, as there is the possibility of an explosion, very high pressure is not used.

Stage 3

Sulphur trioxide is dissolved in sulphuric acid to get oleum ($\text{H}_2\text{S}_2\text{O}_7$). By diluting oleum, sulphuric acid of required concentration can be prepared.



Physical properties

Using concentrated sulphuric acid available in the laboratory, find out the following.

- The colour of sulphuric acid
- Density
- Solubility in water

Take 1 mL of water in a test tube and add one or two drops of concentrated sulphuric acid. Touch the bottom of the test tube. What do you feel?

When concentrated sulphuric acid is diluted water should not be added to the acid. Why? Can you explain?

Chemical properties

Take a little sugar in a test tube and add a few drops of concentrated sulphuric acid. See what happens.

Sugar is $\text{C}_{12}\text{H}_{22}\text{O}_{11}$. You have seen carbon precipitating.

- From sugar, what all elements have been absorbed by sulphuric acid?
- What is the ratio of oxygen and hydrogen absorbed?
- What is the number of water molecules absorbed?

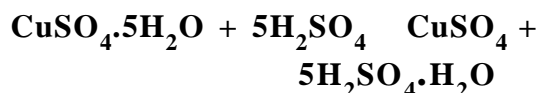


Repeat the experiment with glucose and paper pieces. Note down your observations.

Thus, the absorption of chemically combined water from substances is called

dehydration. Sulphuric acid is a strong dehydrating agent. Let us do another experiment which shows the affinity of sulphuric acid for water.

Take some copper sulphate crystals in a watch glass and add a few drops of concentrated sulphuric acid. What happens?



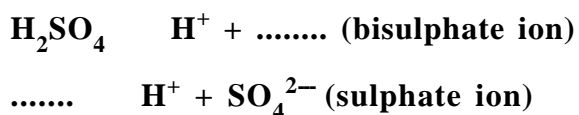
Add a drop of water to this anhydrous copper sulphate. Discuss the reason for the change.

You know that when we prepare SO_2 and HCl in the laboratory, concentrated sulphuric acid is used to make them free of moisture. Such substances that absorb moisture called drying agents.

But to make ammonia moisture free, we do not use concentrated sulphuric acid. Can you find out the reason?

Acidic property

How many hydrogen ions can a molecule of sulphuric acid supply? Is this monobasic or dibasic? Write down the ionisation reaction of a molecule of this acid.

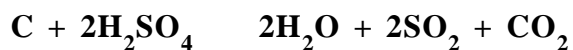


What are the two kinds of salts formed when sulphuric acid reacts with sodium hydroxide? Write the chemical equations.

Make a list of important sulphates, find their uses and write in your science diary.

Oxidising property

The reaction between carbon and sulphuric acid is given below:



Write the oxidation number of the elements and find out which is the oxidising agent and which is the reducing agent.

Concentrated sulphuric acid reacts with sulphur and sulphur dioxide and water are produced. Write the chemical equation. Find out the oxidising agent and the reducing agent. Now you know that sulphuric acid is an oxidising agent.

What is the gas produced when dilute sulphuric acid reacts with metals like magnesium, aluminium, zinc etc?

Reaction with salts

Take a little sodium carbonate in a test tube and add dilute sulphuric acid. Pass the gas produced through lime water to identify the gas. Write the chemical equation.



You know that sulphuric acid is used for the preparation of hydrochloric acid in the laboratory.



Can you write the chemical equation of the reaction between sodium nitrate and sulphuric acid? What is the acid produced?

Identification of sulphates

Take a little dilute sulphuric acid in a test tube and add three or four drops of barium chloride (BaCl_2) solution. Write down your

observation. If this reaction is double decomposition, complete the chemical equation. What is the compound formed?



Add 1 mL of BaCl_2 solution to each of the various solutions shown in the table below. Record your observation.

Solution	Observation on solution addition BaCl_2	Observation when Concentrated HCl is added to the solution after adding BaCl_2
Dil H_2SO_4		
Na_2SO_4		
Na_2CO_3		
K_2CO_3		
K_2SO_4		

Write in your science diary the method to find out whether a given solution contains sulphate ion or not.

Nitric acid (HNO_3)

Write the double decomposition reaction between sodium nitrate and sulphuric acid.



Fill up the blanks and balance the chemical equation. Which acid is produced?

This chemical reaction is used in the laboratory to prepare nitric acid. The arrangement of apparatus is shown in the diagram below.

