

Periodic Table

Lecture 2



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PERIODIC TABLE –BASIC TOOLBOX OF EVERY CHEMIST

Periodic Table of the Elements																	
Number Symbol Name Mass																	
1	2															18	
1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012															10 Ne Neon 20.180	
11 Na Sodium 22.990	12 Mg Magnesium 24.305															18 Ar Argon 39.948	
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.293
55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.085	79 Au Gold 196.967	80 Hg Mercury 200.592	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]
Lanthanide Series			57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.243	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967
Actinide Series			89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]
			Alkali Metal	Alkaline Earth	Transition Metal	Basic Metal	Metalloid	Nonmetal	Halogen	Noble Gas	Lanthanide	Actinide					
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WHAT ARE THE ELEMENTS?

- An **element** is a substance that cannot be broken down into any other substance. Every element is made up of its own type of **atom**. This is why the chemical elements are all very different from each other.
- Everything in the universe contains the atoms of at least one or more elements.
- The **periodic table** lists all the known elements and groups together those with similar properties.



WHERE DO THE ELEMENTS COME FROM?

Ancient scientists – four elements: earth, fire, air, and water

Alchemist – could turn base things into pure gold

BIG BANG – Hydrogen and Helium were formed

Heavier elements formed as a result of fusion (extreme temperature and pressure)

Planets formed from heavier elements



ELEMENTS, COMPOUNDS, MATERIALS

There are 92 elements occurring naturally on Earth

Elements of the same type are made from the same atoms

Atoms of the same element have the same size, mass, and other properties

Atoms of different elements differ in size, mass, and other properties



ATOM – the smallest part of an element that can ever exist



Materials are made of compounds and compounds are made of elements

A BIT OF HISTORY

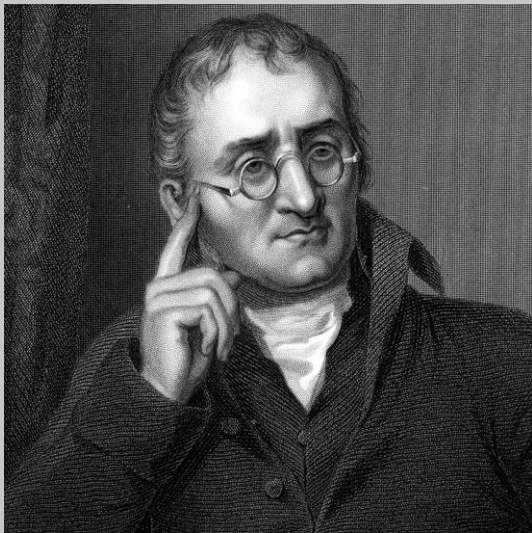
By the 19th century, only 50 elements were known

As scientists and engineers discovered more and more elements they were trapped in a sea of elements of confusingly different properties.

This was a jigsaw puzzle with no instructions, pieces of the wrong shape and missing pieces



HALL OF FAME – John DALTON



1766-1844

Early discovery that elements consisted of atoms.

He also realised that atoms of the different elements
had different masses

Soon scientists had measured all the atomic masses

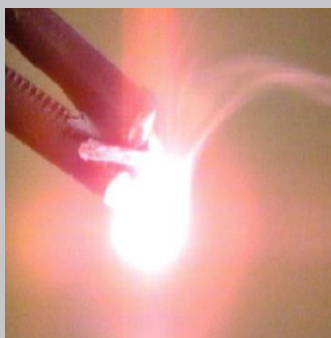
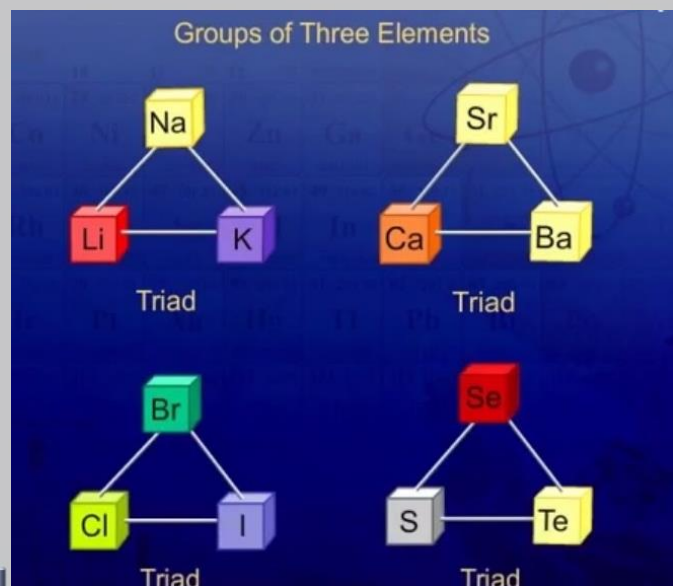


