LEARNING OBJECTIVES

## Module A. Diamonds and Due Diligence

### Lesson 6 - Elements, Matter, and Precious Metals

## Learning Objectives

**By the end of this Lesson, learners will:**

- Define proton, neutron, and electron, including their electrical charges and position in an atom
- Define the terms atomic mass, cation, anion, element, compound and mixture
- Desribe the relationships between atoms, elements, compounds, and mixtures
- Describe the differences between ionic, covalent, and metallic bonding
- Appreciate the 3 states of matter, and that minerals and metals are solids
- Describe the general structure of the Periodic Table, including the general chemical trends therein
- List the 8 most abundant elements in the Earth's crust from most to least abundant
- Define and give examples of native elements
- Describe some of the basic and distinct properties of metals
- Describe the units for measuring mass and purity of precious metals

INTRODUCTION

## Module A. Diamonds and Due Diligence

### Lesson 6 - Elements, Matter, and Precious Metals

## Introduction

In this Lesson we're going to get familiar with the building blocks of matter and the glue that holds them together – the atoms and chemical bonds. You'll also learn the basics of how to navigate the Periodic Table of the Elements. Make sure you get comfortable with the Periodic Table, as we'll refer back to it throughout the course. But don't worry, you're not being asked to memorize it!

Our textbook touches on atoms, chemical bonds, and matter, but we'll go into further detail in this Lesson. If you feel you want to brush-up on chemistry after this Lesson, be sure to check out the outside sites listed below.

**Essential readings and topics for this lesson in your textbook**

| Topic | Pages |
|---|---|
| Atoms | 8 |
| Crystals | 98 |

**Optional readings for this Lesson outside your textbook on chemistry**

- General Chemistry at Purdue (Bodner Group) - http://chemed.chem.purdue.edu/genchem/topicreview/index.php
  A virtual chemistry textbook - the most applicable sections include Ionic Compounds, Covalent Bonds, Structure of Solids, Structure of teh Atom, Transition Metal Chemistry and Main Group Metals.

- Webelements - http://www.webelements.com/
  An online periodic table of the elements with detailed information
- The Periodic Table of Videos - http://www.periodicvideos.com/
  This fantastic site has an enormous collection of videos about the elements of the periodic table created by chemists at the University of Nottingham. It is worth a visit to watch at least one or two videos - they're fun!



# The Atom and Subatomic Particles

All matter is composed of particles known as atoms. Atoms are made up of protons, neutrons, and electrons. Matter composed of identical atoms are called elements.

### *Protons*

The identity of an atom is determined by the number of protons it contains - this is also called the element's atomic number. For example, the first element of the Periodic Table is hydrogen (H), which has an atomic number of 1 - which means it has 1 proton. The second element of the periodic table is helium (He), which has an atomic number of 2 - which means it has 2 protons. Gold (Au) is an element with an atomic number of 79. Thus, each atom of gold has exactly 79 protons. Each protons carries a single positive electric charge.

### *Neutrons*

Unlike protons, neutrons don't follow as strict of a distribution amongst elements. Usually there are about equal number of neutrons as protons in an atom. However, larger atoms (those with more protons) generally have a greater number of neutrons than protons. Neutrons carry no electric charge.

### *Electrons*

Compared to protons and neutrons, electrons are much much smaller in size. Each electron carries a single negative electric charge.

### *Atomic Mass*

The total number of neutrons and protons defines the atomic mass of an atom. Because electrons are so small, they do not contribute much to the overall atomic mass of an atom. The weights of atoms are given in atomic mass units, or *amu,* where both protons and neutrons have an atomic mass approximately equal to 1 amu. Helium has 2 protons and almost always 2 neutrons. Its atomic mass, therefore, is 4 amu.

In the periodic table of the elements the mass of an element is not normally a round number, but instead is defined to a few decimal places. For example, Au has an atomic number of 79 and an atomic mass of 196.967. This is not to say that gold has 79 protons and 117.967 neutrons. Rather, 196.967 represents the *average atomic mass* of a sample of gold that includes gold atoms with different numbers of neutrons.

The atomic mass of an element is important because as atomic mass increases so does the density of the material that the atom is in. The table below demonstrates this.

| Element | Atomic Number | Average Atomic Mass | Density ($g/cm^3$) |
| --- | --- | --- | --- |
| Copper, Cu | 29 | 63.546 | 8.9 |
| Silver, Ag | 47 | 107.868 | 10.5 |
| Gold, Au | 79 | 196.967 | 19.3 |

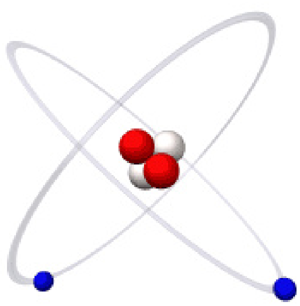
Table of atomic masses and physical properties of selected elements.

