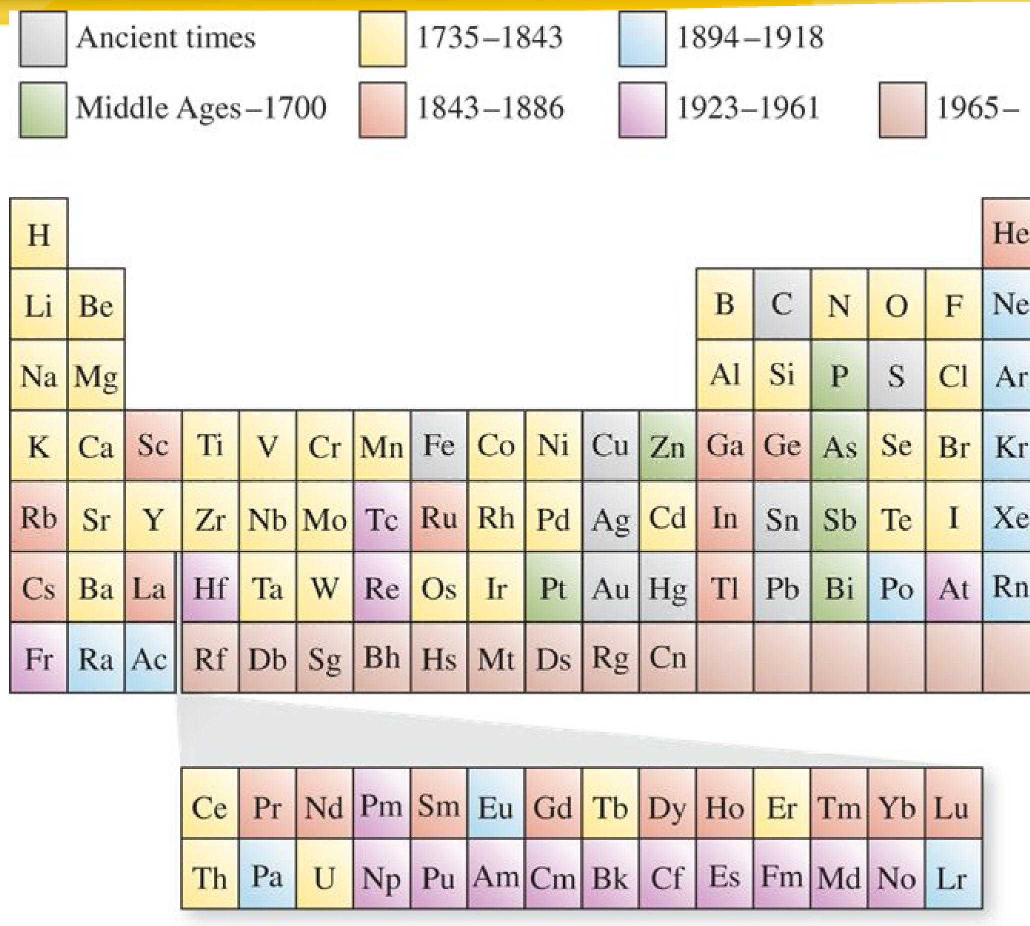
Periodic Table: Facts and Trends

Chemistry
Unit 5 Module 1

Module Concepts

- What names do we use to categorize the elements of the periodic table?
- What are the characteristic properties of each category of elements in the periodic table?