HALL OF FAME – Johann Wolfgang DÖBEREINER

Dobereiner made a breakthrough in 1829 when he noticed that groups of elements were similar. Lithium, sodium, and potassium have similar properties and equally spaced masses 7, 23 and 39. These are Triads.



1780-1849



<https://youtu.be/6ZY6d6jrj-q-0>



OTHER TRIADS:

Similar properties of HALOGENS



Chlorine

Bromine

Iodine



HALL OF FAME – John NEWLANDS



1837-1898

Ordered atoms in order of atomic masses in rows of 8

This was to fit in with Dobereiner's triads

The problem was that the pattern only fitted for the first 15 elements

Copper in the same group as sodium !!?

Newlands' octaves						
H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe
Co and Ni	Cu	Zn	Y	In	As	Se
Br	Rb	Sr	Ce and La	Zr	Di and Mo	Ro and Ru



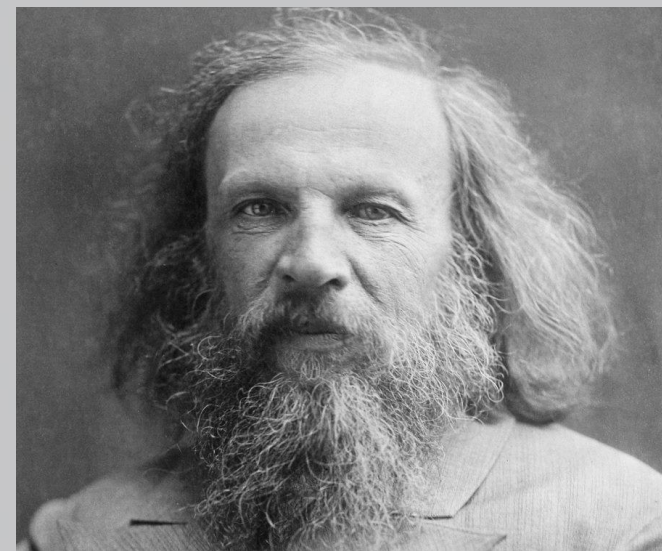
HALL OF FAME – Dmitri MENDELEEV

Periodic Table Oscar Winner

Decided to ignore the elements that did not fit

He recognised that some elements might not have been discovered

He was vindicated by the discovery of Germanium in 1885



1834-1907

Reihen	Gruppe I. - R^2O	Gruppe II. - RO	Gruppe III. - R^2O^3	Gruppe IV. RH^4 RO^2	Gruppe V. RH^3 R^2O^5	Gruppe VI. RH^2 RO^3	Gruppe VII. RH R^2O^7	Gruppe VIII. - RO^4
1	<u>H</u> = 1							
2	<u>Li</u> = 7	<u>Be</u> = 9,4	<u>B</u> = 11	<u>C</u> = 12	<u>N</u> = 14	<u>O</u> = 16	<u>F</u> = 19	
3	<u>Na</u> = 23	<u>Mg</u> = 24	<u>Al</u> = 27,3	<u>Si</u> = 28	<u>P</u> = 31	<u>S</u> = 32	<u>Cl</u> = 35,5	
4	<u>K</u> = 39	<u>Ca</u> = 40	<u>Sc</u> = 44	<u>Ti</u> = 48	<u>V</u> = 51	<u>Cr</u> = 52	<u>Mn</u> = 55	<u>Fe</u> = 56, <u>Co</u> =59 <u>Ni</u> =59, <u>Cu</u> =63
5	<u>(Cu)</u> = 63	<u>Zn</u> = 65	<u>Ga</u> = 68	<u>Ge</u> = 72	<u>As</u> = 75	<u>Se</u> = 78	<u>Br</u> = 80	
6	<u>Rb</u> = 85	<u>Sr</u> = 87	<u>Yt</u> = 88	<u>Zr</u> = 90	<u>Nb</u> = 94	<u>Mo</u> = 96	<u>Ag</u> = 100	<u>Ru</u> =104, <u>Rh</u> =104 <u>Pd</u> =106, <u>Au</u> =108
7	<u>Ag</u> = 108	<u>Cd</u> = 112	<u>In</u> = 113	<u>Sn</u> = 118	<u>Sb</u> = 122	<u>Te</u> = 125	<u>I</u> = 127	
8	<u>Cs</u> = 133	<u>Ba</u> = 137	<u>Di</u> = 138	<u>Ce</u> = 140	-	-	-	- - - -
9	(-)	-	-	-	-	-	-	-
10	-	-	<u>Er</u> = 178	<u>La</u> = 180	<u>Ta</u> = 182	<u>W</u> = 184	-	<u>Os</u> =195, <u>Ir</u> =197, <u>Pt</u> =198, <u>Au</u> =199
