EVALUATING ACADEMIC READINESS
Revised for
FOR APPRENTICESHIP TRAINING

SCIENCE SKILLS
pH SCALE

AN ACADEMIC SKILLS MANUAL
for
The Horticulture Trades

This trade group includes the following trades:
Arborist, and
Horticulturist

Workplace Support Services Branch
Ontario Ministry of Training, Colleges and Universities

Revised 2011

In preparing these Academic Skills Manuals we have used passages, diagrams and questions similar to those an apprentice might find in a text, guide or trade manual.

This trade related material is not intended to instruct you in your trade. It is used only to demonstrate how understanding an academic skill will help you find and use the information you need.

SCIENCE SKILLS
pH SCALE

An academic skill required for the study of the Horticulture Trades

INTRODUCTION

In horticulture trades, you are concerned with the acidity or alkalinity of different soils. This property affects how well a plant will grow in a specific soil. A soil might contain plenty of phosphorus but if the soil is too acidic, most plants can't use the phosphorus. It is unavailable to the plant because in an acidic soil, phosphorus reacts with iron to form an insoluble compound.

Some plants have adapted to certain conditions of acidity or alkalinity and need those conditions to flourish or, even to survive. For example, rhododendrons will only grow on acidic soils. Most coniferous trees grow better in acidic soils, while most deciduous trees prefer a neutral soil that is neither acidic nor alkaline. Important forage crops of legumes such as alfalfa and clover grow better in slightly alkaline conditions.

In this skills manual, we will look at what the terms acidity and alkalinity mean. This skills manual describes the following:

- Basic subdivisions of matter
- Acids and bases
- The pH scale
- Soil pH

BASIC SUBDIVISIONS OF MATTER

Matter *is the term used in science to describe anything that has mass and takes up space*. This term is so broad that it has been divided into smaller categories. The first division of matter is into elements and compounds.

Atoms *are the building blocks of matter.* They in turn are composed of subatomic particles, which include protons, neutrons and electrons.

- Each kind of atom has a specific number of subatomic particles.
- The number of protons in an atom determines what element an atom forms.
- For example, oxygen has eight protons and iron has twenty-six.

Elements
An ***element*** is a substance that can't be broken down further into other substances.

- An element is made from one kind of *atom*.
- Examples include nitrogen, oxygen, hydrogen, carbon, iron, zinc, and aluminum.
- Elements can exist in their pure form or they can combine with other elements to form molecular compounds.

Compounds
When atoms combine, they form ***molecules*** that are held together by chemical bonds that do not easily break. *A **compound** is composed of molecules of two or more elements which are **chemically combined** in a definite proportion.*

- A compound has different characteristics than the elements that form it.
  - For example, hydrogen and oxygen are colourless, odourless gases that exist in the air around us.
  - But, when two atoms of the element hydrogen join with one atom of oxygen, the compound water is formed.
  - Water is completely different from either hydrogen or oxygen.

It takes a very large number of atoms or molecules to form an amount that can be seen by the naked eye. A bottle of water contains an immense number of water molecules.

Some compounds can be dissolved in water to form a solution. *A **solution** is a uniform mixture of small particles of two or more substances.*

- One substance in a solution is the dissolving agent or the ***solvent***.
  - Water is called the universal solvent because it can dissolve many different substances.
- The other substance is the ***solute***.
- Usually there is a lot more solvent than solute.

ACIDS AND BASES

Acids and bases are two classes of chemicals that have generally opposite characteristics. Both acids and bases are often found in solutions with water.

- If they are in a strong solution, they are corrosive or caustic.
- They will damage skin, fabric, plant material, metals and some plastics.
- If they are in properly prepared weak solutions we can use them to do many useful things.

***Acids** taste sour. When dissolved in a solution with water, acids release **hydrogen ions**.*

- A hydrogen ion (H^+) is a hydrogen atom that has lost its only electron.
- These free hydrogen ions give acidic solutions their sour taste and their corrosive nature.
- When compounds present in the soil dissolve to form an acidic solution, we say the soil is acidic.

***Bases** taste bitter and feel slippery. We often refer to bases as **alkaline**. When dissolved in water, bases release **hydroxyl ions**.*

- A hydroxyl ion (OH^-) is a hydrogen atom that has combined with an oxygen atom and has one extra electron,.
- Hydroxyl ions give alkaline solutions their bitter taste, their slippery feel and their caustic nature.
- When compounds found in the soil dissolve to form a basic solution, we say the soil is alkaline.

You can test a substance to see if it is acidic or alkaline by using a material called litmus paper. Acids turn litmus paper red. Bases turn litmus paper blue.

If a water solution of an acid is combined in a specific proportion with a solution of a base, a chemical reaction will occur.

- The molecules of the base and the molecules of acid will break apart and reform into a new solution.
- The new solution will not be acidic nor will it be basic.
  - It will usually be a mixture of water and a salt.
- It will not be caustic or corrosive.
- This solution will be **neutral**.

In soil, there can be compounds that tend to form acidic solutions and compounds that tend to form alkaline solutions.

- If there is the same amount of acidic solution as alkaline solution, they will react with each other and the soil will be neutral.
- If there are more compounds that form acidic conditions, the soil will be acidic.
- If there are more compounds that form alkaline conditions, the soil will be alkaline.

THE pH SCALE

The acidity or alkalinity of a substance is rated on a scale called the ***pH scale***. The pH scale rates the acidity and alkalinity of a substance. The pH scale ranges in value from 0 (very acidic) to 14 (very basic). See Figure 1.