Early development



Mendeleev's early table was incomplete

TABLE I

Distribution of the Elements in Groups and Series

Group.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Series 1	H	—	—	—	—	—	—	
" 2	Li	Be	B	C	N	O	F	
" 3	Na	Mg	Al	Si	P	S	Cl	
" 4	K	Ca	Sc	Ti	V	Cr	Mn	Fe . Co . Ni . Cu
" 5	(Cu)	Zn	Ga	Ge	As	Se	Br	
" 6	Rb	Sr	Y	Zr	Nb	Mo	—	Ru . Rh . Pd . Ag
" 7	(Ag)	Cd	In	Sn	Sb	Te	I	
" 8	Cs	Ba	La	Ce	Di ?	—	—	— — — —
" 9	—	—	—	—	—	—	—	
" 10	—	—	Yb	—	Ta	W	—	Os . Ir . Pt . Au
" 11	(Au)	Hg	Tl	Pb	Bi	—	—	
" 12	—	—	—	Th	—	U	—	
	R_2O	R_2O_2	R_2O_3	R_2O_4	R_2O_5	R_2O_6	R_2O_7	Higher oxides
	—	RO	—	RO_2	—	RO_3	—	RO_4
	—	—	—	RH_4	RH_3	RH_2	RH	Hydrogen compounds

Modern Periodic Table - Moseley

- Organized in order of increasing atomic number instead of mass
- This creates patterns – or periodic trends

Metals, Non-metals, Metalloids

	1A 1	2A 2	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8	8B 9	8B 10	1B 11	2B 12	3A 13	4A 14	5A 15	6A 16	7A 17	8A 18	
1	1 **H** $1s^1$																	2 **He** $1s^2$	1
2	3 **Li** $2s^1$	4 **Be** $2s^2$											5 **B** $2s^22p^1$	6 **C** $2s^22p^2$	7 **N** $2s^22p^3$	8 **O** $2s^22p^4$	9 **F** $2s^22p^5$	10 **Ne** $2s^22p^6$	2
3	11 **Na** $3s^1$	12 **Mg** $3s^2$											13 **Al** $3s^23p^1$	14 **Si** $3s^23p^2$	15 **P** $3s^23p^3$	16 **S** $3s^23p^4$	17 **Cl** $3s^23p^5$	18 **Ar** $3s^23p^6$	3
4	19 **K** $4s^1$	20 **Ca** $4s^2$	21 **Sc** $4s^23d^1$	22 **Ti** $4s^23d^2$	23 **V** $4s^23d^3$	24 **Cr** $4s^13d^5$	25 **Mn** $4s^23d^5$	26 **Fe** $4s^23d^6$	27 **Co** $4s^23d^7$	28 **Ni** $4s^23d^8$	29 **Cu** $4s^13d^{10}$	30 **Zn** $4s^23d^{10}$	31 **Ga** $4s^24p^1$	32 **Ge** $4s^24p^2$	33 **As** $4s^24p^3$	34 **Se** $4s^24p^4$	35 **Br** $4s^24p^5$	36 **Kr** $4s^24p^6$	4
5	37 **Rb** $5s^1$	38 **Sr** $5s^2$	39 **Y** $5s^24d^1$	40 **Zr** $5s^24d^2$	41 **Nb** $5s^14d^4$	42 **Mo** $5s^14d^5$	43 **Tc** $5s^24d^5$	44 **Ru** $5s^14d^7$	45 **Rh** $5s^14d^8$	46 **Pd** $4d^{10}$	47 **Ag** $5s^14d^{10}$	48 **Cd** $5s^24d^{10}$	49 **In** $5s^25p^1$	50 **Sn** $5s^25p^2$	51 **Sb** $5s^25p^3$	52 **Te** $5s^25p^4$	53 **I** $5s^25p^5$	54 **Xe** $5s^25p^6$	5
6	55 **Cs** $6s^1$	56 **Ba** $6s^2$	57 **La** $6s^25d^1$	72 **Hf** $6s^25d^2$	73 **Ta** $6s^25d^3$	74 **W** $6s^25d^4$	75 **Re** $6s^25d^5$	76 **Os** $6s^25d^6$	77 **Ir** $6s^25d^7$	78 **Pt** $6s^15d^9$	79 **Au** $6s^15d^{10}$	80 **Hg** $6s^25d^{10}$	81 **Tl** $6s^26p^1$	82 **Pb** $6s^26p^2$	83 **Bi** $6s^26p^3$	84 **Po** $6s^26p^4$	85 **At** $6s^26p^5$	86 **Rn** $6s^26p^6$	6
7	87 **Fr** $7s^1$	88 **Ra** $7s^2$	89 **Ac** $7s^26d^1$	104 **Rf** $7s^26d^2$	105 **Db** $7s^26d^3$	106 **Sg** $7s^26d^4$	107 **Bh** $7s^26d^5$	108 **Hs** $7s^26d^6$	109 **Mt** $7s^26d^7$	110 **Ds** $7s^26d^8$	111 **Rg** $7s^26d^9$	112 **Cn** $7s^26d^{10}$	113 — $7s^27p^1$	114 — $7s^27p^2$	115 — $7s^27p^3$	116 — $7s^27p^4$	117 — $7s^27p^5$	118 — $7s^27p^6$	7

