Chapter 3: The Periodic Table of Elements

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1 Pure Substances

We have already discussed the classification of Matter in terms of it's states: solid, liquid and gas. There are many categories for classification of matter, another common one being the distinction between **mixtures** and **pure substances**. In this chapter we will be focusing on pure substances, their composition and their properties.

Pure substances have a common feature that is, they all have a constant composition. This means that any given substance will always contain its component elements in fixed mass ratio regardless of its source or method of preparation.

Pure Substances can be further subdivided into the following categories: **Elements** and **Compounds**.

An **element** is a pure substance that cannot be broken down into simpler substances by chemical processes.
A **compound** is a pure substance which can be broken down into separate elements by chemical processes.

The properties of compounds which we now know are chemically combined elements, are different from those in pure elements. For example, when Magnesium, a shiny grey metal, reacts with colourless oxygen gas under high temperatures it produces a white crystalline mineral called Magnesium Oxide.

$$2\,Mg\,(s) + O_2(g) \longrightarrow 2\,MgO\,(s)$$

In their uncombined forms the reactants looked nothing like the product of their reaction, so even just by physical properties alone we can clearly distinguish between the elements mentioned and the compound formed by the two.

Although there are around 90 naturally occurring elements and a few more that have been created in laboratories, altogether amounting to just over a 100 elements, there are millions of chemical compounds resulting from different combinations of these elements. Each of these compounds have their own specific composition and posses definite physical and chemical properties which distinguishes them from all other compounds.

2 The Periodic Table

Many students feel intimidaed when they first see the periodic table for the first time, but there is a genious systematization to it which you will shortly come to appreciate. When understood, the periodic table will be one of your favourite tools to use in Chemistry.

All known chemical elements are arranged in order of their atomic masses, by doing it was observed that every 8 light elements elements possessed similar physical and chemical properties. These later on made up the 8 groups of the periodic table.

Periodic Table of Chemical Elements

	1	2											3	4	5	6	7	8
1	1 H 1.0079 Hydrogen																	2 He 4.0025 Helium
2	3 Li 6.941 Lithium	4 Be 9.0122 Beryllium											5 B 10.811 Boron	6 C 12.011 Carbon	7 N 14.007 Nitrogen	8 O 15.999 Oxygen	9 F 18.998 Flourine	10 Ne 20.180 Neon
3	11 Na 22.990 Sodium	12 Mg 24.305 Magnesium											13 Al 26.982 Aluminium	14 Si 28.086 Silicon	15 P 30.974 Phosphorus	16 S 32.065 Sulphur	17 Cl 35.453 Chlorine	18 Ar 39.948 Argon
4	19 K 39.098 Potassium	20 Ca 40.078 Calcium	21 Sc 44.956 Scandium	22 Ti 47.867 Titanium	23 V 50.942 Vanadium	24 Cr 51.996 Chromium	25 Mn 54.938 Manganese	26 Fe 55.845 Iron	27 Co 58.933 Cobalt	28 Ni 58.693 Nickel	29 Cu 63.546 Copper	30 Zn 65.39 Zinc	31 Ga 69.723 Gallium	32 Ge 72.64 Germanium	33 As 74.922 Arsenic	34 Se 78.96 Selenium	35 Br 79.904 Bromine	36 Kr 83.8 Krypton
5	37 Rb 85.468 Rubidium	38 Sr 87.62 Strontium	39 Y 88.906 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.906 Niobium	42 Mo 95.94 Molybdenum	43 Tc 96 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.91 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.87 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.29 Xenon
6	55 Cs 132.91 Caesium	56 Ba 137.33 Barium	57-71 La-Lu Lanthanide	72 Hf 178.49 Halfnium	73 Ta 180.95 Tantalum	74 W 183.84 Tungsten	75 Re 186.21 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.97 Gold	80 Hg 200.59 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98 Bismuth	84 Po 209 Polonium	85 At 210 Astatine	86 Rn 222 Radon
7	87 Fr 223 Francium	88 Ra 226 Radium	89-103 Ac-Lr Actinide	104 Rf 261 Rutherfordium	105 Db 262 Dubnium	106 Sg 266 Seaborgium	107 Bh 264 Bohrium	108 Hs 277 Hassium	109 Mt 268 Meitnerium	110 Ds 281 Darmstadtium	111 Rg 280 Roentgenium	112 Uub 285 Ununbium	113 Uut 284 Ununtrium	114 Uuq 289 Ununquadium	115 Uup 288 Ununpentium	116 Uuh 293 Ununhexium	117 Uus 292 Ununseptium	118 Uuo 294 Ununoctium

57 La 138.91 Lanthanum	58 Ce 140.12 Cerium	59 Pr 140.91 Praseodymium	60 Nd 144.24 Neodymium	61 Pm 145 Promethium	62 Sm 150.36 Samarium	63 Eu 151.96 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.93 Terbium	66 Dy 162.50 Dysprosium	67 Ho 164.93 Holmium	68 Er 167.26 Erbium	69 Tm 168.93 Thulium	70 Yb 173.04 Ytterbium	71 Lu 174.97 Lutetium
89 Ac 227 Actinium	90 Th 232.04 Thorium	91 Pa 231.04 Protactinium	92 U 238.03 Uranium	93 Np 237 Neptunium	94 Pu 244 Plutonium	95 Am 243 Americium	96 Cm 247 Curium	97 Bk 247 Berkelium	98 Cf 251 Californium	99 Es 252 Einsteinium	100 Fm 257 Fermium	101 Md 258 Mendelevium	102 No 259 Nobelium	103 Lr 262 Lawrencium

- Alkali Metal
- Alkaline Earth Metal
- Metal
- Metalloid
- Non-metal
- Halogen
- Noble Gas
- Lanthanide/Actinide

Z
Symbol
mass
Name

man-made

Each **column** of the periodic table represents a **group** of elements which as explained previously, exhibit similar chemical behaviour.

