

# Unit 3 (Periodic Table) Test Review Sheet

**Periodic Table of the Elements**

**KEY**

Atomic Mass → 12.011 ← Selected Oxidation States

Symbol → **C**

Atomic Number → 6

Electron Configuration → 2-4

Relative atomic masses are based on <sup>12</sup>C = 12 (exact)

Note: Numbers in parentheses are mass numbers of the most stable or common isotope.

18

4.0030

He

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\*denotes the presence of (2-5-) for elements 72 and above

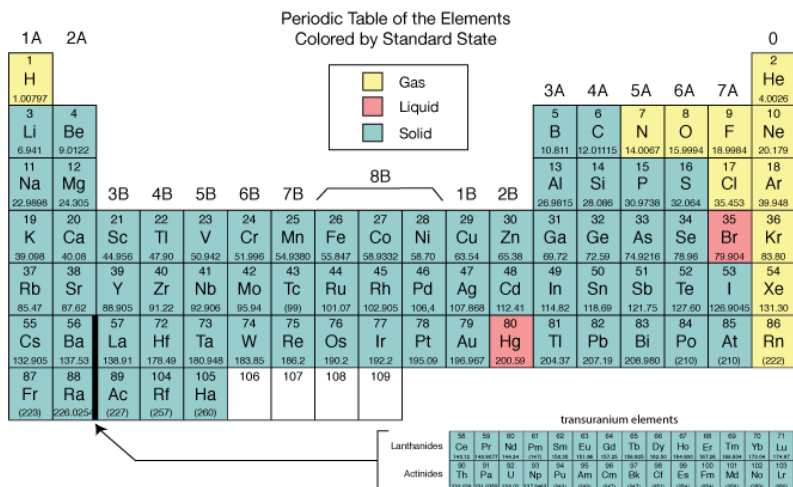
\*\*The systematic names and symbols for elements of atomic numbers 113 and above will be used until the approval of trivial names by IUPAC.

Source: CRC Handbook of Chemistry and Physics, 91<sup>st</sup> ed., 2010-2011, CRC Press

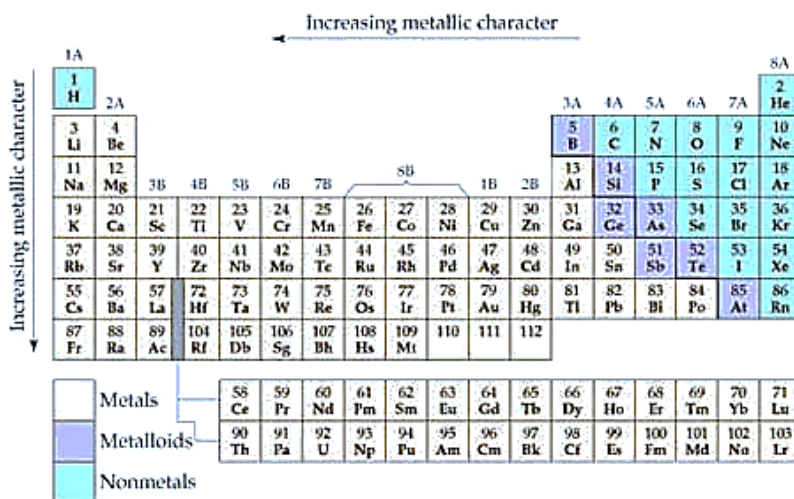
## Basic Organization of Periodic Table

- Periodic Table is organized by increasing atomic number (equal to number of protons)
- Periodic Law: There is repetition of chemical properties when elements are arranged by increasing atomic number
- Elements in a column are referred to being in the same Group (18 Groups)
- Elements in a row are referred to as being in the same Period (7 Periods)
- All elements are classified as metals (left side), nonmetals (right side, but not including Group 18 elements) or metalloids. Look for the **BOLD** staircase in your Periodic Table as the "boundary between metals and nonmetals. Elements with boundaries on the staircase are the metalloids, except aluminum ("Al").
- Hydrogen is the only element on the left side of the **BOLD** "staircase" boundary that is a nonmetal
- Elements in the same Period have the same number of energy shells. For example, all the elements in Period 5 have 5 energy shells and their valence electrons are in the 5th energy shell (highest energy shell).
- Generally, elements in same Group have same # of valence electrons.
- Elements in the same Group have similar chemical properties because they have the same number of valence electrons