### *Atomic Structure*

Protons and neutrons are roughly the same size and are located in the nucleus or core of an atom. Outside this nucleus are the electrons which orbit the atomic core in an unpredictable but organized electron cloud much larger than the size of the nucleus itself. Because the mass of neutrons and protons is so much greater than that of the electrons, nearly all the mass of an atom exists at its nucleus. Strong atomic forces keep the neutrons and protons tightly packed in a dense cluster.

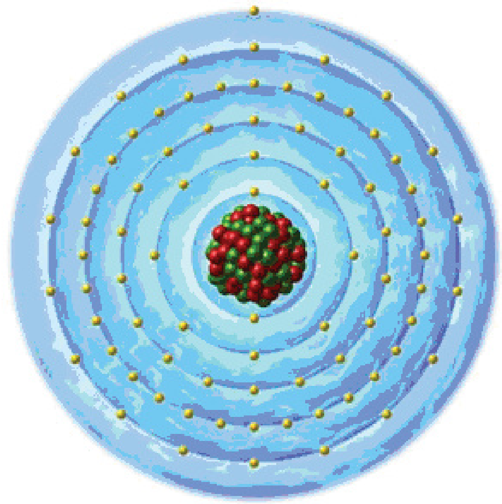
### *Electrical Charges*

Protons have a positive electrical charge, neutrons have no electrical charge, and electrons have a negative electrical charge. The sum of their charges denotes overall ionic or atomic charge. In a basic atom of a given element with all of its allotted electrons, an atom is neutral. This means that all of the negative charges of the electrons are balanced by all of the positive charges of the protons.



An atomic model of the element helium (He).

Helium has an atomic number of 2, meaning it has 2 protons (red sphere). It also usually has two neutrons (white spheres) and two electrons (blue spheres) that orbit the nucleus. Together, the protons and neutrons form the nucleus of the atom. The negative electrical charge of the electrons balance that of the protons.



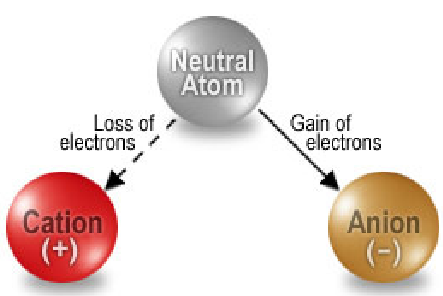
An atomic model of the element gold (Au).

Gold has an atomic number of 79, meaning it has 79 protons (red sphere). It usually has 118 neutrons (green spheres) and 79 electrons (gold spheres) that are orbiting in the electron cloud.

## *Ions*

Some atoms are prone to gaining electrons from outside sources, which results in them having a net negative charge. Other atoms are prone to losing electrons, resulting in a net positive charge. The resulting charge, positive or negative, is called the valence state (or valence charge) of an atom. Charged atoms are called ions; specifically, positively charged ions are called cations while negative ones are called anions. The exchange (gain or loss) of electrons almost always occurs within the outermost portion of the electron cloud.

The electron cloud of an ion can be estimated to be in the shape of a sphere, and its size is defined by the distance from the center of the nucleus to the limit of the cloud. This is called the ionic radius which is measured in units called Angstroms or Å. An Angstrom unit is very short - it is equal to 1/10 of a nanometre. Note that a nanometre is 0.000000001 metre or $10^{-9}$ metre!



