CHAPTER 7

BASIC CHEMISTRY

CHAPTER's Objectives

- To study and explain the concept matter
- To identify states of matter
- To discuss classification of matter as elements, compounds, and mixtures
- To discuss atomic structure and identify its parts the electrons, protons, and neutrons
- To discuss the development of earlier atomic models and atomic spectra
- To study and explain the quantization of energy
- To introduce the atomic number, mass number concepts
- To study isotopes and atomic mass
- To introduces the periodic table of elements

Chemistry is a branch of physical science that deals with matter, energy, and their interactions. It dates back to prehistoric time and passed through three developmental categories.

Alchemy was the first category (300BC-17th century). Alchemists in this domain were influenced by Aristotle idea that matter is composed of four forms: air, fire, earth, and water and the possibility of transformation of one form to another by certain interchanging of their qualities. Seized by these teachings, alchemists had two goals, converting cheap metals like platinum into gold and finding elixir of life, a chemical believed to allow people to live longer and cure all ailments. These two goals were never happened.

Traditional chemistry was the second category (the end of 17th –mid of 19th century), which put an end to Aristotle's four forms of matter theory and the death of alchemy. This stage ushered the great discoveries in chemistry and the appearance of great chemists. Among the discoveries were the vacuum tube, cathode rays, electron, proton, and x-rays. The Dalton's atomic view of matter was adopted in this period.

Modern chemistry extended from mid 19th century -present time. It is a continuation of traditional chemistry work based on the proven idea that the atom is the basic building block of matter. The break of atom and proliferation of nuclear weapons is the most aspect of this period.

Today, chemistry affects our life in many aspects; from the food we eat, the air we breathe, and the technology it brought that improved the quality of life.

7.1 What is matter? The atom concept

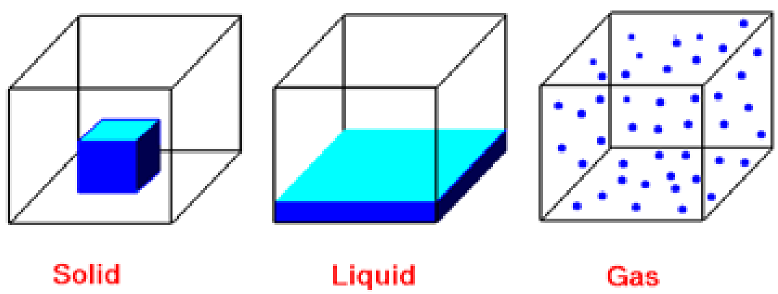
Matter is everything in the universe that has a mass (weight) and takes up space (volume). Examples of matter are air, water, bacterium, and human. All ancient civilizations studied the physical world and its material composition. Among these, the Greek's philosophy had contributed significantly in the development of our thought about the nature of physical world.

Around 450 BC, the Greek philosopher Democritus introduced the concept ***atom***. He reasoned that a continuous breaking of a piece of material into halves will end at some point that it cannot be broken down any further. Democritus thought that this end point is the smallest possible piece of matter that can be reached and called it the atom, a Greek word meaning uncuttable or indivisible. Unfortunately, this atomic view of matter was rejected by his Greek contemporaries.

In 1803, the atom concept was restored by John Dalton, an English chemist, who performed a series of experiments with various chemicals that showed him that matter seems to consist of atoms. Dalton's discovery was the key to understand matter by modern standards.

7.1.1 States of matter

Any matter can exist in a ***solid***, ***liquid***, or ***gaseous*** form. These three forms are called states of matter. In order to define each, we chose a fixed amount of water at solid, liquid, and gaseous forms and place it inside a fixed size container as Figure 7.1 illustrates.



Based on Figure 7.1, we can make the following conclusions

- The solid has a fixed volume and shape. Its volume is fixed by its shape not by the shape of the container
- The liquid has affixed volume, but takes the shape of container. It fills the container according to its volume
- The gas has no fixed volume or shape. It takes the shape and volume of the container

A solid can be converted to liquid by supplying heat. Further supply of heat would change changes liquid to steam (gas). The process can be reversed by removing heat.

7.1.2 Classification of Matter

As Figure 7.2 illustrates, matter may be classified as either pure substances or mixtures. ***Pure substance*** is matter that has constant chemical composition and properties. For example, any sample of pure water contains about 11% hydrogen and 89% oxygen. Figure 7.3 shows examples of pure substances. Pure substances can further be divided into elements and compound.

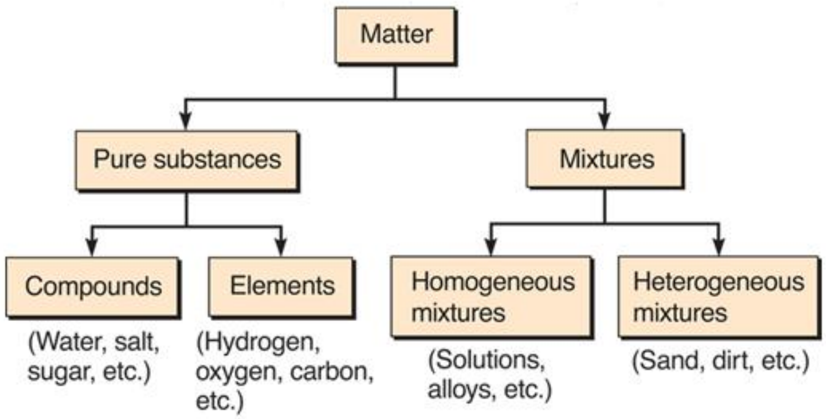


Figure 7.2: Classification of matter into pure substances, mixtures and their subdivisions. Credit: *B.W. Tillery, E. D. Enger, and F. C. Ross, "Integrated science", 3rd Ed., McGraw Hill 2004.*

Figure 7.3: Distilled water and Cane sugar are two examples of pure substances.