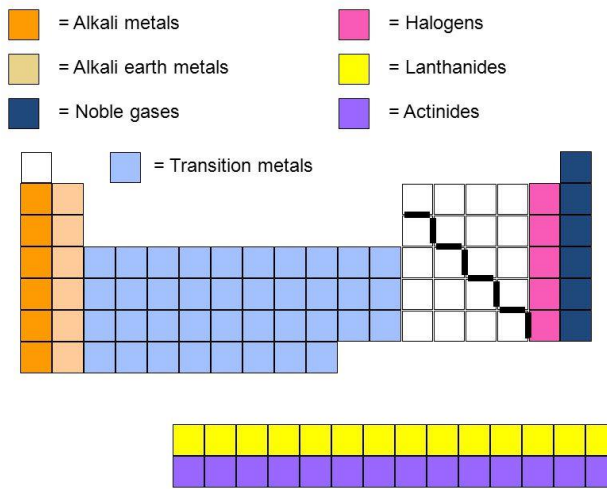
# Phases of the Elements at STP



## Metals, Nonmetals, Metalloids (Semi-Metals)



## Important Groups of the Periodic Table



# Properties of the Elements

## Physical Properties of Elements

There are several physical properties that can be used to describe and identify the elements.

The following is a list of these physical properties and their definitions.

**Concepts & Facts** Study to remember these properties.

**Malleable** describes a solid that is easily hammered and flattened into a thin sheet. (Ex. Aluminum, Al)

**Ductile** describes a solid that is easily drawn into a thin wire. (Ex. Copper, Cu)

**Brittle** describes a solid that is easily broken or shattered into pieces when struck. (Ex. Sulfur, S)

**Luster** describes the shininess of a substance. (Ex. Gold, Au)

**Conductivity** describes the ability of heat or electricity to flow through a substance. (Ex. Copper, Cu)

**Electronegativity** describes an atom's ability to attract electrons from another atom during bonding.

**Ionization energy** describes an atom's ability to lose its most loosely bound valence electrons.

**Density** describes the mass to volume ratio of an element.

**Atomic radius** describes the size of the atom of an element.

**Ionic radius** describes the size of the element after it has lost or gained electrons to become an ion.

Use *Reference Table S* to find and compare electronegativity, ionization energy, atomic radius, and density values of the elements.

See Table S

## Metals

Metallc elements are located to the left of the periodic table.

All elements in Groups 1 to 12 (except hydrogen) are classified as metals.

The rest of the metallic elements are located near the top of Groups 13 through 17.

The majority (about 75%) of the elements are metals.

Below are some general properties (characteristics) of metals.



Iron (Fe)

**Concepts & Facts** Study to remember these properties.

- Almost all metals are solids at room temperature. The exception is mercury (Hg), which is a liquid metal.
- Solid metals are malleable and ductile. Many have high luster.
- Metals tend to have high heat (thermal) and electrical conductivity due to their *mobile valence electrons*
- Metals tend to have low electronegativity values (because they do not attract electrons easily)
- Metals tend to have low ionization energy values (which is why metals lose their electrons easily)
- Metals lose electrons and form positive ions
- Radius (size) of a metal atom decreases as it loses electrons and form a positive ion
- The size of a positive (+) ion is always smaller than the size of the neutral atom

## Metalloids

Metalloids are the seven elements located between the metals and nonmetals.

Metalloid elements are located on the periodic table along the thick zigzag line.

Below are some generally properties (characteristics) of metalloids.

**Concepts & Facts** Study to remember these properties.

- Metalloids tend to have properties of both metals and nonmetals
- Metalloids properties are more like those of metals and less like those of nonmetals
- Metalloids exist only as solids at room temperature.



Tellurium (Te)

## Nonmetals

Nonmetallic elements are located to the right of the periodic table.

All elements in Groups 17 and 18 (except At) are classified as nonmetals. The rest of the nonmetals are located near the bottom of Groups 14, 15 and 16. Hydrogen (in Group 1) is also a nonmetal.

Below are some general properties (characteristics) of nonmetals.