11	<u>(Au)</u> = 199	<u>Hg</u> = 200	<u>Tl</u> = 204	<u>Pb</u> = 207	<u>Bi</u> = 208	-	-	-
12	-	-	-	<u>Th</u> = 231	-	<u>U</u> = 240	-	- - - -



Can you work out which elements are missing?



	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII	Group VII
Period 1	H							
Period 2	Li	Be	B	C	N	O	F	
Period 3	Na	Mg	Al	Si	P	S	Cl	
Period 4	K Cu	Ca Zn	* *	Ti *	V As	Cr Se	Mn Br	Fe Co Ni
Period 5	Rb Ag	Sr Cd	Y In	Zr Sn	Nb Sb	Mo Te	* I	Ru Rh Pd

Sc

Ge

Ga

Tc



HALL OF FAME – Henry MOSELEY



1887-1915

There was still the problem of ignoring some of the elements

Moseley solved this when he used X-ray studies to work out the number of electrons in the atom

By arranging elements in order of the number of electrons the modern Periodic Table dropped out.



THE MODERN PERIODIC TABLE

Orders the 92 naturally occurring elements in order of their number of electrons

Hang on there are suddenly 109 elements; how is that? (newest estimate – 118!!)

This is modern-day Alchemy

Interested in the history of the periodic table? See Youtube resources and video link in Moodle



THE MODERN-DAY ALCHEMY

Take one atoll and add one hydrogen bomb and you can make new elements!

A tad expensive and elements are often highly radioactive and unstable



GROUP NAMES

												Nitrogen group (pnictogens)						Noble gases	
												Boron group (icosagens)		Carbon group (crystallogens)		Oxygen group (chalcogens)		Halogens	
H 1												B 5	C 6	N 7	O 8	F 9	He 2	Ne 10	
Li 3	Be 4											Al 13	Si 14	P 15	S 16	Cl 17	Ar 18		
Na 11	Mg 12	Transition metals										Ga 31	Ge 32	As 33	Se 34	Br 35	Kr 36		
K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	In 49	Sn 50	Sb 51	Te 52	I 53	Xe 54		
Rb 37	Sr 38	Y 39	Zr 40	Nb 41	Mo 42	Tc 43	Ru 44	Rh 45	Pd 46	Ag 47	Cd 48	Tl 81	Pb 82	Bi 83	Po 84	At 85	Rn 86		
Cs 55	Ba 56	La 57	Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Nh 113	Fl 114	Mc 115	Lv 116	Ts 117	Og 118		
Fr 87	Ra 88	Ac 89	Rf 104	Db 105	Sg 106	Bh 107	Hs 108	Mt 109	Ds 110	Rg 111	Cn 112								
		Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71	Lanthanides			
		Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103	Actinides			