An ***element*** is the simplest type of matter, which consists of only one kind of atom and, therefore, it cannot be broken down into simpler matter. Each element has a name and represented by a letter ***symbol*** such as hydrogen H, oxygen O, gold Au, and iron Fe. A sample of gold contains only gold atoms; identical in mass, size, color and different from those other atoms. A ***compound*** is composed of two or more different elements. Compounds are represented by a ***chemical* formula** such as water H_2O and table salt NaCl. Molecules are the building blocks of compounds. A ***molecule*** is a combination of two or more atoms held together by attractive forces (chemical bonds). Examples of molecules are water H_2O, carbon dioxide CO_2, and glucose sugar $C_6H_{12}O_6$. Some elements can also be found in a molecular form such as oxygen O_2, hydrogen H_2, and ozone O_3. Unlike elements, compounds can be broken down to their elements, but by chemical means only.

A ***mixture*** is a group of two or more elements or compounds combined by physical (not chemical) means. Milk, blood, sand, sand, pizza, and wood are common examples of mixtures as Figure 7.4 illustrates some mixtures. Two major differences between mixtures and compounds. First, mixtures have no fixed or constant composition; it varies from sample to another. For example, any two samples of beach sand have different amounts of pieces of rocks, minerals, and sea shells. Second, mixtures compositions can be separated by physical means only.

Mixtures are grouped into homogeneous and heterogeneous. ***Homogeneous mixture*** is one that has matter evenly distributed in the entire sample. A well stirred sample of sugar and tea is an example. ***Heterogeneous mixture*** is one that has matter not evenly distributed in the entire sample. Milk, blood are good examples.



Figure 7.4: sand, pizza, and wood are common examples of mixtures.

Example 7.1

Develop a procedure that separates matter within the following mixtures. Name each

(A) Sample of sulfur and iron
(B) Sample of blood

Solution

Both samples are mixtures. Therefore, each sample can be broken down into its individual matter by physical means only.

(A) Use a magnet to attract the iron. This will leave sulfur and iron physically separated
(B) Use centrifugation. The spinning centrifugal machine separates the denser matter (plasma) and lighter matter (blood cells).

Example 7.2

Develop a procedure that separates the elements oxygen and hydrogen from a sample of water. Name it

Solution

Water is a compound. Therefore, it can be broken down into its elements by chemical means only. Electrolysis is a most common technique used to break water into its constituents, hydrogen and oxygen. Figure 7.5 shows electrolysis device. Why salt is added?

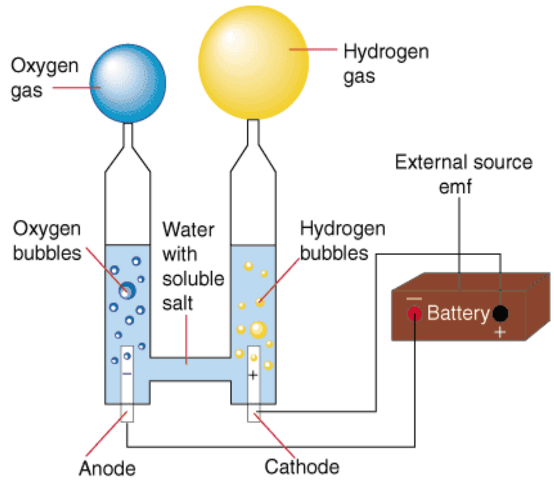


Figure 7.5: electrolysis device to separate oxygen and hydrogen. Whys is the size of hydrogen is double that of oxygen

Example 7.3

Which of the following pure substances are elements, and which are compounds? Is the smallest component of each a molecule or an atom?

(A) Methane gas, which contains carbon and hydrogen.
(B) Baking soda, which contains sodium, hydrogen, carbon, and oxygen.
(C) Chlorine gas, which contains only chlorine.
(D) An ancient silver coin, which contains only silver.
(E) A marble statue, which contains calcium, carbon, and oxygen.

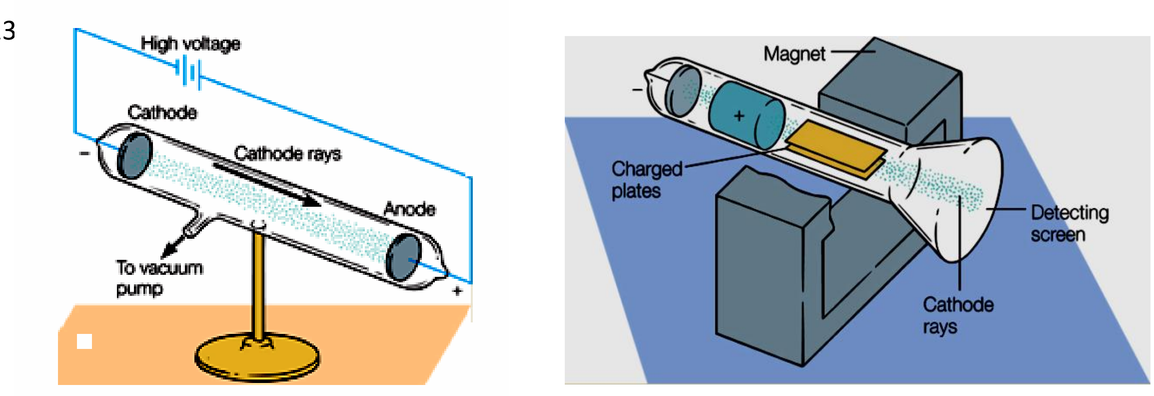
Solution

(A) Compound because it contains two elements. Made up of molecules (CH_4).
(B) Compound because it contains three elements. Made of molecules ($NaHCO_3$).
(C) Element because it contains only one element. Made up of molecules (Cl_2).
(D) Element because it contains one element. Made up of atoms (Ag).
(E) Compound because it contains three elements. Made up of molecules ($CaCO_3$).