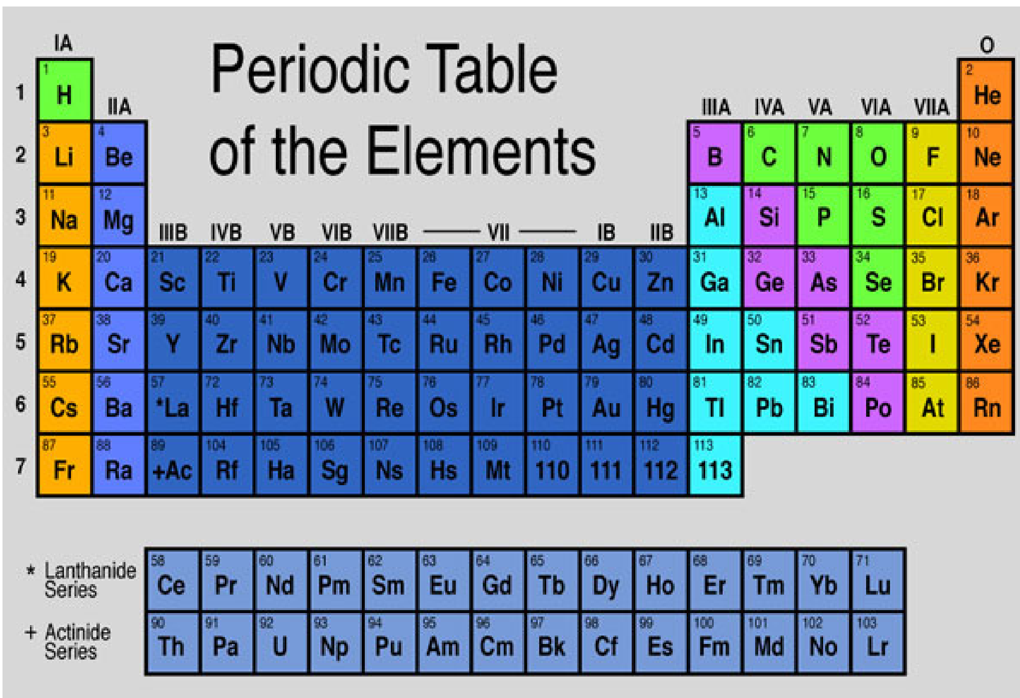

An atom can lose electrons and become a cation, a positively charged ion. If it gain electrons, it becomes an anion, a negatively charged ion.

# Elements, Compounds and Mixtures

## *Elements*

Elements are the basic building blocks of matter. Recall from the previous section that elements are composed of identical atoms. There are ~117 known elements, each with its own symbol that acts as a shorthand notation. Some familiar elements and symbols are Au for gold, C for carbon, Ag for silver, and Pt for platinum.

Approximately 90 of the elements occur naturally, usually combined with other elements in compounds, while the rest are synthetically produced in laboratories. Many of these natural elements are part of our everyday vocabulary, such as oxygen (O), carbon (C), nitrogen (N), and potassium (K) but others are much more obscure, such as beryllium (Be), scandium (Sc), and rhodium (Rh). In the world of minerals and gems, we will be focusing on some common elements that you will become quite familiar with.




Periodic Table of the Elements

## *Compounds*

Elements combine and interact through chemical bonds. When two or more elements join together they form a compound. As with an element, a compound is represented by symbols called chemical formula. Examples of common compounds and their formulae are water ($H_2O$) composed of hydrogen (H) and oxygen (O), carbon dioxide ($CO_2$) composed of C and O, and salt (NaCl) composed of sodium (Na) and chlorine (Cl). Most gemstones are compounds, including sapphire ($Al_2O_3$) composed of aluminum (Al) and O and emeralds ($Be_3Al_2Si_6O_{18}$) composed of beryllium (Be), Al, silicon (Si), and O.

## *Mixtures*

Mixtures differ from compounds in that a mixture is comprised of two or more compounds that are not interacting through chemical bonding. The world of rocks and minerals is a perfect example of this. Minerals, like sapphires, are compounds that are held together through chemical bonding. Rocks, on the other hand, can be thought of as bulk mixtures of minerals held together through an interlocking physical network of mineral grains **not** through chemical bonding. This is similar to how furniture can be made whole with joints, nails and screws that physically hold the pieces together while the individual pieces are independently held together through chemical bonding that make up the wood itself.

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BONDING

## Module A. Diamonds and Due Diligence

Lesson 6 - Elements, Matter, and Precious Metals

## Chemical Bonds

If elements are thought of as the building bonds or bricks of matter, then chemical bonds are the mortar that holds everything together. These bonds are strong attractive forces between atoms and keep everything neat and tidy. They form when outer electrons from two or more atoms interact resulting in their atoms becoming "joined". The two main types of bonding seen in nature are covalent and ionic.

### *Ionic bonding*

Ionic bonding occurs between two atoms, one with a strong tendency to gain electrons (the anion) and the other with a strong tendency to lose electrons (the cation). Here, the cation can be thought of as having "donated" electrons (and therefore becoming positively charged with less electrons than it started with) to the anion (which then becomes negatively charged with the extra electron).

Normal table salt (NaCl) is a good example of ionic bonding where Na, which usually has a valence of +1, combines with Cl, which usually has a valence of -1, in a one-to-one ratio. This is a simple case, and in reality most compounds are more complicated than this. In the mineral world, most bonding that occurs is ionic bonding, where electrons are donated from cation to anion.