58 **Ce** $6s^24f^15d^1$	59 **Pr** $6s^24f^3$	60 **Nd** $6s^24f^4$	61 **Pm** $6s^24f^5$	62 **Sm** $6s^24f^6$	63 **Eu** $6s^24f^7$	64 **Gd** $6s^24f^75d^1$	65 **Tb** $6s^24f^9$	66 **Dy** $6s^24f^{10}$	67 **Ho** $6s^24f^{11}$	68 **Er** $6s^24f^{12}$	69 **Tm** $6s^24f^{13}$	70 **Yb** $6s^24f^{14}$	71 **Lu** $6s^24f^{14}5d^1$
90 **Th** $7s^26d^2$	91 **Pa** $7s^25f^26d^1$	92 **U** $7s^25f^36d^1$	93 **Np** $7s^25f^46d^1$	94 **Pu** $7s^25f^6$	95 **Am** $7s^25f^7$	96 **Cm** $7s^25f^76d^1$	97 **Bk** $7s^25f^9$	98 **Cf** $7s^25f^{10}$	99 **Es** $7s^25f^{11}$	100 **Fm** $7s^25f^{12}$	101 **Md** $7s^25f^{13}$	102 **No** $7s^25f^{14}$	103 **Lr** $7s^25f^{14}6d^1$

Color your periodic table

Metals – shades of red
- Alkali metals – red*
- Alkaline Earth metals – pink*
- Transition metals – orange*
- Inner Transition metals – yellow

Other metals - Light Green

Metalloids – Dark Green

Non-metals – shades of blue/purple
- Halogens – dark blue*
- Noble gases – purple*
- Other non-metals – light blue

Element Categories

- All of the elements on the periodic table fall into one of *four major categories*:
  1. Metals (to the left of the stair-step line) are generally *solids at room temperature*, they are *good conductors* of heat and electricity based on their sea of electrons bonding model, they are generally *shiny* (i.e. *lustrous*), *ductile* (can be pulled into thin wires) and *malleable* (can be pounded into thin sheets).

Metals and Metal Alloys

Element Categories – Cont'd

2.Non-metals (to the right of the stair-step line) can be *solids, liquids, or gases* at room temperature. They are *very poor conductors* (i.e. insulators) of heat and electricity. They are generally *brittle if solid*, rather than being ductile and malleable. They are generally *non-lustrous*.

Element Categories – Cont'd

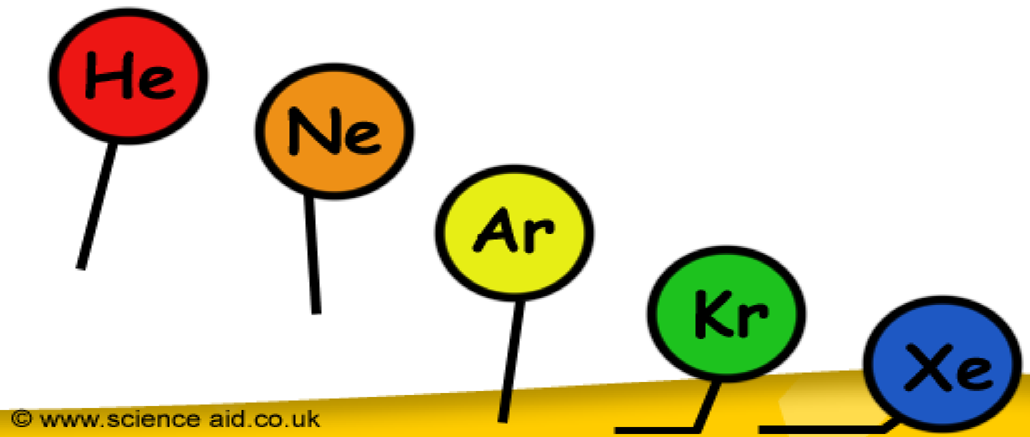
3.Semi-metals or metalloids (bordering the stair-step line, *except Al*, which is a true metal) have characteristics of both metals and nonmetals. They are usually good *semi-conductors* (i.e. they conduct heat and electricity only at very high or very low temperatures).