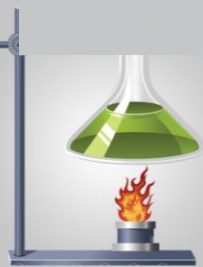
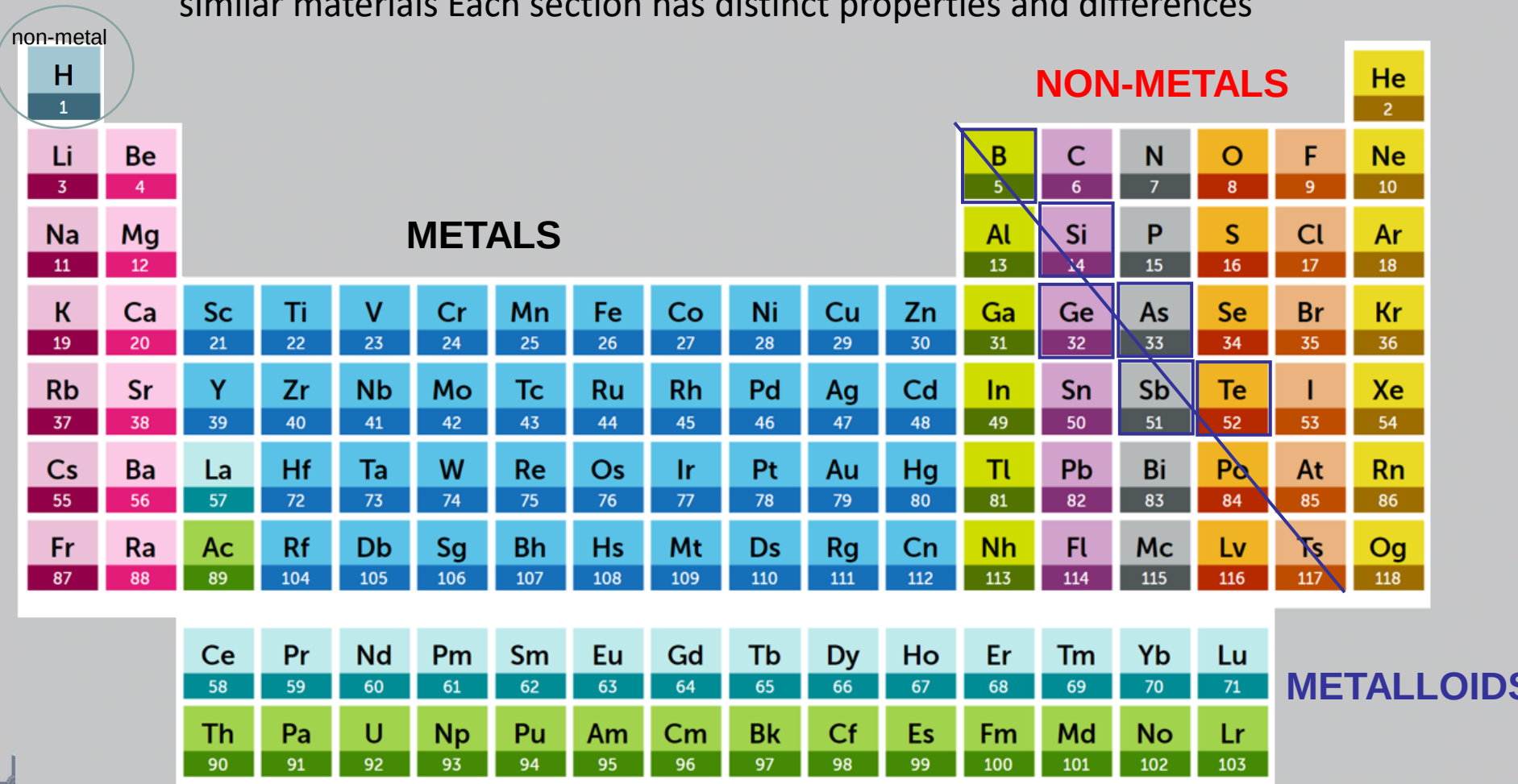
Inner transition metals



<https://www.rsc.org/periodic-table>

METALS, NON-METALS, METALLOIDS

A simple classification which splits the periodic table into families of similar materials Each section has distinct properties and differences