### *Covalent bonding*

Covalent bonding occurs when atoms "share" valence (or outermost) electrons between them. Covalent bonding is much more common in organic compounds (those that form living matter). However, in the gem world, this type of bonding is best observed in diamond.

Diamond is a compound made up of carbon (C). The carbon atoms share electrons between them in a tight 3D network forming "molecules" of interconnected C atoms. These covalent bonds are very strong and give diamond its hardness and strength.

### *Metallic bonding*

A third type of bonding that is less common in nature, but commonly studied by scientists, are metallic bonds. This is the type of bonding, which not surprisingly, is typical in metals such as silver, gold, and copper. Valence electrons in metallically bonded compounds are shared throughout the entire material (not simply between two atoms) and are free to move about. This is why electricity generated from power plants is transferred along metal power lines.

STATES OF MATTER

Module A. Diamonds and Due Diligence

Lesson 6 - Elements, Matter, and Precious Metals

## States of Matter

Matter exists in three fundamental states or phases: solid, liquid, and gas. Some compounds, like water ($H_2O$), can change from one state to another at Earth's surface conditions through heating and cooling, allowing us to observe it in its solid (ice), liquid (water), and gas (water vapour) states.

Minerals and metals are solids. However, they sometimes pass through the liquid state *en route* to being refined into a purer form. For example, gold is recovered from the rock as a solid. It is then collected in large batches, melted to a liquid by heating up to ~1065 °C (the melting point of pure gold), and poured into the form of a block. As the temperature cools below ~1065 °C, the liquid gold converts back to solid gold. Gold can also exist in the gas state if it is heated past its boiling point of ~2856 °C.

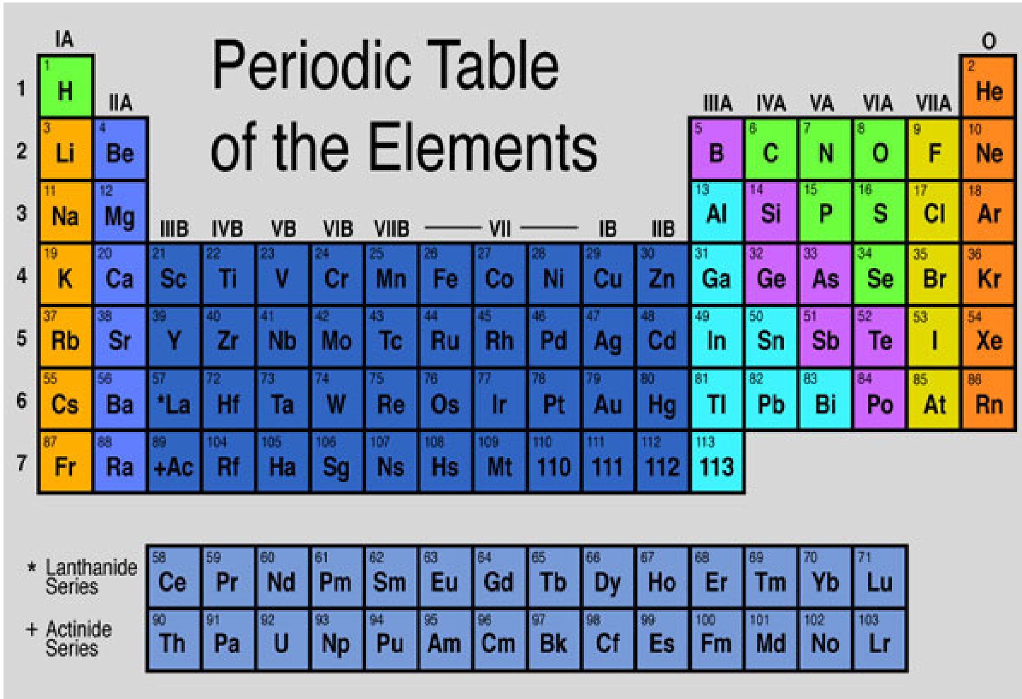
THE PERIODIC TABLE

Module A. Diamonds and Due Diligence

Lesson 6 - Elements, Matter, and Precious Metals

## The Periodic Table of the Elements

The Periodic Table of the Elements is perhaps the most important reference for chemists and scientists alike. It takes all of the known elements and places them in order according to atomic number, or elemental identity. The shape of the table is influenced by which electron shells/orbitals are available for filling for each element. It is arranged in rows (also known as periods) starting from the top left such that hydrogen starts the first row with 1 proton, lithium starts the second row with 3 protons, sodium starts the third row with 11 protons, and so on. Because we can roughly say that with increasing number of protons there is an increasing number of neutrons, then the chart is also roughly organized with increasing atomic weight from left to right and top to bottom.