7.2 parts of the atom: electrons, protons and neutrons

7.2.1 The discovery of electron

In 1897 the British scientist J.J. Thompson discovered the ***electron*** using ***cathode ray vacuum tube*** illustrated in Figure 7.6(a). It consists of a glass tube connected to a vacuum pump and two metal plates (anode and cathode) connected to a high voltage battery. During operation, the electrical current (cathode rays) causes the reaming gas to glow green. The greenish beam then collected at the anode. The beam was then passed through crossed electric and magnetic fields as shown in Figure 7.6(b).



(a) (b)

Figure 7.6: (a) The Cathode ray vacuum tube. **(b)** the electric and magnetic fields deflect the cathode rays**.** Credit**:** *B.W. Tillery, E. D. Enger, and F. C. Ross, "Integrated science", 3rd Ed., McGraw Hill 2004.*

Thomson measured the deflection caused by the electric and magnetic fields and with the application of Newton's second law he was able to calculate the charge to mass ratio of individual particle of the beam. He concluded the following

- The mass of each particle of the cathode rays is very small
- All particles have the same charge to mass ratio, which suggest that the particles were identical
- The nature of deflection by electric field suggested that the particles carry a negative charge
- The particles had the same ratio of charge to mass regardless of the kind of cathode. It seemed that same particles were present in all cathode rays

Thomson had discovered the ***electron***, a subatomic particle with the small mass and negative charge. In 1906 scientists found that the electron had a charge of 1.6×10^{-19} Coulomb and a mass of 9.11×10^{-31} kg. Because the atom is neutral, Thomson concluded that there must be a balancing positive charge within the atom.

Thomson's model of the atom: The plum pudding model

In 1889 J.J. Thomson suggested a model for the atom. In his model, the atom is represented as a sphere of positive electricity like a "pudding" with electrons distributed evenly as "plum" as illustrated in Figure 7.7. According to this model, the atom mass is distributed all over the atom.

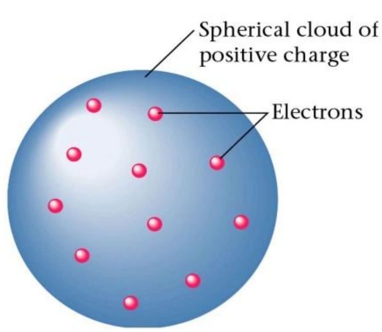


Figure 8.7: Thomson's "plum pudding" model of the atom.

7.2.2 The discovery of the nucleus: The proton

Unsatisfied by Thomson model, Ernest Rutherford, a British physicist, did an experiment in 1907. He fired on a thin foil of gold by a beam of positively charged alpha particles emitted by a radioactive material. Using the apparatus shown in Figure 7.8, Rutherford noticed that when alpha particles struck the foil, most of the particles passed through but a few were deflected at different angles; some were rebound with 180^0. The scattered particles were detected by their light flashes on a screen.

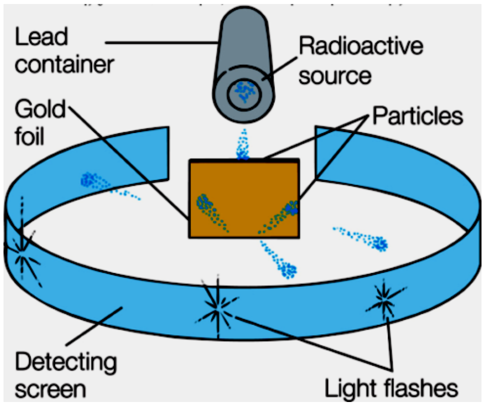


Figure 7.8: the apparatus used by Rutherford in his discovery of the nucleus. Credit: *B.W. Tillery, E. D. Enger, and F. C. Ross, "Integrated science", 3rd Ed., McGraw Hill 2004.*

Rutherford concluded the following

- The atom is mostly empty space, has a central part called a nucleus surrounded by electrons
- The nucleus is small, dense concentration of mass and contains a positive charge
- Any positive charge projected into the nucleus would be deflected due to a repulsive force

In another experiment done in 1919, Rutherford concluded that the hydrogen nucleus is indeed a positively charged particle he called the ***proton*** that is present in all nuclei. Scientist realized that the proton is about 2000 times heaver that the electron and the magnitude of its charge is the same as that of the electron, but with a positive sign, $+1.6 \times 10^{-19}$Coluomb.

Rutherford's model of the atom: The planetary model

In 1911, Rutherford proposed his model of the atom in. Figure 7.9 illustrates this model, which is called the planetary model of atom. The model, locate the nucleus (like the sun) at the centre of the atom surrounded by a cloud of orbiting electrons (like the planets). Most of the atomic mass is concentrated in its nucleus (why?). The Coulomb force is responsible of keeping the electrons orbiting the nucleus.

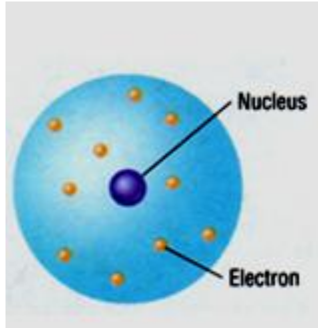


Figure 7.9: Rutherford's planetary model of the atom. Electrons orbit a positive nucleus.

7.2.3The discovery of the neutron

In 1920, Rutherford suggested the existence of another particle beside the proton inside the nucleus. He found that atomic mass (mass of protons) does not match with that of the number of protons in the nucleus. In 1930s many experimental investigations proved the existence of another particle inside the nucleus. In 1932, James Chadwick, a British physicist, was able to capture this particle, he identified it as uncharged particle approximately the same mass as the protons and called it the ***neutron***.

7.3 Quantization of energy

In 1900, the German physicist Max Plank proposed a formula that could explain the energy emitted by hot objects (solid, liquid, and gas). In this proposal, energy is emitted in a discrete units or bundles he called ***quanta*** plural of a ***quantum*** and is related to the frequency of the emitted quantum by some whole number multiple of hf or

$$E = nhf, \qquad n = 1,2,3,... \tag{7.1}$$

Where

n Is the number of emitted quanta, h is Plank's constant, and f is the frequency

$h = 6.626 \times 10^{-34} J.\text{sec}$

Equation (7.1) is called ***Plank's quantum hypothesis***. I n 1905, Albert Einstein applied Plank's quantum concept to light. According to Einstein idea, light consists of discrete units or bundles of energy called ***photons***. The energy of a photon is directly proportional to its frequency, or

$$E = hf \tag{7.2}$$

The higher the frequency of light, the greater the energy the photon carries.