<https://www.rsc.org/periodic-table>

METALS, NON-METALS, METALLOIDS

Metals:

- Lustrous solids
- High melting points
- Conduct electricity
- Malleable and ductile
- Act as reducing agents in reactions

Non-Metals:

- Poor structural materials
- Low melting points
- Often gases or liquids
- Non conductors
- Discrete molecular structures
- Often act as oxidising agents (oxygen)

Metalloids:

- Solids
- Giant molecular structures
- High melting points
- Semiconductors (Silicon)



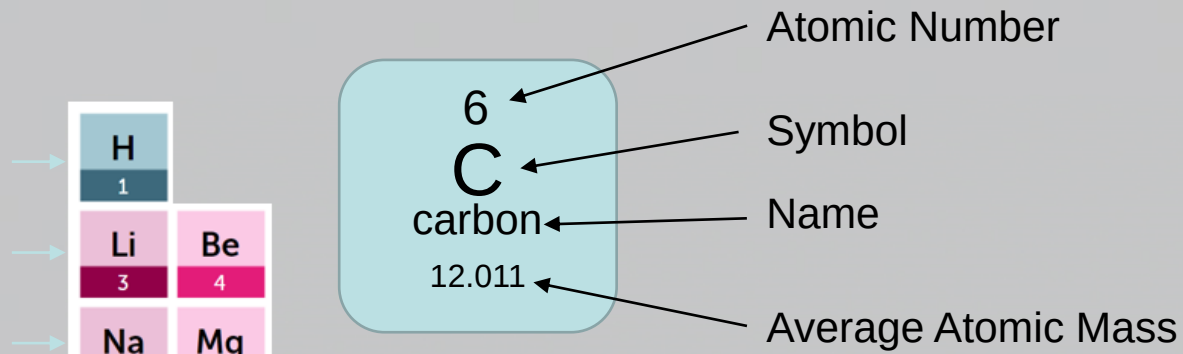
GROUP NUMBERS

1 IA	Old UPAC (UK, Europe) New UPAC																13 IIIB	14 IVB	15 VB	16 VIB	17 VIIIB	18 0
H 1	2 IIA											B 5	C 6	N 7	O 8	F 9	He 2					
Li 3	Be 4	3 IIIA	4 IVA	5 VA	6 VIA	7 VIIA	8	9 VIII	10	11 IB	12 IIB	Al 13	Si 14	P 15	S 16	Cl 17	Ar 18					
K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34	Br 35	Kr 36					
Rb 37	Sr 38	Y 39	Zr 40	Nb 41	Mo 42	Tc 43	Ru 44	Rh 45	Pd 46	Ag 47	Cd 48	In 49	Sn 50	Sb 51	Te 52	I 53	Xe 54					
Cs 55	Ba 56	La 57	Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84	At 85	Rn 86					
Fr 87	Ra 88	Ac 89	Rf 104	Db 105	Sg 106	Bh 107	Hs 108	Mt 109	Ds 110	Rg 111	Cn 112	Nh 113	Fl 114	Mc 115	Lv 116	Ts 117	Og 118					
		Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71							
		Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103							



PERIODS AND BOXES

PERIODS



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

6

C

carbon

12.011

Symbol

Name

Average Atomic Mass

Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71
Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103



NAMES OF ELEMENTS

Most symbols are abbreviations of the name of the element

Some notable exceptions, e.g. Na (natrium – Hebrew/Latin for alkali.)

K (Kalium- from alkali; Arabic for Plant Ash)

Fe (Ferrum), Pb (Plumbum)

Ag (Argentum - moon),

Au (Aurum - sun)

All Latin names



SUMMARY

- Elements of the same kind are made of the same atoms
- Atoms of a given element have the same mass
- Elements are arranged in a periodic table according to their number of electrons
- Period table consists of vertical groups and horizontal periods
- Elements are either metals, non-metals, or metalloids



Practice problem 1:

List the names, chemical symbols, and atomic numbers of the alkali metals. Describe their reaction with water



Practice problem 2:

List the names, chemical symbols, and atomic numbers of the halogens. Identify the normal physical state of each.