**Concepts & Facts** Study to remember these properties.

- Nonmetals are found in all three phases: solid, liquid and gas.
- Most nonmetals exist as molecular gases and solids. Bromine is the only liquid nonmetal.
- Solid nonmetals are generally brittle and dull (lack luster, not shiny)
- Nonmetals have low or poor electrical and heat (thermal) conductivity
- Nonmetals tend to have high electronegativity values (because they attract and gain electrons easily)
- Nonmetals tend to have high ionization energy (which is why nonmetals do not lose electrons easily)
- Nonmetals gain electrons and form negative ions
- Radius of a nonmetal atom increases as it gains electrons and forms a negative ion
- The size of a negative (-) ion is always bigger than that of the neutral atom



Sulfur (S)

Metals, Nonmetals,  
and Metalloids

# Important Groups of the Periodic Table

## Group 1 - The Alkali Metals

THE GROUP 1 ELEMENTS ARE SHINY, SOFT, AND HIGHLY REACTIVE METALS, NONE OF WHICH OCCUR NATURALLY AS FREE ELEMENTS

**MELTING POINTS**

Li	Na	K
180.5°C	97.7°C	63.4°C
Rb	Cs	Fr
39.3°C	28.4°C	270°C

ALL OF THE GROUP 1 METALS HAVE **ONE VALENCE ELECTRON**

THE ALKALI METALS REACT WITH WATER TO FORM METAL HYDROXIDES

LiOH NaOH KOH RbOH CsOH

ALKALI METALS REACT WITH OXYGEN TO FORM METAL OXIDES

ALKALI METALS REACT WITH HALOGENS TO FORM IONIC SALTS

USES OF THE ALKALI METALS

LITHIUM	SODIUM	POTASSIUM	RUBIDIUM & CAESIUM	FRANCIUM
ANTI-DEPRESSANTS IN BATTERIES	STREET LAMPS	FERTILISERS	ATOMIC CLOCKS	RADIOACTIVE

## Group 2 - The Alkaline Earth Metals

THE GROUP 2 ELEMENTS ARE SHINY, SILVERY-WHITE, AND SOMEWHAT REACTIVE METALS, SOME OF WHICH OCCUR NATURALLY AS FREE ELEMENTS

**MELTING POINTS**

Be	Mg	Ca
1287°C	650°C	850°C
Sr	Ba	Ra
764°C	725°C	700°C

ALL OF THE GROUP 2 METALS HAVE **TWO VALENCE ELECTRONS**

THE ALKALINE EARTH METALS REACT WITH WATER TO FORM METAL HYDROXIDES... EXCEPT FOR Be

$M(OH)_2$

GROUP 2 METALS REACT WITH OXYGEN TO FORM METAL OXIDES

GROUP 2 METALS REACT WITH HALOGENS TO FORM METAL HALIDES

**RADIUM** WHICH HAS A PROTECTIVE OXIDE LAYER PREVENTING REACTION

RADIUM IS A RADIOACTIVE ELEMENT WHICH USED TO BE USED TO MAKE GLOW IN THE DARK PAINT

USES OF THE ALKALINE EARTH METALS

BERYLLIUM	MAGNESIUM	CALCIUM	STRONTIUM	BARIUM
EMERALDS	ALLOY WHEELS	BONES	FIREWORKS	RAT POISON
TELESCOPE MIRRORS	FLARES	BLACKBOARD CHALK	TREATING OSTEOPOROSIS	GLASSMASKING

## Group 7 - The Halogens

GROUP 7 IS THE ONLY GROUP THAT CONTAINS ELEMENTS IN ALL THREE STATES OF MATTER, THEY ARE ALL REACTIVE NON-METALS

**IODINE & ASTATINE** SOLIDS AT ROOM TEMPERATURE

**BROMINE** LIQUID AT ROOM TEMPERATURE

**FLUORINE & CHLORINE** GASES AT ROOM TEMPERATURE

THE HALOGENS ALL FORM DIATOMIC MOLECULES EXCEPT FOR ASTATINE

HYDROFLUORIC ACID LEACHES CALCIUM FROM BONES AND CAN CAUSE VERY PAINFUL BURNS

IT ALSO DISSOLVES GLASS

THE HALOGENS REACT WITH OXYGEN TO FORM HALOGEN OXIDES

THE HALOGENS ARE USED AS OXIDISING AGENTS WHILE HALIDE IONS ARE USED AS REDUCING AGENTS

ALL OF THE GROUP 7 ELEMENTS HAVE **SEVEN VALENCE ELECTRONS**

THE REACTIVITY OF THE HALOGENS DECREASES DOWN THE GROUP AS IT BECOMES HARDER TO ADD AN ELECTRON

ESTIMATED AMOUNT OF ASTATINE IN THE EARTH'S CRUST AT ANY ONE TIME

**1 GRAM**

USES OF THE HALOGENS

FLUORINE	CHLORINE	BROMINE	IODINE
TOOTH PASTE	BLEACH	FIRE RETARDANT	DISINFECTANTS
REFRIGERANT GASES	CHEMICAL WARFARE	MATERIALS	