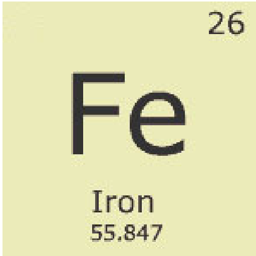



The Periodic Table

There are 7 periods (or rows) of elements, 18 groups (or columns), and a subset of two periods called the Actinides and Lanthanides. The first and second columns of elements are the alkali metals and alkaline earth metals. Elements in the central portion of the table are called Transition Metals (dark blue) and include elements such as iron (Fe), chromium (Cr) and tungsten (W). Elements with a bright blue background are classified as semi-metals (sometimes referred to as "other metals" or "post transition metals") and include aluminum (Al) and lead (Pb). The next group (purple background) are the metalloids, including silicon (Si) and arsenic (As). Nonmetals, include the biologically important elements carbon (C), nitrogen (N), oxygen (O), phosphorus (P), and sulfur (S) (bright green background). The second last column includes the halogen elements and the final column are the noble gases. So in general, from left to right, we have:

- alkali metals
- alkaline earth metals
- Transition metals
- semi-metals
- metalloids
- Nonmetals
- halogen
- noble gases
- ...plus the lanthanides and actinides...

Most Periodic Tables will list the given name (e.g., iron, see figure below), the atomic number=number of protons (e.g., 26), the atomic symbol (e.g., Fe), and the average atomic mass (e.g., 55.847 amu). This makes for a neat and tidy block of data that allows scientists to look at general chemical trends very quickly. For example, information about possible valence states of an element, other elements that behave similarly to it, and relative size of an element, can be gleaned simply from the position of an element within the Periodic Table.




Information on iron from a Periodic Table.

GROUPS OF THE PERIODIC TABLE OF ELEMENTS



## Element Groups

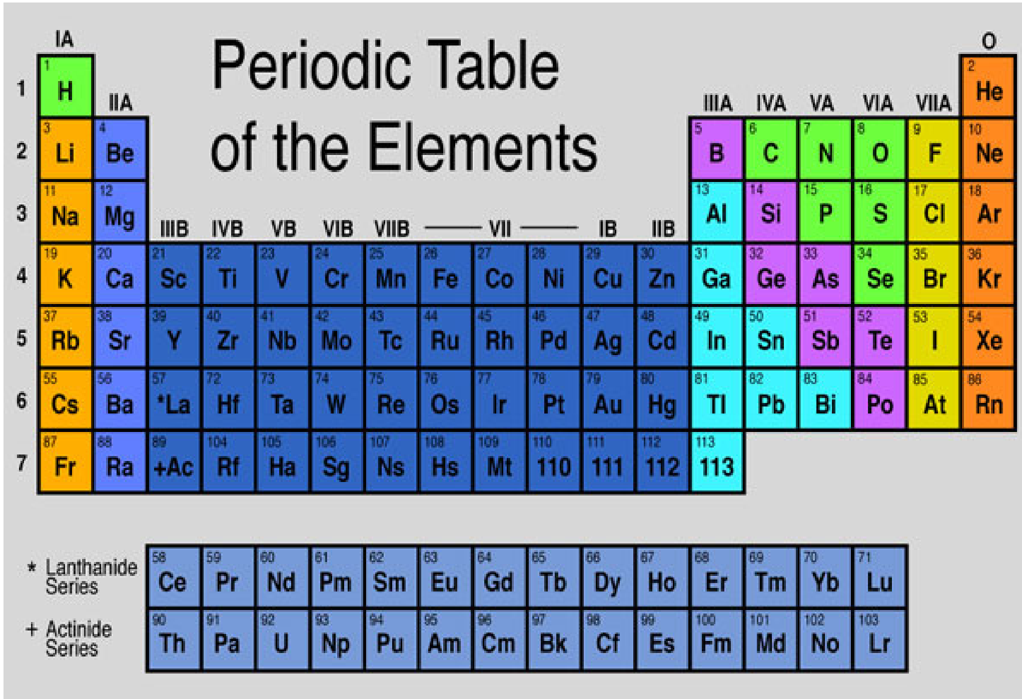
A group is a column of elements in the Periodic Table. Elements within a group have similar chemical behavior because of the similarity in the distribution of their electrons, especially in the valence (outermost) shell. Starting from the left and working towards the right, the elements of the first group (light orange background in Periodic Table below) are called the alkali metals and tend to give up an electron, resulting in a characteristic +1 valence charge. A familiar element in this group is sodium (Na), part of the NaCl (table salt) molecule. Although hydrogen sits at the top of the column, it does not actually belong to the alkali metals group.

