THE PERIODIC TABLE

Organizing the Elements

Dmitri Mendeleev (1834-1907), a chemistry professor at the University of St. Petersburg, observed one evening in 1869 that if the elements were arranged in order of increasing atomic mass, certain properties were repeated several times.

He built a table by lining up the elements in horizontal rows in order of increasing atomic mass. Every time he came to an element with properties similar to one already in the row, he started a new row. Each column then contained elements with similar properties.

The modern periodic table is built upon Mendeleev's work.

Element Year of Discovery	Property	Mendeleev's Prediction in 1871	Actual Properties
ekaaluminum (gallium) 1875	atomic weight density of metal melting point solubility	68 g/mol 6.0 g/ml low sol. in ammonia	69.7 g/mol 5.96 g/ml 30°C sol. in ammonia
ekaboron (scandium) 1877	atomic weight density of oxide oxide formula solubility	44 g/mol 3.5 g/ml Eb_2O_3 sol. in acids	43.7 g/mol 3.86 g/ml Sc_2O_3 sol. in acids
ekasilicon (germanium) 1886	atomic weight density of metal color of metal melting point density of oxide oxide formula density of chloride chloride formula BP of chloride	72 g/mol 5.5 g/ml dark gray high 4.7 g/ml EsO_2 1.9 g/ml $EsCl_4$ below 100°C	72.6 g/mol 5.47 g/ml grayish white 900°C 4.70 g/ml GeO_2 1.89 g/ml $GeCl_4$ 86°C

THE PERIODIC TABLE OF THE ELEMENTS

The elements in the present Periodic Table are arranged in atomic number order

	1																18
1	1 H	2											13	14	15	16	17	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg	3	4	5	6	7	8	9	10	11	12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	103 Lw															

The horizontal rows on the Periodic Table are called “Periods.”

1	H			PERIOD 1									He
2	Li	Be		PERIOD 2			B	C	N	O	F	Ne	
3	Na	Mg		PERIOD 3			Al	Si	P	S	Cl	Ar	
4	K	Ca	Sc	PERIOD 4		Zn	Ga	Ge	As	Se	Br	Kr	
5	Rb	Sr	Y	PERIOD 5		Cd	In	Sn	Sb	Te	I	Xe	
6	Cs	Ba	Lu	PERIOD 6		Hg	Tl	Pb	Bi	Po	At	Rn	
7	Fr	Ra	Lw	PERIOD 7									

Lanthanide Series	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
Actinide Series	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No

The number of the period is the same as the number of the outermost principle energy level of the atoms in that period

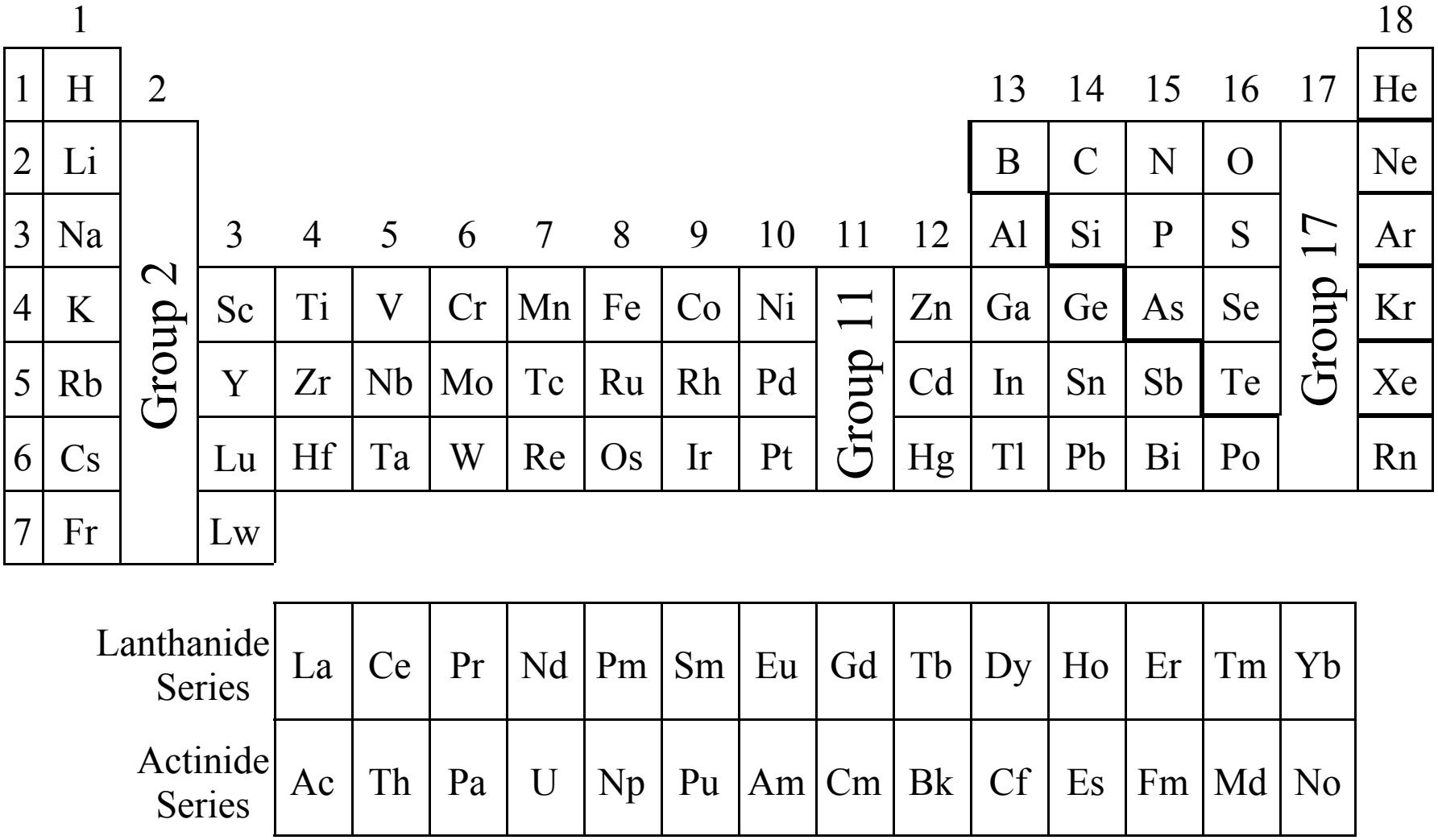
The vertical columns on the Periodic Table are called “Families.”