Example 7.4

What is the energy of a photon of a red light of frequency $4.60 \times 10^{14}\, Hz$?

Solution

Given:

$f = 4.6 \times 10^{14} Hz \quad red\ photon$

$Wanted:\ E$

$\because E = hf \;\Rightarrow \therefore E = (6.63\times10^{-34}\,J.\text{sec})(4.6\times10^{14}\,Hz) = 3.05\times10^{-19}\,J$

7.3 Light from the atom: The atomic spectra

In 1665, Isaac Newton discovered that a solar white light splits into bands of colors when it passes through a prism as illustrated in Figure 7.10. The separation of light into its colors is called ***spectrum***. Today, scientists realized three types of spectra: continuous, emission, and absorption spectra. Our discussion will be focused on the emission spectrum only.

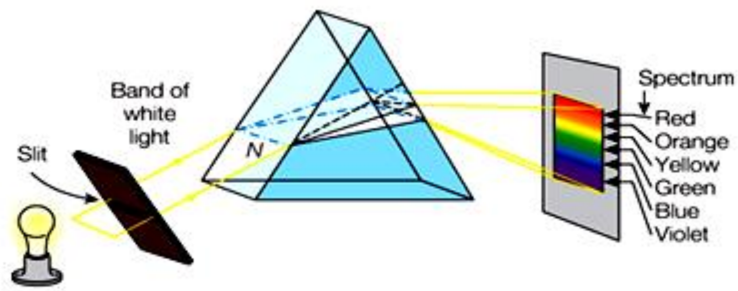


Figure 7.10: **A** continuous spectrum of a white light emitted by a hot light bulb. Credit: *B.W. Tillery, E. D. Enger, and F. C. Ross, "Integrated science", 3rd Ed., McGraw Hill 2004.*

Emission spectrum

It is the spectrum of hot gases at low pressure. The spectrum consists of separate lines of colors; each represents a specific frequency or energy. Figure 7.11 shows the emission line spectrum of a bulb filled with hydrogen. It consists of four distinguished colors specific for hydrogen only.

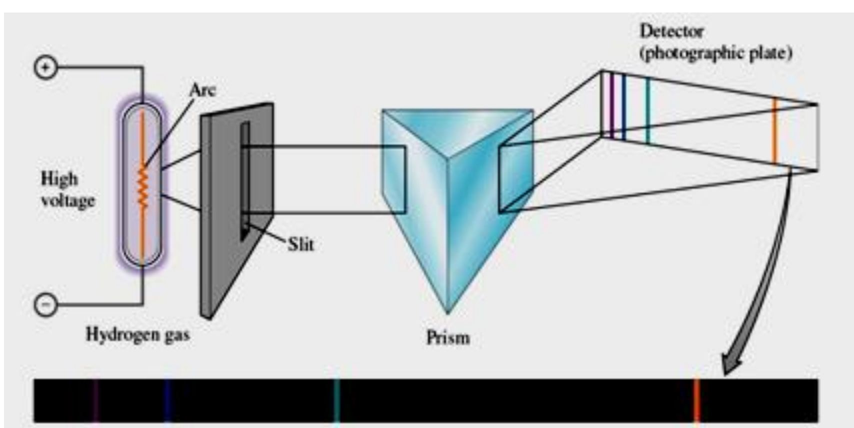


Figure 7.11: the Emission spectrum of hydrogen. Each color represents a frequency or energy

Emission line spectrum is considered as the atom's fingerprint, which can be can be used to identify the atom. No two atoms can have the same line spectrum as Figure 7.12 illustrates.

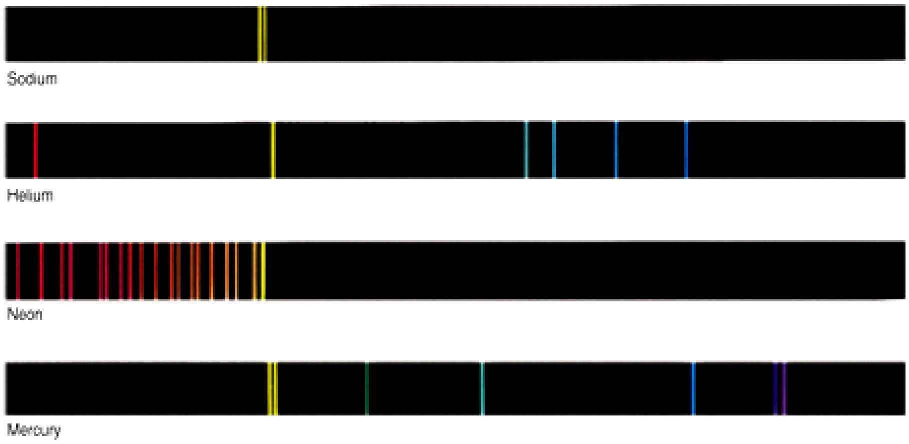


Figure 7.12: Line emission spectra of sodium, helium, neon, and mercury atoms.

7.4 What caused the emission of light? Bohr model of the atom

In 1913, Niels Bohr, a Danish physicist, proposed an atomic model of hydrogen atom, which provided answers and solutions to the problem regarding the light emitted by hydrogen atom. Bohr model implies the following

- The electron as shown in Figure 7.13 is orbiting the proton in allowed circular orbits identified by numbers: $n = 1,2,3,\ldots$ with $n=1$ is the orbit with the lowest energy (ground state).

