IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB	VIIIB	VIIIB	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1 H 1.0079																	2 He 4.0026
3 Li 6.9417	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.066	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.693	29 Cu 63.546	30 Zn 65.390	31 Ga 69.723	32 Ge 72.610	33 As 74.922	34 Se 78.960	35 Br 79.904	36 Kr 83.800
37 Rb 85.468	38 Sr 87.620	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.940	43 Tc (97.907)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.76	52 Te 127.60	53 I 126.904	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 *La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	84 Po (208.98)	85 At (209.99)	86 Rn (222.02)
87 Fr (223.02)	88 Ra (226.03)	89 †Ac (227.03)	104 Rf (261.11)	105 Db (262.11)	106 Sg (263.12)	107 Bh (262.12)	108 Hs (265.13)	109 Mt (266.14)									

*Lanthanides

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (144.91)	62 Sm 150.36	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.97

†Actinides

90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237.05)	94 Pu (244.06)	95 Am (243.06)	96 Cm (247.07)	97 Bk (247.07)	98 Cf (251.08)	99 Es (252.08)	100 Fm (257.10)	101 Md (258.09)	102 No (259.10)	103 Lr (262.11)

Avogadro's Number (N_A) = 6.02214×10^{23} mol^{-1}
Atomic Mass Unit (u) = 1.66054×10^{-27} kg
Electron charge (e) = 1.60218×10^{-19} C
Faraday's constant (F) = 9.64853×10^{4} C/mol
Universal gas const. (R) = 8.20578×10^{-2} L.atm/(mol.K) = 8.31451 J/(mol.K)
Plank's constant (h) = 6.62607×10^{-34} J.s
Rydberg's constant = 1.09678×10^{7} m^{-1}
Speed of light (c) = 2.99792×10^{8} m/s

Atom composition

	Location	Charge	amu
Neutron (n)	Inside nucleus	neutral	1.00867 amu
Proton (p)	Inside nucleus	+1	1.00728 amu
Electron (e)	Outside nucleus	-1	0.000549 amu

amu: atomic mass unit = 1/12 the mass of a carbon atom

Atomic symbols

$$^{24}_{12}\mathrm{Mg}$$

Atomic number:
number of protons, always the same for elements with the same letter symbol

Mass number:
Mass of the element = number of protons + number of neutrons

Atomic mass vs atomic weight

Isotope:
Atoms with the same atomic number, but different masses. This happens when tow otherwise identical atoms have different numbers of neutrons

Carbon atoms that have 6 protons and 6 neutrons have an atomic mass of 12

Some carbon atom, have 6 protons and 7 or 8 neutrons, these atoms are called carbon-13, or carbon-14 atoms

Atomic weight: weighted average of atomic mass of all different isotopes

There are ______________ electrons, ____________protons, and ____________neutrons in an atom of

$${}^{132}_{54}\mathrm{Xe}$$

Given the chemical symbol, including superscript indicating mass number for the ion with 22 protons,26neutrons, and 19 electrons

nuclide - atom with a specific number of protons and neutrons in its nucleus.
⇒ There are 271 stable nuclides in nature, others are radioactive

Nuclide is composed of nucleons (proton, neutron)

radionuclide - unstable isotope that undergoes nuclear decay
⇒ All isotopes of elements with > 83 protons are radioactive;

The particles in the nucleus are hold together by a very strong attractive force only found in the nucleus called the **strong force**

The **neutrons** play an important role in stabilizing the nucleus, as they add to the strong force, but don't repel each other like the **protons** do.