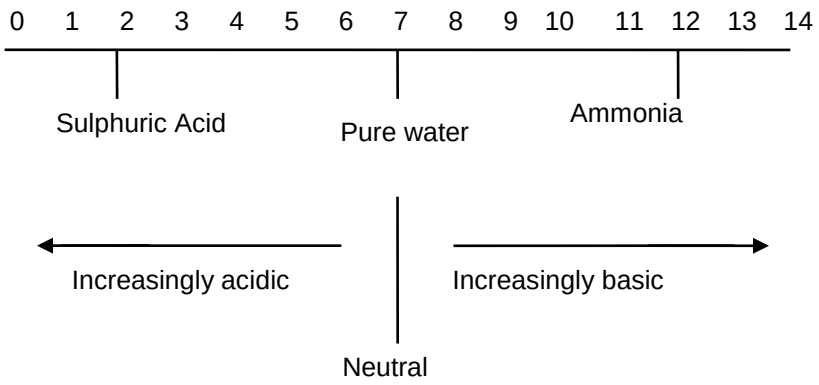

FIGURE 1: The pH Scale

- Pure water is considered ***neutral:*** neither acidic nor basic. Its pH, 7, is right in the middle.

- *Any substance with a pH less than 7 down to 0 is acidic.*
  - The smaller the number, the greater the acidity.
  - Sulphuric acid is a very strong acid, with a pH value of around 2.

- *Any substance with a pH greater than 7 is considered basic.*
  - The closer the number is to 14, the greater the alkalinity.
  - Ammonia is a strong base, with a ph of 12.

SOIL pH

The acidity of a soil depends on many factors.

The parent material making up the soil influences the acidity.

- Soils which are formed from underlying parent material of granite, sandstone and shale tend to be acidic.
  - These soils occur around the Great Lakes and the eastern half of North America.
- Soils formed from parent materials such as limestone that contain a high amount of calcium tend to be alkaline or neutral.
  - These soils occur in the prairie regions.

The amount of rainfall that runs through the soil also influences the acidity.

- Areas that receive a large amount of rainfall are more acidic because the water percolating through the soil dissolves basic compounds and carries them away, leaving an excess of hydrogen ions.
- If there is more evaporation from the soil in the summer than is replaced by rain, water is pulled upward.

- These conditions occur on the prairies where the soil has a lot of calcium in it. The water and calcium tend to form alkaline soils.

Most nitrogen fertilizers cause the soil to become more acidic.

- This can eventually cause problems as many soil organisms are not adapted to these more acidic soils.
  - Soil organisms such as bacteria and earthworms are needed to break down plant material and to change soil nutrients into a form that plants can use.

Acid rain will also cause soils to become more acidic.

pH and Plant Health
In acidic or alkaline conditions, many soil nutrients become unavailable to growing plants.

- If the pH falls below 5.5, most phosphorus becomes tied up with iron and unavailable.
- If the pH is above 8, most iron becomes tied up and unavailable

Most plants grow best in a soil that is close to neutral, in the range of pH 6 to 7.

- The pH of a soil can be changed by adding different soil amendments.
  - To make a soil more acidic, aluminum fertilizer can be added.
    - Aluminum compounds react with water to form hydrogen ions (H^+), causing the soil to become more acidic.
  - To neutralize a soil that is too acidic, calcium carbonate from limestone can be spread on the soil.
    - Calcium releases hydroxyl ions (OH^-) which neutralize the acidic hydrogen ions.

CONCLUSION

Acidic soils are created when compounds in the soil react in a water solution to release hydrogen ions (H^+). Alkaline soils are created when compounds in the soil react in a water solution to release hydroxyl ions (OH^-).

The amount of hydrogen ions compared to the amount of hydroxyl ions is measured by the pH scale. A substance with a pH of 7 is neutral, with the same number of hydrogen ions as hydroxyl ions. In this case, the ions react together to form water. Water is considered a neutral substance. Its pH is 7 on the scale.

An acidic substance ranges in pH from just below 7 to 0. A substance with a pH of 1 is very acidic. It has many free hydrogen ions. An alkaline substance ranges in pH from just above 7 to 14. A substance with a pH of 14 is very alkaline. It has many more hydroxyl ions than hydrogen ions.

Soil acidity depends on the underlying parent material, the amount of rainfall compared to evaporation and the type of fertilizer used.

Horticulturists and arborists need to be aware of the soil pH and its affect on the soil. Plant technicians must be able to tell what kind of soil they are dealing with. They must also know what plants will grow well in that soil. They should know how to amend the soil to change the pH if necessary.

Answer the following questions on acids and bases. The answers are on the next page.

1. If a substance turns blue litmus paper red, it is an _____ .
2. If a substance turns red litmus paper blue, it is a _____ .
3. An acid compound releases _____ ions when dissolved in water.
4. A basic compound releases _____ ions when dissolved in water.
5. A neutral solution can be made by mixing _____ with _____.
6. The pH scale ranges in value from 0 to _____.
7. Pure water is considered _____ . It has a pH of _____ .
8. Any substance with a pH less than 7 is _____ .
9. Any substance with a pH greater than 7 is _____ .
10. A soil with a pH of 5 is slightly _____ .
11. A soil with a pH of 9 is _____ .

ANSWER PAGE

1. acid
2. base
3. hydrogen
4. hydroxyl
5. an acid, a base
6. 14
7. neutral, 7
8. acidic
9. basic or alkaline
10. acidic
11. alkaline