	IA															O
1	H	IIA										IIIA	IVA	VA	VIA	VIIA	He
2	Li	IIA Family										B	C	N	O	VII A Family	Ne
3	Na		IIIB	IVB	VB	VIB	VIIB	7 VIII 6		IB	IIB	Al	Si	P	S		Ar
4	K		Sc	Ti	V	Cr	Mn	Fe	Co	Ni	IB Family	Zn	Ga	Ge	As	Se	Kr
5	Rb		Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd		Cd	In	Sn	Sb	Te	Xe
6	Cs		Lu	Hf	Ta	W	Re	Os	Ir	Pt		Hg	Tl	Pb	Bi	Po	Rn
7	Fr		Lw														

Lanthanide Series	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
Actinide Series	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No

Elements in the same family have similar chemical and physical properties

The vertical columns on the Periodic Table are also called “Groups.”



Occasionally, families or groups are named from the element at the top of the group
For example, Group 16 is also called the oxygen group or oxygen family
Group 14 is sometimes called the carbon family, etc.

SOME COMMON FAMILY NAMES

	IA																	
1	H	IIA																He
2	Li	Be											B	C	N	O	F	Ne
3	Na	Mg	IIIB	IVB	VB	VIB	VIIB	VIII		IB			Al	Si	P	S	Cl	Ar
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra	Lw															

7 Alkali Metals

7 Alkaline Earth Metals

7 Transition Elements

6 Noble gases

6 Halogens

Lanthanide Series	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
Actinide Series	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No

THE ELECTRON CONFIGURATIONS OF THE ELEMENTS

	IA												IIIA	IVA	VA	VIA	VIIA	O
1	$1s^1$	IIA																$1s^2$
2	$2s^1$	$2s^2$											$2p^1$	$2p^2$	$2p^3$	$2p^4$	$2p^5$	$2p^6$
3	$3s^1$	$3s^2$	IIIB	IVB	VB	VIB	VIIB	7 VIII 6			IB	IIB	$3p^1$	$3p^2$	$3p^3$	$3p^4$	$3p^5$	$3p^6$
4	$4s^1$	$4s^2$	$3d^1$	$3d^2$	$3d^3$	$3d^4$	$3d^5$	$3d^6$	$3d^7$	$3d^8$	$3d^9$	$3d^{10}$	$4p^1$	$4p^2$	$4p^3$	$4p^4$	$4p^5$	$4p^6$
5	$5s^1$	$5s^2$	$4d^1$	$4d^2$	$4d^3$	$4d^4$	$4d^5$	$4d^6$	$4d^7$	$4d^8$	$4d^9$	$4d^{10}$	$5p^1$	$5p^2$	$5p^3$	$5p^4$	$5p^5$	$5p^6$
6	$6s^1$	$6s^2$	$5d^1$	$5d^2$	$5d^3$	$5d^4$	$5d^5$	$5d^6$	$5d^7$	$5d^8$	$5d^9$	$5d^{10}$	$6p^1$	$6p^2$	$6p^3$	$6p^4$	$6p^5$	$6p^6$
7	$7s^1$	$7s^2$	$6d^1$															