The elements of the second group are collectively called the alkaline earth metals. These elements (blue background) usually lose two electrons, resulting in a characteristic +2 valence charge. Calcium (Ca) and magnesium (Mg), 2 of the important bone-forming ingredients, are elements of this group.

The middle block of elements (ranging from Sc down and across to element 112) are called the transition metals. These elements (dark blue background) can have variable valence charges, usually up to +4 but sometimes as high as +6. Note how the precious metals Cu (copper), Ag (silver), and Au (gold) are all Group 11 transition metals and thus share similar physical properties. The metals Pt (platinum), Pd (palladium), and Ni (nickel) are similarly related as Group 10 elements.

Elements with a bright blue background are classified as semi-metals or other metals. These include aluminum (Al) and lead (Pb). The next group (purple background) are the metalloids, including silicon (Si) and arsenic (As). Nonmetals, include the biologically important elements carbon (C), nitrogen (N), oxygen (O), phosphorus (P), and sulfur (S) (bright green background).

Elements in the 17th group (yellow background) are called the halogens, and will almost always have a -1 charge. Familiar elements in this group are chlorine (Cl) and iodine (I). Those with orange background on the far right are the noble gases, which do not combine with other elements. Notable gases in this group are helium (He) and neon (Ne). The two large blocks below the table are the Lanthanide and Actinide series elements.




Grouping of elements in the periodic table.

Note how the precious metals Cu, Ag, and Au all exist in one column and also share similar physical properties. The metals Pt, Pd, and Ni also show similar physical properties as they belong to the same group of elements. Furthermore, elements from the block of transition elements often endow gemstones with their striking colours, as we'll see later. These elements play an important role in the world of gemstones and precious metals.

To reiterate from the introduction, it is **not** necessary to memorize the Periodic Table, but you must be familiar with its structure and how the elements are grouped within the structure.

## GEOLOGICAL ABUNDANCE OF THE ELEMENTS



## Abundance of Elements in Earth's Crust

Although the Periodic Table appears to suggest that the ~112 elements are equally abundant and distributed proportionally on Earth, this is far from the case. The chemical composition of the Earth's crust is in fact made up of 8 dominant elements which comprise 98.5%; all other elements combined make up the remaining 1.5%. This distribution is shown in the table below. Consequently, the bulk of the minerals you will encounter will have their base chemical formula closely associated with these 8 elements.

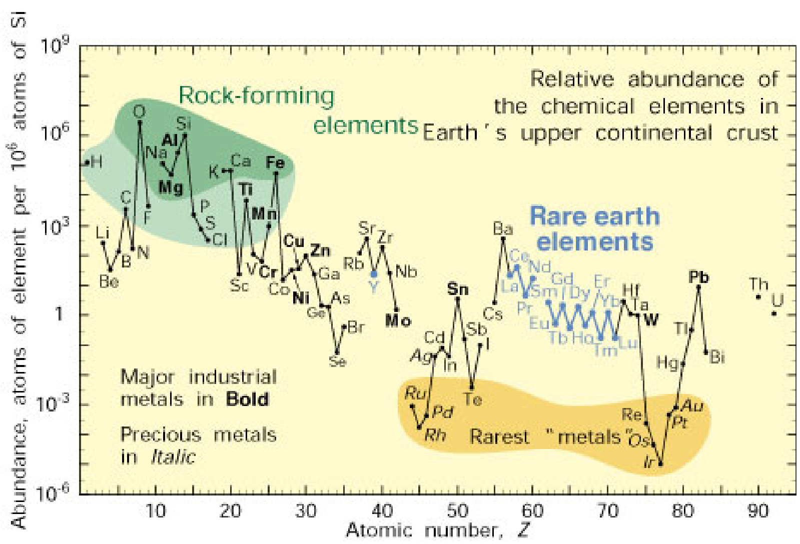
| Element, Symbol | Abundance in Earth's |
| --- | --- |

| | Crust, % |
|---|---|
| oxygen, O | 46.0 |
| silicon, Si | 27.5 |
| aluminum, Al | 8.0 |
| iron, Fe | 5.0 |
| calcium, Ca | 4.0 |
| sodium, Na | 3.0 |
| potassium, K | 3.0 |
| magnesium, Mg | 2.0 |
| all others | 1.5 |

Abundance of Elements in the Earth’s Crust.