Germanium

Tellurium

Element Categories – Cont'd

4. <u>Noble gases</u> comprise the last vertical column (Group 18) in the periodic table. They are all *gases* at room temperature. They are very *unreactive* (i.e. inert) because they have *full s and p orbitals* (i.e. the *stable octet*, or *stable duet* in the case of helium).



- In addition, there are also several groups/families (i.e. vertical columns) of the periodic table that have unique names and properties.

Alkali metals

Alkali metals
3 **Li** $2s^1$
11 **Na** $3s^1$
19 **K** $4s^1$
37 **Rb** $5s^1$
55 **Cs** $6s^1$
87 **Fr** $7s^1$

- Alkali metals (first group, except Hydrogen).
- Only have one valence electron.
- Very reactive metals, so reactive they do not exist in elemental form in nature, only in compound form.
- React *violently* with water producing alkaline solutions (i.e. pH>7, basic!)
- http://www.youtube.com/watch?v=m55kgyApYrY

Alkaline Earth metals

Alkaline earth metals

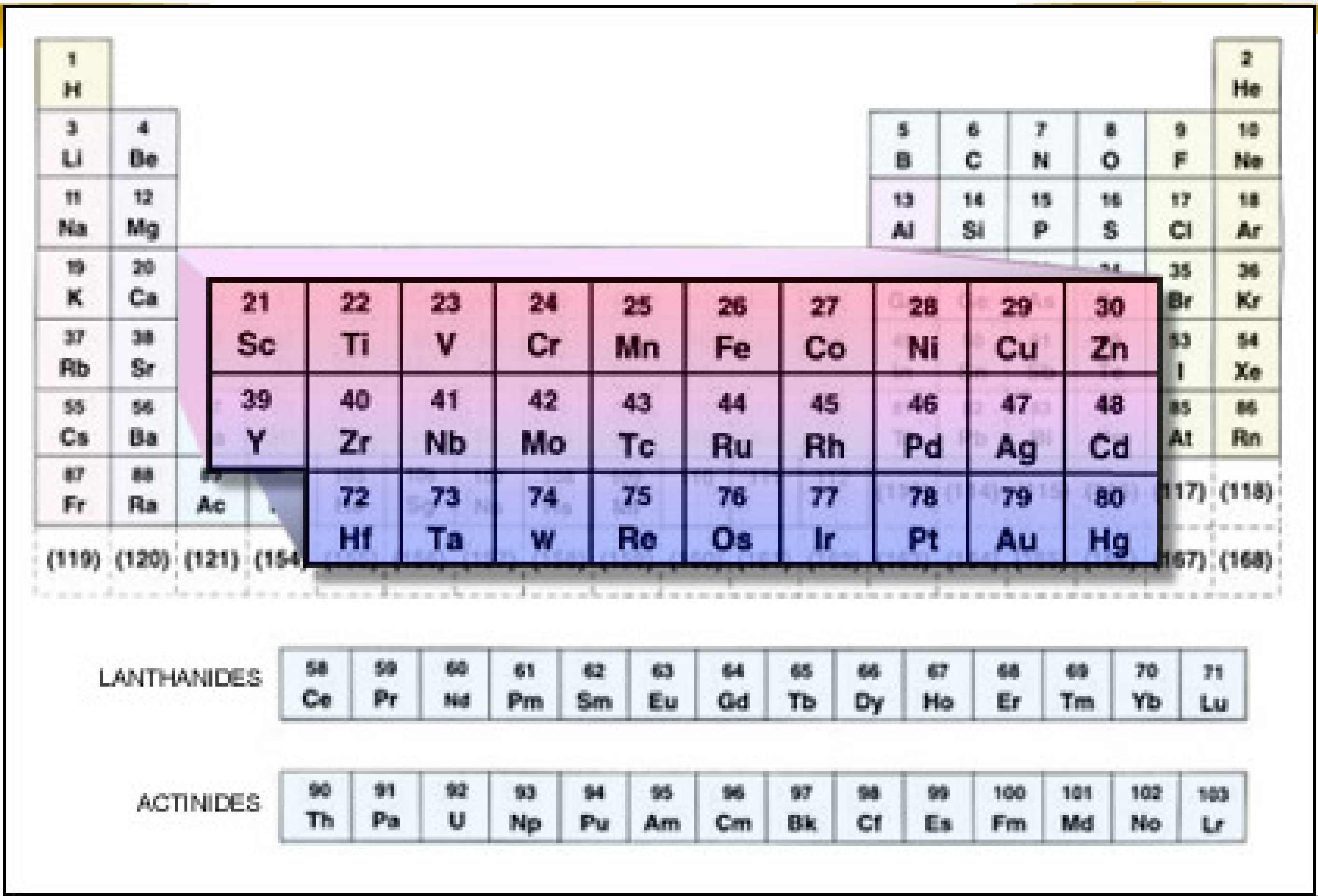
4 **Be** $2s^2$
12 **Mg** $3s^2$
20 **Ca** $4s^2$
38 **Sr** $5s^2$
56 **Ba** $6s^2$
88 **Ra** $7s^2$