## Group 8 - The Noble Gases

THE GROUP 8 ELEMENTS ARE ALL ODOURLESS, COLOURLESS, MONATOMIC GASES WITH A VERY LOW CHEMICAL REACTIVITY

**BOILING POINTS**

HELIUM	ARGON	KRYPTON	XENON	RADON
-269°C	-186°C	-152°C	-107°C	-62°C
	NEON			
	-249°C			

THE NOBLE GASES ARE ALL MONATOMIC AND RARELY FORM COMPOUNDS

THE COLOURS IN 'NEON' SIGNS ARE CAUSED BY IONISED NOBLE GASES

He Ne Ar Kr Xe

1 H 2 He 3 O

75% 23% 1%

HELIUM IS THE SECOND MOST ABUNDANT ELEMENT IN THE UNIVERSE

RADON IS RADIOACTIVE AND CAN ENTER HOMES THROUGH BASEMENTS AFTER RADIOACTIVE DECAY OF ROCKS BELOW THE EARTH

ALL OF THE GROUP 8 ELEMENTS HAVE A **FULL OUTER SHELL OF ELECTRONS**

THE GROUP 8 ELEMENTS ARE VERY UNREACTIVE AS THEY ALREADY HAVE A FULL VALENCE ELECTRON SHELL

HELIUM HAS THE LOWEST BOILING POINT OF ALL ELEMENTS IN THE PERIODIC TABLE

**-269°C**

USES OF THE NOBLE GASES

HELIUM	NEON	ARGON	KRYPTON	XENON
BALLOONS	NEON LIGHTS	MEDICAL LASERS	CAMERA FLASHES	MEDICAL IMAGING
	REFRIGERANT	LIGHT BULBS		

# The Transition Metals

A LARGE GROUP OF METALS IN THE CENTRE OF THE PERIODIC TABLE, THEY ARE LESS REACTIVE THAN THE GROUP 1 & 2 METALS, AND HAVE HIGH MELTING POINTS & DENSITIES

21 Scandium	22 Titanium	23 Vanadium	24 Chromium	25 Manganese	26 Iron	27 Cobalt	28 Nickel	29 Copper	30 Zinc
39 Yttrium	40 Zirconium	41 Niobium	42 Molybdenum	43 Technetium	44 Ruthenium	45 Rhodium	46 Palladium	47 Silver	48 Cadmium
72 Hafnium	73 Tantalum	74 Tungsten	75 Rhenium	76 Osmium	77 Iridium	78 Platinum	79 Gold	80 Mercury	

**3422°C** TUNGSTEN HAS THE HIGHEST MELTING POINT OF ANY METALLIC ELEMENT

THERE ARE THREE MAGNETIC METALS **IRON, COBALT AND NICKEL**

MERCURY IS THE ONLY LIQUID METAL AT ROOM TEMPERATURE

UNLIKE GROUP 1 & 2 METALS TRANSITION METALS CAN FORM CO-ORDINATION COMPLEXES WITH OTHER ATOMS & MOLECULES

TRANSITION METALS HAVE VARIOUS OXIDATION STATES

MANGANESE HAS TEN POSSIBLE OXIDATION STATES

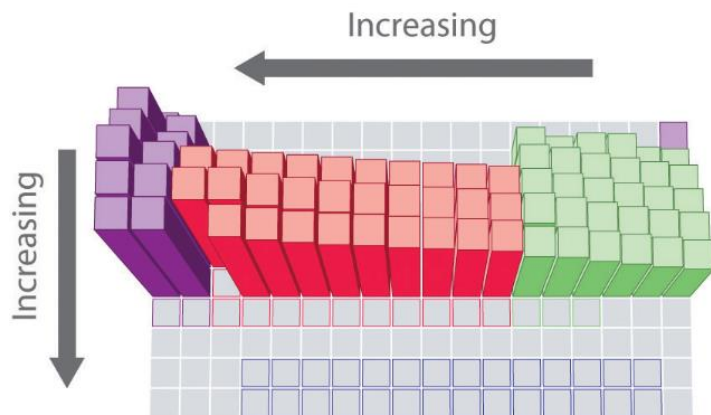
COPPER, SILVER & GOLD ARE KNOWN AS THE COINAGE METALS

TRANSITION METALS FORM COLOURED COMPOUNDS

COLOURS:  $Cu^{2+}$ ,  $Cr^{3+}$ ,  $Fe^{3+}$ ,  $Mn^{2+}$ ,  $Ni^{2+}$ ,  $Co^{2+}$ ,  $Zn^{2+}$

