

Homework 23

During 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*.

hydrogen 1 H 1.0079																				helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122											boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180			
sodium 11 Na 22.990	magnesium 12 Mg 24.305											aluminium 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948			
potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80			
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29			
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 *	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]		
francium 87 Fr [223]	radium 88 Ra [226]	89-102 * *	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	ununnium 110 Uun [271]	ununium 111 Uuu [272]	unbinium 112 Uub [277]		ununquadium 114 Uuq [289]						

* Lanthanide series

lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

** Actinide series

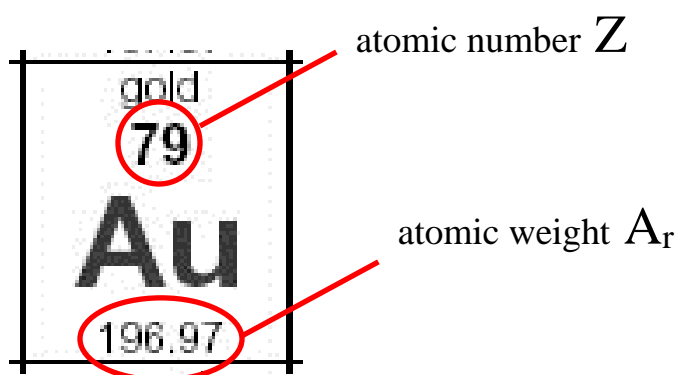
Periodic table of elements.

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 ($T=300\text{K}$, 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 1.66×10^{-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?