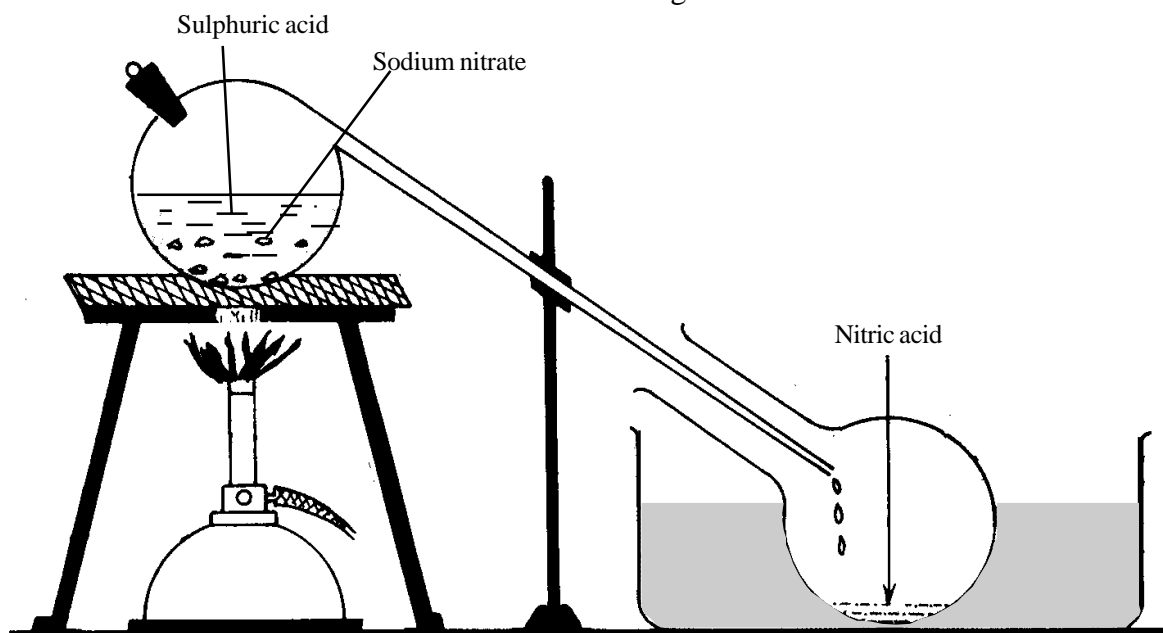


Figure 10.3

Note the important uses of nitric acid.

- **Oxidising agent in the fuel of rockets.**
- **Manufacture of fertilisers**
- **Manufacture of explosives**
- **For making paints and medicines**
- **In the preparation of polymers like cellophane, rayon etc.**
- **Preparation of aqua regia**
- **Purification of silver and gold**
- **Etching on metals**
- **As a chemical in the laboratory**

A test for proteins

If nitric acid comes in contact with your skin, the skin becomes yellow. It is because yellow Xantho Proteic acid is produced as a result of the reaction of nitric acid with proteins in the skin. This then is a test to detect the presence of proteins. Nitric acid will burn the skin, pierce it and enter inside. So we should be highly careful in handling nitric acid.

Prepare a list of the nitrate salts used in the manufacture of fertilisers. Can you find out the nitrogen compounds used as explosives?

Industrial manufacture

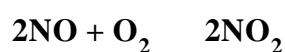
Nitric acid which is of very high industrial importance is manufactured by "Ostwald Process". The acid is prepared from ammonia in three stages.

The first stage is the production of nitric oxide (NO) by heating ammonia and oxygen in the presence of platinum.

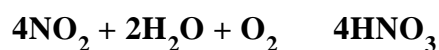


Balance this equation. Here platinum is a catalyst.

The second stage is the combination of NO with more oxygen resulting in the production of nitrogen dioxide.



Nitric acid is obtained by dissolving nitrogen dioxide in water in the presence of Oxygen.



Make a chart in your science diary showing the industrial manufacture of nitric acid.

Physical properties

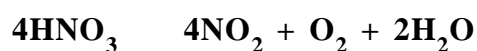
Keep open a bottle of nitric acid for a short time. What do you see?

The acid vapour reacts with moisture in air to produce fumes. This is the reason. Now, can you explain why concentrated nitric acid is called fuming nitric acid? List the physical properties of nitric acid, its colour, density and its solubility in water.

Chemical properties

Action of heat

Take a little concentrated nitric acid in a boiling tube and heat it strongly. Note the colour of the gas evolved.



- What is this coloured gas?
- What is the other gas produced?
- What is oxidation state of nitrogen in nitric acid?
- What is the oxidation state of nitrogen in NO_2 ?
- When the nitrogen atom in HNO_3 takes part in chemical reaction, will it accept or give out electron?
- Is HNO_3 an oxidising agent? Or, is it a reducing agent? Why?