The precious metal elements (e.g., Au, Pt, Ag, and Rh) occur very rarely in the Earth's crust. Below is a graph showing the relative abundance of the elements on the vertical axis and sorted by atomic number on the horizontal axis. Note the highlighting of the top eight rock-forming elements (dark green grouping), the rarest metals (yellow grouping), and the Rare Earth Elements (also known as the Lanthanide Series).

Because of the large variability in abundance of elements, the vertical scale of this graph is in logarithmic scale. The graph shows amounts of atoms normalized by (106 x abundance of Si atoms).




Relative abundance of the elements in the Earth's crust. Figure courtesy of US Geological Survey.

Most elements are generally very rare; their weights are therefore commonly referred in parts per million, or ppm. The value of '1 ppm' indicates that there will be 1 gram for every million grams of the material (i.e., 1 gram in every tonne). A value of 10,000 ppm is equivalent to 1% (10,000 parts for every million). The level of concentration in the Earth's upper crust for Au is approximately 0.002 ppm. This is the same as 2 parts per billion (ppb), meaning for every billion atoms counted, only two will be gold!

Exactly as "%" (parts per hundred), the "ppm" and "ppb" are generally dimensionless and may represent different units (weight, volume, count of atoms, etc.). Unless specified otherwise, the ppm and ppb are used in Earth Sciences as units of weight.

NATIVE ELEMENTS



## Native Elements

When elements occur by themselves in rock (i.e., not chemically bonded to other elements), they are considered to be in their native state. About 20 elements can occur in their native state (not including gases); all are either metals, semi-metals, or non-metals, and are considered to be minerals. Of these elements, the native metals make-up the largest group, examples of which include Au, Ag, Cu, and Pt. Gold nuggets, for example, are called native gold. Once these metals have been "worked on" or "tampered with" they then lose their classification as a mineral. Native metals were commonly used in antiquity because ancient cultures often did not have the technology to refine or purify metals that occurred naturally as compounds. For example, iron was not used by many cultures until humans learned how to extract it from hematite ($Fe_2O_3$), a common host compound for iron.

A good example of a native non-metallic mineral is diamond (pure C); an example of a native semi-metallic mineral is arsenic (As). We are going to leave the semi-metals and non-metals for later in the course and concentrate here on the properties of the native metals.

NATIVE METALS AND THEIR PROPERTIES

Module A. Diamonds and Due Diligence

Lesson 6 - Elements, Matter, and Precious Metals

## Native Metals and Their Properties

Most metals, when exposed to oxygen in the air will react (or corrode) to form a metal oxide. This is true for elements such as Fe and Cu (although Cu reacts much slower than Fe); these are often called base metals. Base metals are normally found in nature either as oxide minerals (chemically bonded to O) or sulfide minerals (chemically bonded to sulfur) but in special cases, can be present as native metals.

Metals that do not react to oxygen are called noble metals. This includes Au and Pt. The term precious metal is indicative of the value of a metal, but does not have any chemical connotations. Historically, however, the term precious metal has been applied largely to only the noble metals. For example, uranium (U), although neither a native metal nor a noble metal, is considered a precious metal because of its value.

Gold, silver, copper, and platinum are the four primary native metals and, as expected, are characterized by metallic bonds. Common traits of native metal minerals that differentiate them from most other minerals include good electrical conductivity, good thermal conductivity, high densities, malleability, ductility, and a metallic luster.

**Electrical conductivity** describes the ability of a material to conduct electricity. **Thermal conductivity**

describes the ability of a material to conduct heat. **Density** is defined as the mass of a material in a defined volume and is measured in grams per cubic centimetre (sometimes reported as 'Specific Gravity'). **Malleable** metals are those that can be hammered into other shapes without fracturing the material. **Ductile** metals are those that can be pulled out into a wire-like shape. **Metallic luster** is simply the appearance of a mineral that is like a metal, and naturally the native metal minerals display this trait, especially when polished as for jewellery.