## Trends of the Periodic Table

- **Atomic Radius (Size)**



### Calculated atomic radius (pm)

- Atomic radius decreases along a Period as the atomic number increases (left to right due to the larger positive charge of the nucleus pulling closer valence electrons that are all in the same energy level for all the elements in the same Period)
- Atomic radius increases down a Group as the valence electrons are in higher energy shell which allows the valence electrons to be farther away from the nucleus
- Atomic radius for an element is provided in Table S

- **Ionic Radius vs. Atomic Radius**



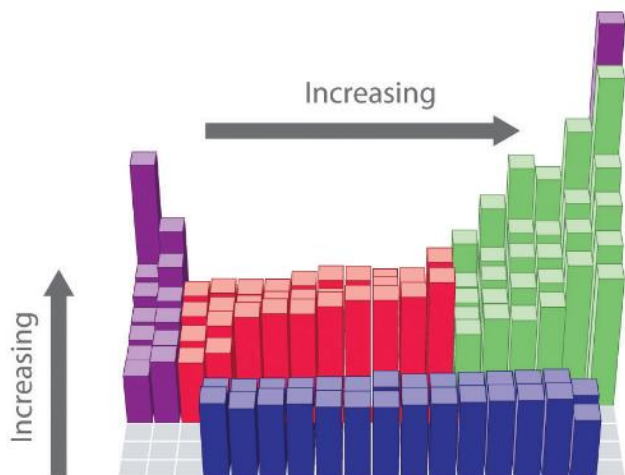
Positive ions have **smaller** atomic radius than neutral atom

For example:  $K^{1+}$  ion has a smaller radius than the neutral K atom. We say the ionic radius is smaller. This is due to the valence electron being lost and the ion having one less energy shell, making the ion smaller.

Negative ions have **larger** atomic radius than positive atom

For example:  $Cl^{1-}$  has a larger radius than the neutral Cl atom. We say the ionic radius is larger. The reason is more difficult to understand since the number of energy shells does not change. The reason the ionic radius is larger is because the extra valence electrons gained cause the electrons to repel each other and force the other valence electrons to move further out to create more space. Thus, the radius of the ion gets larger.

- **Ionization Energy**



**Ionization energy** is the energy required to remove an electron from the outermost shell of an atom

-Ionization energy generally increases along a Period due to increase in the positive charge of the nucleus (see atomic size)

-Ionization energy decreases down a Group as valence electrons are in higher Principal Energy levels. If the valence electron has more energy, then it is farther away from the nucleus and it is easier to remove the electron from the atom.

-Ionization energy for an element is provided in Table S

**First ionization energy (kJ/mol)**

Since metals tend to lose electrons, then the lower the ionization energy, the easier it is for the metal to lose electrons. This makes the metal more reactive.

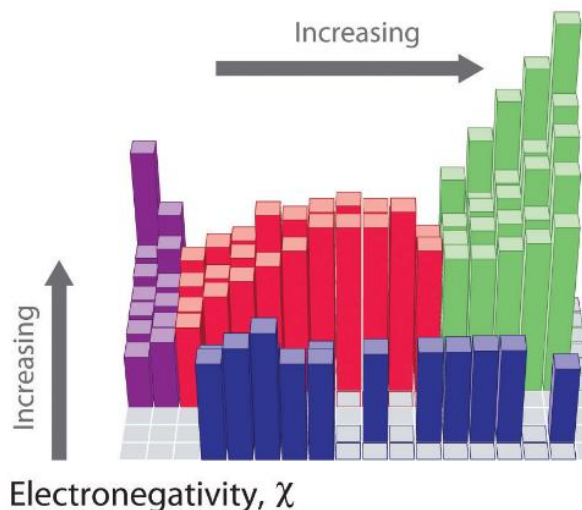
- **Electronegativity**

**Electronegativity** is the ability of an atom to attract electrons

-Nonmetals (except for noble gases) have higher electronegativities than metals. So the higher the electronegativity of a nonmetal, the more reactive it is.

-Scale of electronegativity is from 0 (low) to 4 (high)

-Electronegativity values for an element are provided in Table S. You can compare the electronegativities of any two elements to determine which one will attract electrons more. If the electronegativity is the same, then both have the same ability to attract electrons



Electronegativity,  $\chi$

\*Noble Gases have an unusually **high** ionization energy and **little (or no)** electronegativity because they have a completely filled outer shell of electrons. They do not want to lose the electrons they have and they do not want any more electrons-because this would destabilize them.