Radioactive decay

Elements that have unstable nuclei have the tendency to spontaneously undergo changes that alter their nuclear composition

- Alpha production (α):

$$^{238}_{92}U \rightarrow \ ^{4}_{2}He + \ ^{234}_{90}Th$$

- Beta production (β):

$$^{234}_{90}Th \rightarrow \ ^{234}_{91}Pa + \ ^{0}_{-1}e$$

- Gamma ray production (γ):

$$^{238}_{92}U \rightarrow \ ^{4}_{2}He + \ ^{234}_{90}Th + 2\,^{0}_{0}\gamma$$

- Positron production:

$$^{22}_{11}Na \rightarrow \ ^{0}_{1}e + \ ^{22}_{10}Ne$$

- Electron capture:

$$^{201}_{80}Hg + \ ^{0}_{-1}e \rightarrow \ ^{201}_{79}Au + \ ^{0}_{0}\gamma$$

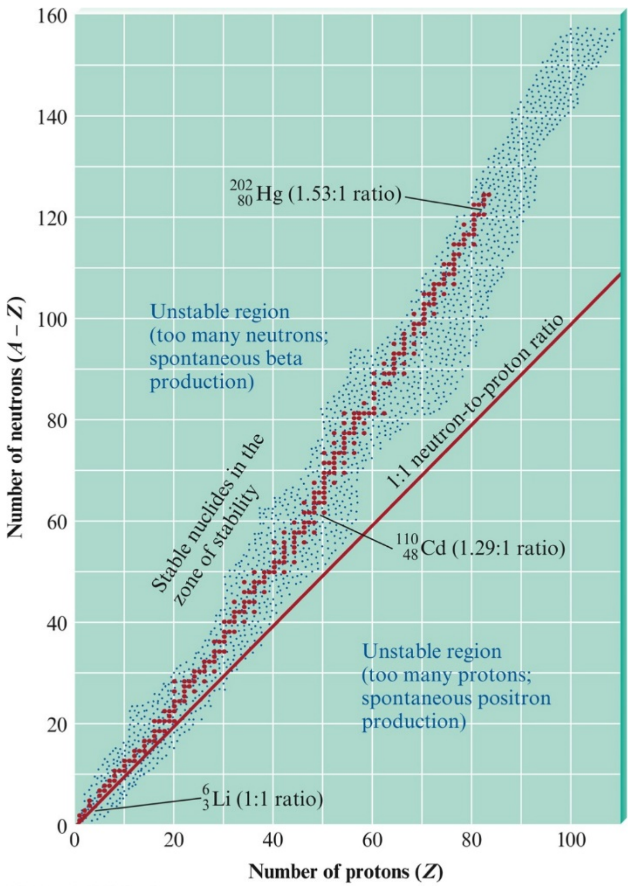
N/Z ration

The ratio between neutron/proton (N/Z) is a good measure of stable nuclide

If the N/Z ratio is too **high**, neutrons are converted to protons via β **decay**

If the N/Z ratio is too **low**, protons are converted to neutrons via **positron emission** or **electron capture (Z<83)**

via α **decay (Z>83)**



Z	Not stable when	Threshold >th, β decay
1:20	Mass # fall outside Atomic mass +/- 2	<1, positron emission/ electron capture
20:40		<1.25, positron emission/ electron capture
40:83		<1.5, positron emission/ electron capture
>83	Not stable	<1.6, α decay

Y-100 is radioactive. Which mode of decay would be expected for this nucleus?

S-28 is radioactive. Which mode of decay would be expected for this nucleus?

U-235 is radioactive. Which mode of decay would be expected for this nucleus?

Kinetics of radioactive decay

$$\text{Rate} = kN$$

The rate of decay is proportional to the number of nuclides.

Half-Life

- Time required for the number of nuclides to reach half the original value.

$kt_{1/2} = 0.693$ $t_{1/2}$ = half-life; k = rate constant

$\ln \frac{A_t}{A_0} = -kt$ A_0 = initial activity or amount; A_t = activity after a certain time

$\frac{A_t}{A_0}$ = fraction of material remaining after time t

EX: A first order reaction is 35% complete at the end of 55 minutes. What is the value of *k*?

$kt_{1/2} = 0.693$

$$\ln \frac{A_t}{A_0} = -kt$$

A sample of aluminum-32 is found to have an activity of 400. After 10 hours the activity has decreased to 200. What is the rate constant for the decay of aluminum-32?

Thermodynamic stability of the nucleus: mass defect and binding energy

mass defect:
difference in mass between **actual** and **hypothetical formation** of a nucleus

binding energy

$$^{4}_{2}\mathrm{He}$$