$4f^1$	$4f^2$	$4f^3$	$4f^4$	$4f^5$	$4f^6$	$4f^7$	$4f^8$	$4f^9$	$4f^{10}$	$4f^{11}$	$4f^{12}$	$4f^{13}$	$4f^{14}$
$5f^1$	$5f^2$	$5f^3$	$5f^4$	$5f^5$	$5f^6$	$5f^7$	$5f^8$	$5f^9$	$5f^{10}$	$5f^{11}$	$5f^{12}$	$5f^{13}$	$5f^{14}$

Elements in the same family have the same number of valence electrons and similar electron configurations

PHYSICAL STATE OF THE ELEMENTS
AT 25°C AND 1 ATM

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	7 VIII 6			IB	IIB	IIIA	IVA	VA	VIA	VIIA	O
1	GAS H_2																	GAS He_1
2	Li	Be											B	C	GAS N_2	GAS O_2	GAS F_2	GAS Ne_1
3	Na	Mg											Al	Si	P	S	GAS Cl_2	GAS Ar_1
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	LIQUID Br_2	GAS Kr_1
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I_2	GAS Xe_1
6	Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	LIQUID Hg	Tl	Pb	Bi	Po	At_2	GAS Rn_1
7	Fr	Ra	Lw															

Most of the elements are solids
Two elements are liquids, mercury (metal) and bromine (nonmetal)
H - O - F - Br - I - N - Cl (HOFBrINCl) are diatomic
All Group O (18) are monoatomic gases

CLASSIFICATION OF THE ELEMENTS

Most of the elements on the Periodic Table are "Metals."

Nonmetals

Semimetals (Metalloids)

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	7 VIII 6			IB	IIB	IIIA	IVA	VA	VIA	VIIA	O
1	H																	He
2	Li	Be											B	C	N	O	F	Ne
3	Na	Mg											Al	Si	P	S	Cl	Ar
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra	Lw															

Lanthanide Series	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
Actinide Series	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No

The Properties of the Elements

THE PERIODIC LAW: The chemical and physical properties of the elements are a periodic function of their atomic number.

Elements in the same family have the same number of valence electrons and therefore, have similar chemical and physical properties.

The closer two elements are located in the same family, the more similar their properties. For example, in the VA family, nitrogen and phosphorus are more similar than antimony and bismuth.

Properties of Metals

Most of the elements on the Period Table are metals (roughly two-thirds)
Malleable (hammered or rolled in sheets)
Ductile (drawn into a wire)
Good conductors of heat and electricity
All metals have a silvery, “metallic” luster except copper and gold
Metals have relatively low ionization energies
Metals have low electronegativities
All metals are solids at room conditions except mercury which is a liquid
The most reactive metals are the Group IA and IIA elements
The elements with the most metallic properties are found on the lower left side of the Periodic Table
Metals react by losing electrons forming positive ions
Metals contain few valence electrons (usually three or less)

Properties of Nonmetals

Nonmetals are found on the top right portion of the Periodic Table
Nonmetallic solids lack a metallic luster (dull)
They may be colored solids, colored gases, or colorless gases (except bromine, a liquid)
Nonmetals which are solids at room temperature are either hard and brittle or soft and wax-like
Poor conductors of both heat and electricity
Nonmetals have high ionization energies
Nonmetals have high electronegativities
The most reactive nonmetals are found on the right side of the Periodic Table (Group VIA and VIIA)
Elements with the most pronounced nonmetallic properties are found in the upper, right hand corner of the Periodic table
Nonmetals react by gaining electrons forming negative ions
Nonmetals have four or more valence electrons (except hydrogen)

Metalloids (Semimetals)

Metalloids have properties which are between those of the metals and nonmetals

Metalloids have properties of both metals and nonmetals

Metalloids are semiconductors

Metalloids which are located above the line separating metals and nonmetals have more pronounced nonmetallic properties

Metalloids which are located below the line separating metals and nonmetals have more pronounced metallic properties

All metalloids are solids

Transition Elements

The transition elements are those elements in the middle of the Periodic Table from Group IIIB to Group IB (Sc to Cu)

The elements in Group IIB are **not** transition elements (Zn, Cd, Hg)

In the transition elements, electrons from the outermost **two** sublevels ("s" and "d") may be involved in chemical reactions

Ions containing the transition elements are usually colored, both in solid compounds and in solution

Transition elements generally exhibit more than one positive oxidation state

Transition elements generally form more than one binary compound with the halogens or oxygen

All transition elements are metals

Noble Gases or Inert Gases

The “noble gases” are found in Group “O” (Group 18) on the Periodic Table of the Elements.

The noble gases are all monoatomic (single atom) gases.

The noble gases are called “noble gases” because they do not react under normal conditions.

Only the noble gases xenon, Xe, and krypton, Kr, have been reacted.

The noble gases have the most stable electron configuration of all elements and either have eight or two valence electrons (He only).

The noble gases have the highest ionization energy of any element in the period.