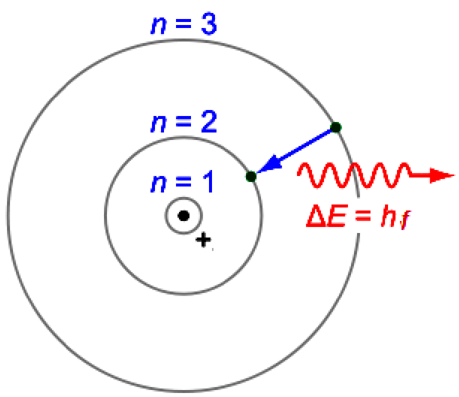


Figure 7.13: Bohr model of hydrogen atom.

- The orbits are separated from one another by empty space where the electrons cannot exist
- The electron in an allowed orbit does not emit light as long as it remains in that orbit
- Electrons can move from one orbit to the next by gaining or losing energy

- An electron gains energy from an outside source (like heat, or light) and jumps from an allowed lower to an allowed higher orbit. Once in a high energy orbit, the electron immediately jumps back to its initial orbit and emits light (photon) as depicted as a wavy line in Figure 7.10
- The photon represents a certain frequency f (color) , and carries energy given by

$$\Delta E = E_{final} - E_{initial} = hf \qquad \textbf{(7.3)}$$

According to this view, hydrogen atomic structure would look like that illustrated in Figure 7.14

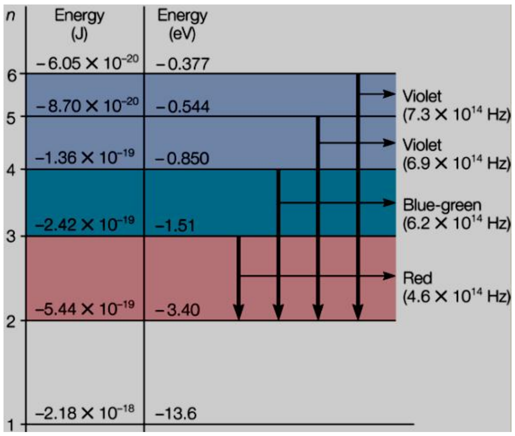


Figure 7.14: Hydrogen atomic structure given by its line emission spectrum. Negative signs means bounded electron (not free) Credit: *B.W. Tillery, E. D. Enger, and F. C. Ross, "Integrated science", 3rd Ed., McGraw Hill 2004.*

Example 7.2

How much energy is needed to move an electron in a hydrogen atom from $n = 2$ to $n = 6$ (use Figure 7.14 for information)

Solution

$$\because E = hf, \quad and \ \ for$$
$$n = 6, \ \ E_H = E_{final} = 6.05 \times 10^{-20} J$$
$$n = 2, \ \ E_L = E_{intial} = 5.44 \times 10^{-19} J$$
$$E = E_{final} - E_{initial} = (-6.05 \times 10^{-20} J) - (5.44 \times 10^{-19} J)$$
$$E = 4.84 \times 10^{-19} J$$

7.5 Mass of the atom: Atomic number and mass number

Because the masses of proton (1.7×10^{-24}g), the neutron (about same as proton), and electron (9.11×10^{-28}g) are very small in comparison with the things around us, scientists use a small system of measurement of mass. In this system, hydrogen atom was given a mass of 1**amu** (**a**tomic **m**ass **u**nit) because it is the lightest (1 proton), helium is 4amu (2protons and two neutrons); carbon is 12amu (6 protons and 6 neutrons), and so on. Usually the mass of the electron is ignored in this scale (why?).

Atomic number (Z- number)

Atomic number or Z-number is the number of protons inside the nucleus. For example, the atom of hydrogen has one proton and, therefore, it has an atomic number of 1, helium has 2, oxygen has 6, and gold has 79. Atomic number is a property of the atom (element) and is used to identify the element. No two atoms can have same atomic numbers.

Mass Number (A-number)

Mass number or A-number is the sum of the number of protons (Z) and neutrons (N) in the nucleus or

$$A = Z + N \tag{7.4}$$

For example an atom of nitrogen that has 7 protons and 7 neutrons has a mass number of 14

Chemical identification of an atom

Usually, an atom (element) is identified by a symbol (letter) with its Z and A-numbers written at the lower and upper left of the symbol. Example, carbon and silver are identified as: ${}^{A}_{Z}X$: ${}^{12}_{6}C,\ {}^{108}_{47}Ag$

Example 7.5

For each of the following atoms, determine (a) A, (b) Z, and (c) N numbers. Find also the number of electrons. Assume the atoms are at normal conditions: ${}^{59}_{27}Co,\ {}^{96}_{42}Mo,\ and\ {}^{133}_{55}Cs$

Solution

Given Data: Atoms at normal conditions with given A, Z, and N- numbers.

Wanted: identify and determin $A,\ Z,\ N,$ and number of electrons in each atom

Atom	A-number	Z-number	N-number	No. electrons
${}^{59}_{27}Co$	59	27	32	27
${}^{96}_{42}Mo$	96	42	54	42
${}^{133}_{35}Cs$	133	35	98	35

7.6 Isotopes

Isotopes are atoms of the same element that have same atomic number bur different numbers of neutrons. Nearly all naturally occurred elements are found as mixtures of isotopes. For example, hydrogen as Figure 7.15 illustrates is found in three forms or isotopes; all have same Z-number but different N-number.

Magnesium Mg with Z=12 is another example. Some magnesium atoms have 12 neutrons, others have 13 neutrons, and others have 14 neutrons.

