## Homework 21

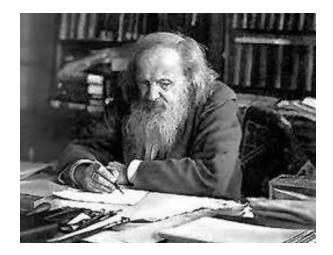
## Periodic table of elements.

Last class we started discussing periodic table of elements. Chemical elements are the "building blocks" of nature. All the objects around us are "constructed" from chemical elements. In spite of great variety of the objects and substances around us there are only 118 chemical elements (some of them are not shown in the table below). They are systematized and arranged in the table which is called *periodic table of elements*.

<u> </u>	-		(17)	10.00	100		1511	15	1150	10	19.00	100	0.70	100	100	101		
hydrogen 1																		helium 2
H																		He
1.0079 lithium	beryllium	1										1	boron	carbon	nitrogen	oxygen	fluorine	4.0026 neon
3	4												5	6	7	8	9	10
Li	Be												В	С	N	0	F	Ne
6.941 sodium	9.0122 magnesium												10.811 aluminium	12.011 silicon	14.007 phosphorus	15.999 sulfur	18.998 chlorine	20.180 argon
11	12												13	14	15	16	17	18
Na	Mg												A	Si	P	S	CI	Ar
22.990 potassium	24.305 calcium		scandium	titanium	vanadium	chromium	manganese	iron	cobalt	nickel	copper	zinc	26.982 gallium	28.086 germanium	30.974 arsenic	32.065 selenium	35.453 bromine	39.948 krypton
19	20		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca		Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
39.098 rubidium	40.078 strontium		44.956 yttrium	47.867	50.942 niobium	51.996 molybdenum	54.938 technetium	55.845 ruthenium	58.933 rhodium	58.693 palladium	63.546 silver	65.39 cadmium	69.723 indium	72.61 tin	74.922 antimony	78.96 tellurium	79.904 iodine	83.80
37	38		39	zirconium 40	41	42	43	44	45	46	47	48	49	50	51	52	53	xenon 54
Rb	Sr		Υ	Zr	Nb	Мо	Тс	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Те		Xe
85.468 caesium	87.62 barium		88.906 lutetium	91.224 hafnium	92.906 tantalum	95.94 tungsten	[98] rhenium	101.07 osmium	102.91 iridium	106.42 platinum	107.87 gold	112.41 mercury	114.82 thallium	118.71 lead	121.76 bismuth	127.60 polonium	126.90 astatine	131.29 radon
55	56	57-70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba	$\star$	Lu	Hf	Та	W	Re	Os	Ir	Pt	Au	Hg	TL	Pb	Bi	Po	At	Rn
132.91 francium	137.33 radium		174.97 lawrencium	178.49 rutherfordium	180.95 dubnium	183.84 seaborgium	186.21 bohrium	190.23 hassium	192.22 meitnerium	195.08 ununnilium	196.97 unununium	200.59 ununbium	204.38	207.2 ununguadium	208.98	[209]	[210]	[222]
87	88	89-102	103	104	105	106	107	108	109	110	111	112		114				
Fr	Ra	* *	Lr	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub		Uuq				
[223]	[226]		[262]	[261]	[262]	[266]	[264]	[269]	[268]	[271]	[272]	[277]		[289]				
Ianthanum cerium praseodymium neodymium promethium samarium europium gadolinium terbium dysprosium holmium erbium thulium ytterbium																		
*Lanti	*Lanthanide series			cerium 58	praseodymium 59	neodymium 60	promethium 61	samarium 62	europium 63	gadolinium 64	terbium 65	dysprosium 66	holmium 67	erbium 68	thulium 69	ytterbium 70		
Lanti	ando	001100	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb		
			138.91 actinium	140.12 thorium	140.91 protactinium	144.24 uranium	[145] neptunium	150.36 plutonium	151.96 americium	157.25 curium	158.93 berkelium	162.50 californium	164.93 einsteinium	167.26 fermium	168.93 mendelevium	173.04 nobelium	9	
* * Act	* * Actinide series			90	91	92	93	94	95	96	97	98	99	100	101	102		
				Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No		
			Ac	000.04	004.04	000.00	100.71	10.441	10.401	10.471	10.470	105.41	to cot	10571	105.01	105.01	1	

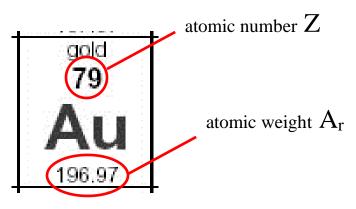
Periodic table of elements.

The periodic table was first suggested by a Russian chemist Dmitri Mendeleev in 1869. He found that if the chemical elements are arranged according their atomic weight, their chemical properties exhibit periodicity, that is why it is called "periodic".



Dmitri Mendeleev (1834-1907).

Only two of the chemical elements – mercury and bromine - are liquids at normal conditions (T=300K, atmospheric pressure), eleven elements are gases. The other elements are solids except nine elements (109-111 and 113-118) in the end of the table whose chemical properties are still unknown. The most important parameter which determines chemical properties of an element is the atomic number *Z*. The atomic number is the number of protons in the atomic nucleus.



The number of neutrons in the nucleus is denoted as N. The sum of Z and N gives the mass number A.

N+Z=A

Since the proton and neutron have approximately same mass we can estimate the mass of the atom by multiplying the atomic number A to the proton (or neutron) mass. In this estimation we neglected the total mass of electrons (which is much smaller than the mass of protons) and another correction which is called "mass defect". The number of neutrons in the atomic nucleus has just a weak effect on the chemical properties of the substance. Atoms having same Z but different N are called isotopes. A typical way to refer to a certain isotope is to place the mass number after the element's name. For example: *iodine-131* or *uranium-238*. Since the number of protons is the same in all isotope nuclei of a certain element, we can find in the periodic table as an atomic number. For example, this number for the isotope uranium-238 is 92. So this particular isotope has 238-92=146 neutrons.

Most of the natural elements are mixture of isotope atoms which have different mass. Average of the atomic masses of the isotopes gives *atomic weight*  $A_r$ .

Atomic weights are given in the periodic table (see figure above). In what units are they expressed? The unit which is used is called "unified atomic mass unit". It is equal to 1/12 of free atom of a carbon isotope *carbon-12* which is 1.66 x  $10^{-27}$ kg.

- 1. Find the number of protons and neutrons in the nucleus of Caesium-137.
- 2. One of the alchemist dreams was making gold (Au) out of lead (Pb). How we should change the atom of lead to obtain the atom of gold?
- 3. What element we will obtain if we merge nuclei of two isotopes helium-3 and helium 4?