Each **row** of the periodic table is organised according to ascending values of the atomic masses of elements, towards the right direction of the **period**.

Elements in the table are represented in boxes similar to the figure below. Each box contains the following information: Atomic number, Element Symbol, Element Name and Atomic Mass.

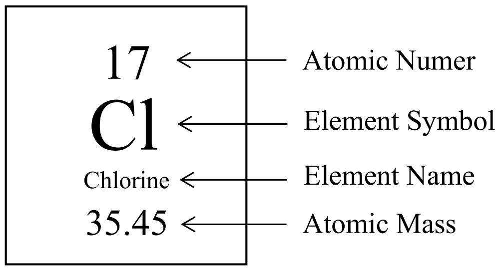

Figure 1: Periodic labelling.

The **atomic number** is equal to the number of protons present in the nucleus of an atom which is equal to the number of electrons orbiting the nucleus.
The **atomic mass** is equal to the mass of one atom of the element.

Exception to the Rule:

When looking at the placement of tellurium and iodine in the periodic table, Te has the heavier atomic mass. The chemical properties of tellurium are like those of selenium because both are semimetallic elements that form compounds like those of Sulfur. Iodine resembles bromine because these elements are non-metallic halogens that form compounds like those of chlorine. Therefore, the order in the table cannot be based solely on atomic mass.

3 Valency

Noble gases exist in a stable state i.e. their electronic configuration allows for the electron shells to be full. All other remaining elements ar not as stable and consequently come with either a positive or negative charge. This occurs when elements give, take or share their electrons to achieve the octate state.

Valency can be defined as combining the capacity of an element i.e. the capacity of an atom to give, take or share electrons.

Non-metals partake in what we call covalent bonding which is the sharing of electrons, while metals undergo ionic bonding where electrons are either donated or accepted by the atoms.

3.1 How is Valency Calculated?

If the outermost shell of an atom contains 4 or less than 4 electrons, then the valency of an element is equal to the number of electrons present in the outermost shell and if it is greater than 4, then the valency of an element is determined by subtracting the total number of electrons.

However, the valency of an atom does not need to calculated nor memorised since it can easily be determined by looking at the periodic table.

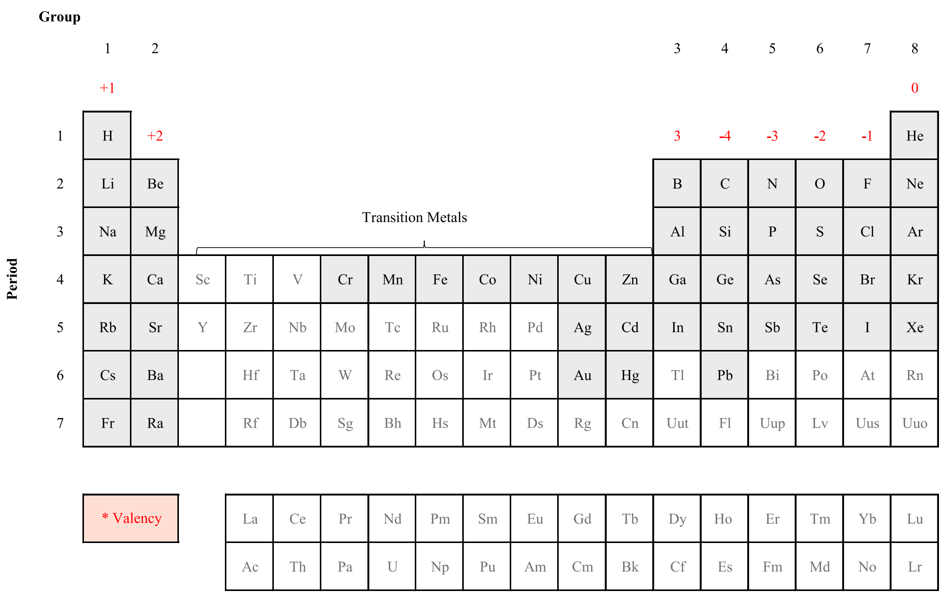

Figure 2: Obtaining valency values from the periodic table.

Exception to the Rule:
The Valency of transition metals are not immediately obvious, the following are examples of two elements which do not follow the usual path.

Copper (Cu) has two valences: Cu I (cuprous) has one valence electron and Cu II (cupric) has two valence electrons. For example Copper(I)chloride, oxidation state is +1 while in Copper(II) Sulfate, the oxidation state is +2. Generally, the valenc y of a copper atom is either +1 or +2.

Zinc (Zn) has 2 electrons in it's outer shell. This means that Zinc can lose the two electrons to achieve it's stable state. Therefore, the valency of Zinc is +2.