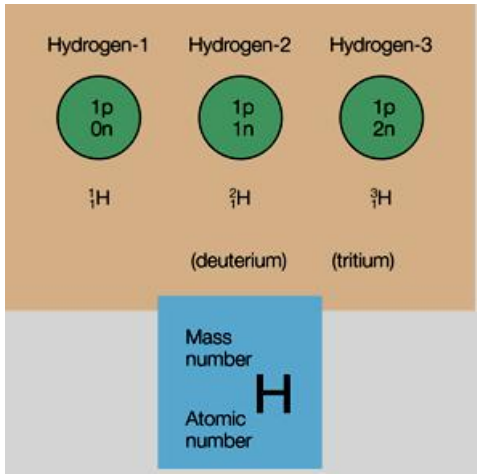


Figure 7.15: Natural hydrogen is found in three forms or isotopes. Credit: *W. Tillery, E. D. Enger, and F. C. Ross, "Integrated science", 3rd Ed., McGraw Hill 2004.*

7.7 Periodic table

Periodic table is the arrangement of all elements by increasing atomic number such that elements having similar chemical behavior are grouped in vertical columns; each column is called a ***group*** (or a family). Figure 7.16 shows the periodic table. Each horizontal row in the table is called a ***row***. There are 18 groups and 7 rows. The periodic table implies the following

- At the top of each column is a number that is assigned to each group
- Numbers to the left of first group indicate the number of horizontal rows
- Each element is inside a box , which includes its symbol, atomic number (top), and its atomic mass (bottom)
- All elements in every group are similar in their chemical properties. For example, all ***alkali elements*** are highly reactive. However, the ***inert*** (or noble) ***gases*** are not reactive
- The elements located along the heavy line are called ***metalloids*** and include B, Si, Ge, As, and Tb. Metalloids are elements that show some properties of metals and other properties of nonmetals. Metalloids are semiconductors because they can act as conductors or insulators.
- About 80% of elements are metals. A metal is an element that donates electrons. Non metal is an element that accept donated electrons

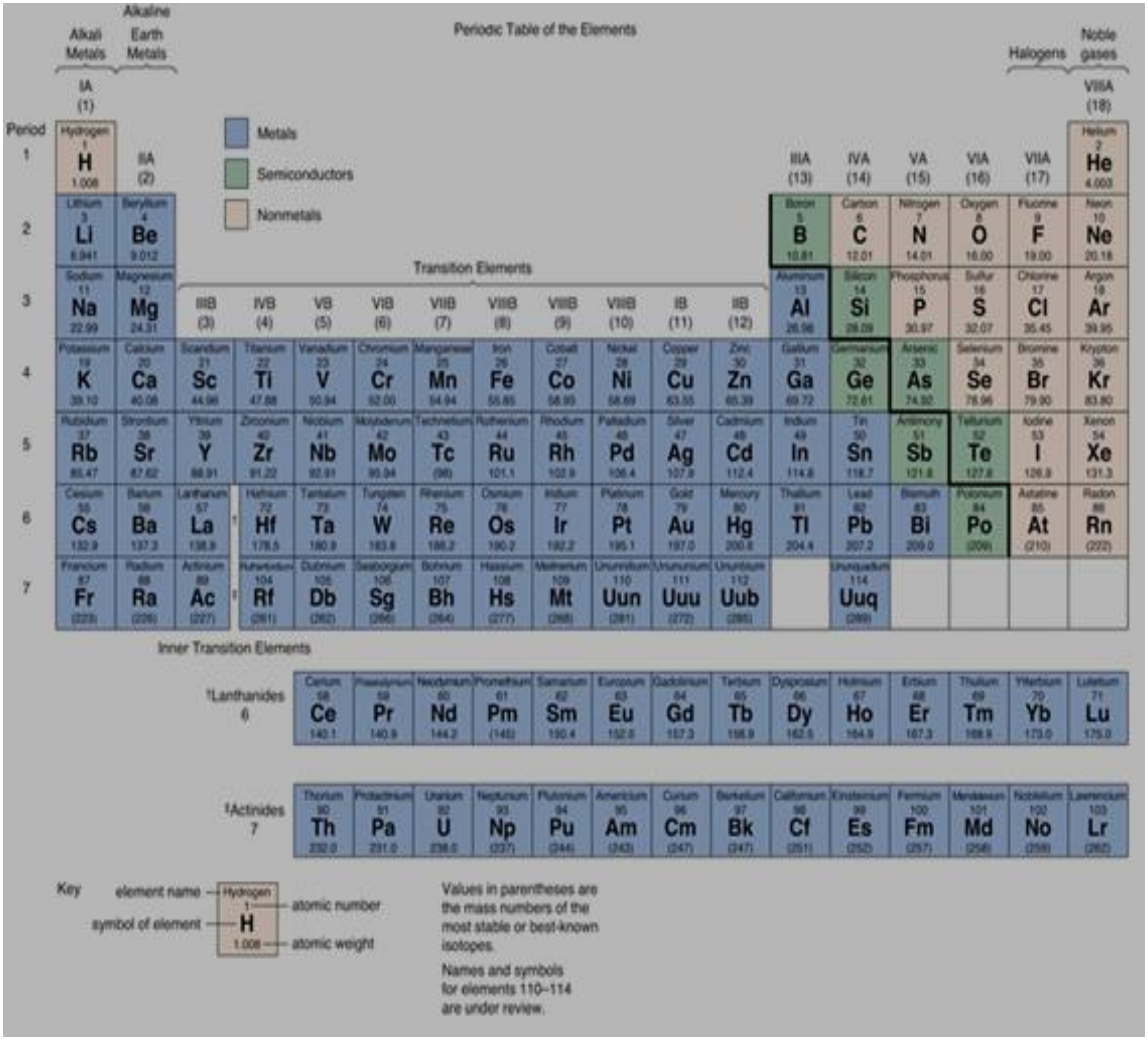


Figure 7.16: Periodic table of elements. Credit: *W. Tillery, E. D. Enger, and F. C. Ross, "Integrated science", 3rd Ed., McGraw Hill 2004.*