- Alkaline Earth metals (second group).
- Have two valence electrons.
- Also react with water to produce alkaline (i.e. basic) solutions with a pH > 7, though they react much less violently.

Alkaline Earth Elements

- So we know why they are called “alkaline” elements. But why “Earth”?
- “Earth” refers to one of the Greek elements, one of four fundamental substances. Earth elements were defined as those unreactive toward fire. Compounds of group 2 are unreactive toward fire, such as $CaCO_3$, a substance found in seashells and chalk.

Transition Metals



Transition Metals

- Transition metals are the *d* block elements.
- They form a bridge between the *s* and *p* blocks of the periodic table.
- They represent a section of the periodic table where the elements are “transitioning” from the left side (metals) to the right side (nonmetals)
- Like all metals, these elements are good conductors of electricity and have a high luster. They are typically less reactive than alkali and alkaline earth metals.
- Some are so unreactive that they exist in nature as free elements.

Halogens

Halogens
9 **F** $2s^2 2p^5$
17 **Cl** $3s^2 3p^5$
35 **Br** $4s^2 4p^5$
53 **I** $5s^2 5p^5$
85 **At** $6s^2 6p^5$

- Halogens (group 17).
- Contain seven valence electrons.
- Most reactive non-metals.
- Pair very nicely with alkali metals of group 1 to form "salts" because the elements in Group 1 are trying to lose 1 electron to achieve a stable octet while those of Group 17 are trying to gain 1 electron to achieve a stable octet. This explains the name "halogen" which means "salt-former".
- Exist as diatomic elements in nature. (F_2, Cl_2, Br_2, etc.)

Noble Gases

Noble gases
2 **He** $1s^2$
10 **Ne** $2s^22p^6$
18 **Ar** $3s^23p^6$
36 **Kr** $4s^24p^6$
54 **Xe** $5s^25p^6$
86 **Rn** $6s^26p^6$

- Noble gases (group 18).
- Contain eight valence electrons because they have full s and p orbitals – satisfy the octet rule. (He, however, only has 2 valence electrons.)
- In a chemical reaction, these elements will not lose or gain electrons because they have already achieved stability.
- Since they are already stable, they will rarely react and are called inert.

Representative Elements

- The *s* and *p* blocks of the periodic table comprise what is known as the “main block” or “representative” elements. These are elements that gain, lose, or share electrons in order to achieve a noble gas configuration or stable octet or duet.