Refer to the tables below for a preview of the ranges of values of properties for selected materials. Do not memorize the numbers in these tables! Note how the 4 primary native metals (in bold) compare with other materials in terms of the selected properties.

| Material | Thermal conductivity (W/m*°C) |
|---|---|
| Air | 0.025 |
| Water (liquid) | 0.6 |
| Glass | 1.1 |
| Ice | 2 |
| Sapphire | 34 |
| Lead | 35.3 |
| Platinum | 70 |
| **Gold** | **318** |
| **Copper** | **380** |
| **Silver** | **429** |
| Synthetic Moissanite | 300 - 500 |
| Diamond | >1000 |

| Material | Electrical Conductivity (S/m * 1,000,000) |
|---|---|
| Diamond* | <0.0000000001 |
| Synthetic Moissanite | variable but generally very low, dependant on dopants |
| Most minerals | <0.00001 |
| Water | 0.005 |
| Platinum | 9 |
| Aluminum | 38 |
| **Gold** | **45** |
| **Copper** | **59** |
| **Silver** | **63** |

*Note: Boron impurities can increase the electrical conductivity in diamond

| Material | Density ($g/cm^3$) |
|---|---|
| Water | 1.0 |
| Quartz | 2.7 |
| Fluorite | 3.2 |
| Synthetic Moissanite | 3.22 |
| Diamond | 3.5 |
| Sapphire | 4 |
| Pyrite | 5 |
| Magnetite | 5.2 |
| Galena | 7.5 |
| Nickel | 8.8 |
| **Copper** | **8.9** |
| **Native Silver** | **10.5** |
| **Gold** | **19.3** |



## Karats, Carats, Carobs, Carrots, and more!

Because of their long historical association with human cultures, precious metals, their weights, and purities are still measured in non-universal and non-standard systems. It is a bit confusing, but hopefully we'll get it straight here!

### *Mass*

Let's start with the Metric System Internationale (SI), since we will be using this system throughout this course. The common base unit for mass is the gram. One gram is defined as the mass of 1 cubic centimeter of pure water at standard temperature and pressure (0 °C and 1 atm). One thousand milligrams equals one gram (1000 mg = 1 g), and one thousand grams equals one kilogram (1000 g = 1 kg).

Some metals are measured in ounces, which is equivalent to 28 grams. The ounce is part of the British/Imperial system of measurement. There are 16 ounces to a pound.

Many precious metals are sometimes measured in troy ounces, which is equivalent to ~31.1 grams. Also part of the British system; there are 12 troy ounces to a troy pound.

### *Purity*

Purity, or fineness, of gold is described in karats with 24-karat (24K) gold being pure gold (100%). This is the form that bullion is stored in. Jewellery, however, rarely has this high purity because pure gold is too soft. Most jewellery is actually 14 karat gold, meaning that it is 14 parts gold and the remaining 10 parts can be anything else (58% pure). Similarly, 18K gold is 18 parts gold and 6 parts something else (75% pure). 22K gold is 22 parts gold and 2 parts something else (92% pure). The non-gold portion is usually a mixture of silver and copper, although other metals may be present.


Gold ring showing an 18 Karat (18K) stamp that indicates the purity of the gold used, as well as the hallmark of the jeweller: BEL.

Purity is also described in percent, with 100% of a metal being pure, and 99.9% being essentially pure. Silver is commonly measured in fineness, with a value of 1 indicating 100% pure silver. It is quite common to see .999 stamped on silver items. Sterling silver is a standard alloy and is 92.5% Ag and 7.5% Cu.


Example of silver marked/stamped with "935" indicating it has at least 93.5% silver content.

The purity of platinum group metals is usually denoted on a scale of 1 to 1000, with 1000 being pure. Thus, platinum stamped with 900 will be 90% pure Pt.

Carat (not be confused with karat) is the most common unit used for weighing gemstones. The word carat is thought to have its origin in the word "carob", and certainly has nothing to do with carrots although if you eat too many carrots your skin can go a golden hue.

## CHECK YOUR UNDERSTANDING

Module A. Rocks, Minerals and Gems

Lesson 6 - Elements, Matter, and Precious Metals

## Learning Objectives

- Define proton, neutron, and electron, including their electrical charges and position in an atom
- Define the terms atomic mass, cation, anion, element, compound and mixture

- Desribe the relationships between atoms, elements, compounds, and mixtures
- Describe the differences between ionic, covalent, and metallic bonding
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- Describe the units for measuring mass and purity of precious metals

## Check Your Understanding

- How abundant is silicon (Si) in the Earth's crust?
- What are some common traits of the native metals that differentiate them from most other minerals?
- What is the difference between a noble metal and a precious metal?
- What is Sterling Silver?

# L06 CYU Form

**Using the periodic table of the elements, what is the chemical symbol of Carbon?**

**Using the periodic table of the elements, what is the atomic mass of Carbon?**

**Using the periodic table of the elements, what is the atomic number of Carbon?**

**If you had a ring that was 75% pure gold, how many karats would it be?**

- 8 Kt
- 10 Kt
- 12 Kt
- 18 Kt
- 24 Kt
- 75 Kt

Submit