SUMMARY OF CHAPTER 7

The concept atom is old. It dates back to the ancient Greek philosophers who attempted to understand matter and its constituents. Atomists, is one of the Greek schools of thought who put forth the idea that matter is made up of atoms, an invisible and indivisible entity. The idea was rejected by the mainstream thinkers (Socrates, Plato, and Aristotle). Two thousands latter, the concept was revived as much interest on matter and its physical and chemical changes had increased. Work on electricity in vacuum (not in wires) accidently led to the discovery of ***electron*** in 1897 by J.J Thomson. Thomson found that the electron carries a negative charge and has a tiny mass. This event ushered the birth of modern physics. Subsequent work on atom resulted in the discovery of other parts of the atom. In 1911, Ernest Rutherford discovered the ***nucleus***; a tiny central part of atom that carries a positive charge. Eight years later in 1919, Rutherford discovered the ***proton***; a particle that carries a positive charge and located inside the nucleus. In 1932, James Chadwick discovered the ***neutron***. Models of atomic structure were introduced to picture the atom. Among these the "***plum pudding model***" of Thomson, "***planetary model***" of Rutherford, and Rutherford's refined model or "***Bohr model***" of Bohr. Bohr model was developed to explain the light emitted by an excited hydrogen atom. This model is based on the quantization of energy introduced earlier by Max Plank in 1900. Plank postulated that energy emitted by heated objects is not continuous as the classical physics claimed, but in a discrete manner in the form of quanta (plural of quantum). In 1905, Elbert Einstein applied Plank's postulate to light and introduced the ***photon*** concept (quantum of light). ***Matter*** is everything in the universe that has a mass and occupies space. It can be in any of the three phases; solid, liquid, or gas. Matter can be classified as ***pure substance*** or ***mixtures***. Pure substance has constant chemical composition and properties, mixtures do not. An ***element*** is the simplest pure substance, which consists of atoms and cannot be broken down into simpler form. Each atom of an element carries the element properties; an atom of gold retains all the properties of gold like color and density. The ***compound*** is a pure substance, which consists of molecules. A ***molecule*** is a combination of at least of two atoms. Accordingly, the compound can be broken down by chemical means only into its constituents. Water is a compound that can be broken down into oxygen and hydrogen. A ***mixture*** is not pure substance; it is a combination of molecules and/or compounds. Mixtures can be broken down into their constituents by physical means only like filtration. Mixtures can be ***homogeneous*** meaning that matter in the mixture is evenly distributed throughout the sample and ***heterogeneous*** meaning that matter is not evenly distributed throughout the sample. ***Isotopes*** are atoms of the same element that have same ***atomic number*** (number of protons), but different number of neutrons. The increase in the discovery of the number of chemical elements led chemists to arrange them in a chart called the ***periodic table*** based on their atomic numbesr from 1 to 113. The periodic table displays all the natural and manmade elements in 18 **groups** (or families) and 7 ***rows***. Elements with similar chemical behavior like reactivity with other elements were placed in the same group**.**

Basic Equations

$$E = nhf, \qquad n = 1,2,3,... \tag{7.1}$$

$$E = hf \tag{7.2}$$

$$\Delta E = E_{final} - E_{initial} = hf \tag{7.3}$$

$$A = Z + N \tag{7.4}$$

Basic Facts and principles

1. No two atoms can have same line spectrum
2. No two atoms can have same number of protons
3. The energy of a photon is directly proportional to the frequency of light and given as: $E = hf$
4. A single photon is emitted when the electron makes a downward jump. The photon's energy is exactly equal to the difference in the energy of the two orbits: $\Delta E = E_{final} - E_{initial} = hf$

Chapter 7 worksheet

Part 1: Multiple choices: Choose the right answer

1. Which particle, the proton, neutron, or electron is described by the following?
- **A.** Has the smallest mass
- **B.** Has a negative charge
- **C.** Found outside the nucleus
- **D.** Responsible for the magnetic behavior of atom

2. Which particle, the proton, neutron, electron is described by the following
- **A.** Has a mass about the same as a proton
- **B.** Found in the nucleus
- **C.** Has no charge
- **D.** Discovered in 1932 by James Chadwick

3. Which of the following particles have opposite charges?
- **A.** Two electrons
- **B.** Two protons
- **C.** A proton and neutron
- **D.** A proton and electron

4. The atomic number is used to determine the number of
- **A.** Neutrons in an atom
- **B.** Electrons in an atom
- **C.** Protons in an atom
- **D.** Neutrons and protons in an atom

5. The mass number is used to determine the number of
- **A.** Protons plus neutrons in an atom
- **B.** Protons and electrons in an atom
- **C.** Electrons in an atom
- **D.** Protons in an atom

6. In which group, the following elements are located in the periodic table: F, Cl, Br, I, and At
- **A.** Group 13
- **B.** Group 14

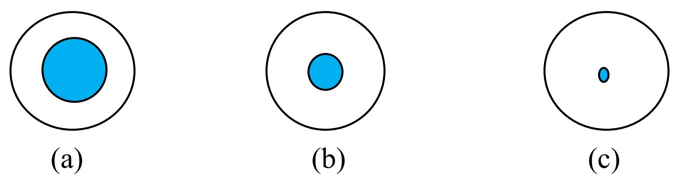
C. Group 6
D. Group 17

7. The existence of a tiny, massive, and positively charged nucleus was concluded from the experiment that
- **A.** Alpha particles were deflected by magnetic field
- **B.** Some alpha particles were deflected by a foil of metal gold
- **C.** Some alpha particles were deflected by light
- **D.** Some alpha particles were deflected by neutrons

8. According to Rutherford experimentation, the volume of the atom is mostly
- **A.** Filled with electrons
- **B.** Filled with electrons and protons
- **C.** Filled with protons and neutrons
- **D.** Empty space

9. According to Bohr's model, an electron gains or losses energy only by
- **A.** Moving with high or low kinetic energy
- **B.** Jumping from one allowed orbit to another allowed orbit
- **C.** Jumping from one atom to another
- **D.** Removing it from the atom

10. Which of the following diagrams best represents the size of the atomic nucleus relative to the size of the atom?



- **A.** (a)
- **B.** (b)
- **C.** (c)
- **D.** All of the above is true

11. The element $^{59}_{27}Co$
- **A.** 27 neutrons
- **B.** 59 neutrons
- **C.** 32 neutrons
- **D.** 86 neutrons

12. The element $^{80}_{35}Br$
- **A.** Is a member of the inert or noble gases group
- **B.** Is a member of alkali group
- **C.** Is a transition element
- **D.** Is a member of halogen group

13. The element in row 5 and group 13 is
- **A.** Ga
- **B.** In
- **C.** Tl
- **D.** Pb

Part 2: True or False. If your answer is false, then correct the statement.