Reaction with non metals

Put a piece of glowing carbon in nitric acid. What do you see? What is the colour of the gas?

Which is the oxidising agent and which is the reducing agent?

Heat sulphur with concentrated nitric acid in a test tube. Add BaCl_2 solution to this. What is the colour of the precipitate? Presence of which acid is indicated? Write the oxidation state in the chemical equation and find out the oxidising agent.



Write the chemical equation of the reaction of nitric acid with phosphorous.

Reaction with metals

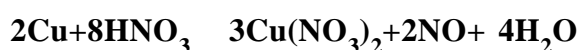
We have seen that hydrogen is evolved when metals react with acids. But, because

of the oxidising property of nitric acid hydrogen becomes water and oxides of nitrogen are formed. Very dilute nitric acid will produce hydrogen.

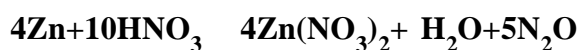
Reaction with concentrated nitric acid.



Reaction with dilute nitric acid.

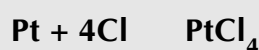
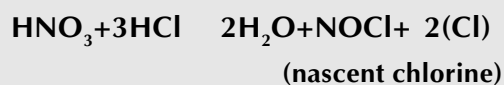


Have you heard of laughing gas? This gas is nitrous oxide (N_2O) produced by the action of zinc on very dilute nitric acid on heating.



Aquaregia

This solution known as 'aquaregia' dissolves the noble metals gold and platinum. Aquaregia is a mixture of 3 parts of concentrated hydrochloric acid and 1 part of concentrated nitric acid. The atomic chlorine (nascent chlorine) produced by this mixture converts metals into their chlorides.



By using aquaregia to test the purity of gold, there is the chance of getting duped.

Pure nitric acid does not react with the noble metals Au, Pt etc. But the mixture made

using hydrochloric acid and nitric acid in the ratio 3:1 dissolves these metals. Therefore, this mixture is known as aquaregia.

Reaction with alkalis

You have already studied the reaction of acids on alkalis. Complete the equation given below.

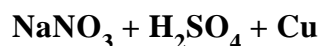


How many atoms of hydrogen are there in a molecule of nitric acid that can be given to an alkali? What is its basicity? How many kinds of salts will this make? Fill up the following chemical equations and record them in your science diary.



Test for nitrates

Add concentrated sulphuric acid and a few copper chips to a solution of nitrate and heat. Note the colour of the gas evolved.



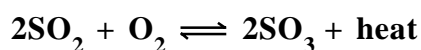
Take a little salt solution in a test tube and add an equal amount of freshly prepared saturated ferrous sulphate solution. Shake the solution well. Pour concentrated sulphuric acid slowly along the sides of the test tube. What do you see in the place where the solutions touch each other? This test used to identify nitrates is known as "Brown Ring Test".

SUMMARY

- The chemical properties of sulphuric acid, viz. oxidation property, the property of absorbing water, dehydrating nature, producing acids by reacting with salts etc. make this acid industrially important.
- Nitric acid decomposes on heating
- Nitric acid is a strong oxidising agent. According to the differences in concentration, it reacts with metals differently. The large use of nitrates makes this acid industrially important.
- We add nitrate fertilisers to the soil to provide nitrogen for the growth of plants.

MORE ACTIVITIES FOR YOU

1. Sulphuric acid is used to make many chemicals. Make a list of such chemicals.
2. See the equation of one stage of the contact process.



Answer the following

1. **Equation denoting backward reaction**
 2. **How is the forward reaction affected by rise in temperature?**
 3. **Reason for making use of optimum temperature.**
 4. **How can pressure be changed to increase the quantity of the product?**
3. The wood shelves where concentrated sulphuric acid is kept become blackish in colour. Can you find the reason?
 4. Examine the following chemical changes
When iron filings were heated with sulphur compound A with black colour is obtained. When this compound reacts with dilute sulphuric acid (H_2SO_4), gas B with the smell of rotten eggs is formed. When B is burned in oxygen blue flame was observed and precipitate C with yellow colour was obtained. When B was passed through lead nitrate solution a black precipitate D and colourless solution E were obtained. Identify A, B, C, D and E.
 5. Can you suggest a method to separate gold from a solid solution of gold and silver?
 6. Oxygen is used as a catalyst in all stages of industrial manufacture of nitric acid. Which special feature of these reactions is indicated by the use of greater quantity of oxygen. Can you find out the reason why low temperatures are made use of in the oxidation of Nitric oxide?