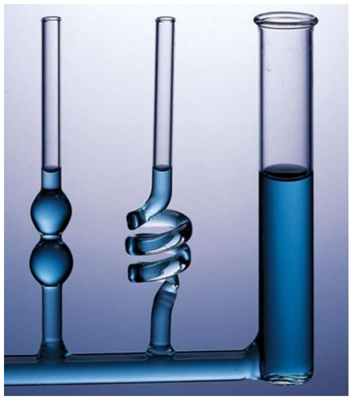
1. An element is a pure substance that can be broken down into simpler matter
   - **A.** True
   - **B.** False
2. A compound is pure substance that cannot be broken down into simpler matter.
   - **A.** True
   - **B.** False
3. A molecule is a combination of two or more atoms.
   - **A.** True
   - **B.** False
4. The light emitted by an atom (spectrum) gives the scientists a tool to study the structure of the atom.
   - **A.** True
   - **B.** False
5. A hot object like a solid, liquid, or a condensed gas emits bands of colors called a continuous spectrum
   - **A.** True
   - **B.** False

Part 3: Exercises

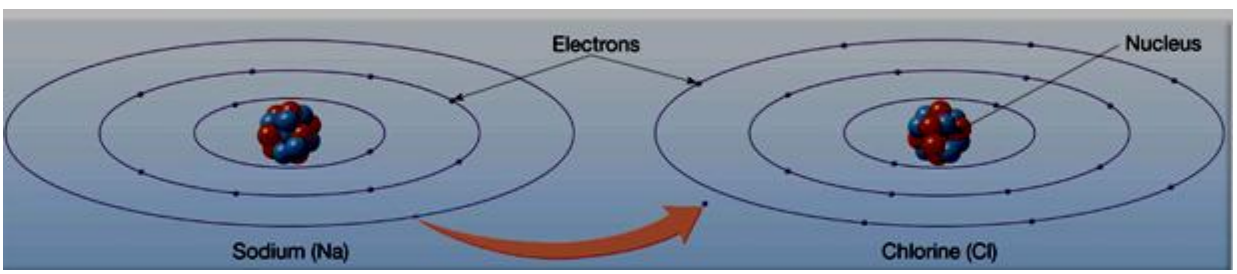
1. Determine the charge and mass (in amu) of nuclei made up of the following particles
   - **A.** 3 protons and 4 neutrons
   - **B.** 10 protons and 12 neutrons
   - **C.** 35 protons and 46 neutrons
   - **D.** 56 protons and 81 neutrons
2. Determine the number of electrons in each nucleus described in Ex. 1
3. Determine the number of protons, neutrons, and electrons in the following atoms:
   $^{23}_{11}Na,\ ^{40}_{20}Ca,\ ^{211}_{86}Rn$
4. Use the periodic table in Figure 7.16, state the atomic number, number of protons, and number of neutrons of each of the following elements
   - **A.** Potassium
   - **B.** Nitrogen
   - **C.** Gold
   - **D.** copper
5. Consider an atom that has 34 electrons and is at normal conditions
   - A. How many protons are in its nucleus?
   - B. What is its atomic number?
   - C. What is its name, and what is its symbol?

Part 4: learning from observation

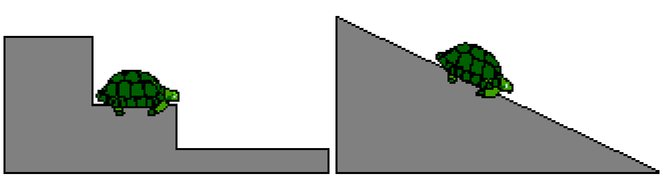
- Describe the property of liquids displayed in this picture



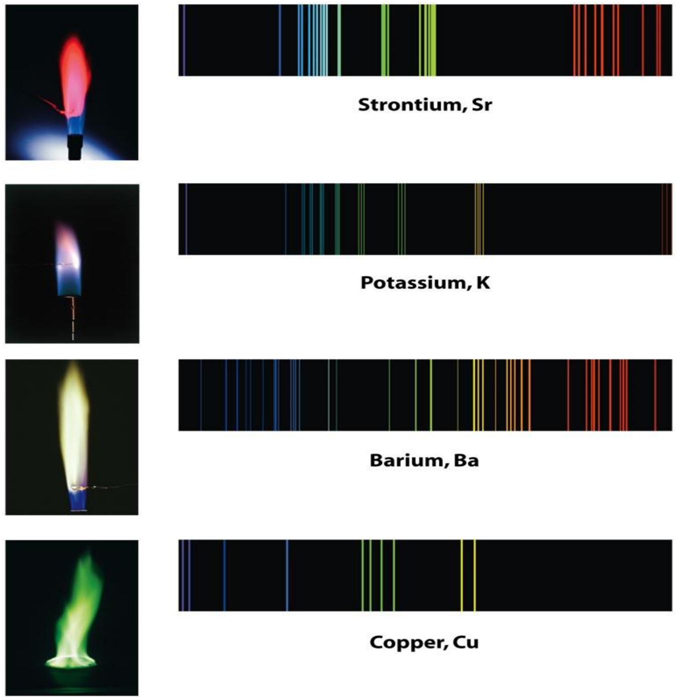
2. Sodium is a metal and chlorine is nonmetal. Describe the mechanism of their interaction to form table salt (NaCl)



3. Describe the system's (turtle) energy in both the steps and ramp path



4. ?



Part 5: challenge questions

1. Why Rutherford did not use liquids or gases to fire on by alpha particles?
2. Microwaves, widely used in houses, are a form of radiation (photons). Why microwaves be considered safe to use at home, while gamma radiation is considered unsafe? Hint: Which photon has high frequency?
3. Why the atomic mass of the atoms in the periodic table is not given in whole numbers?