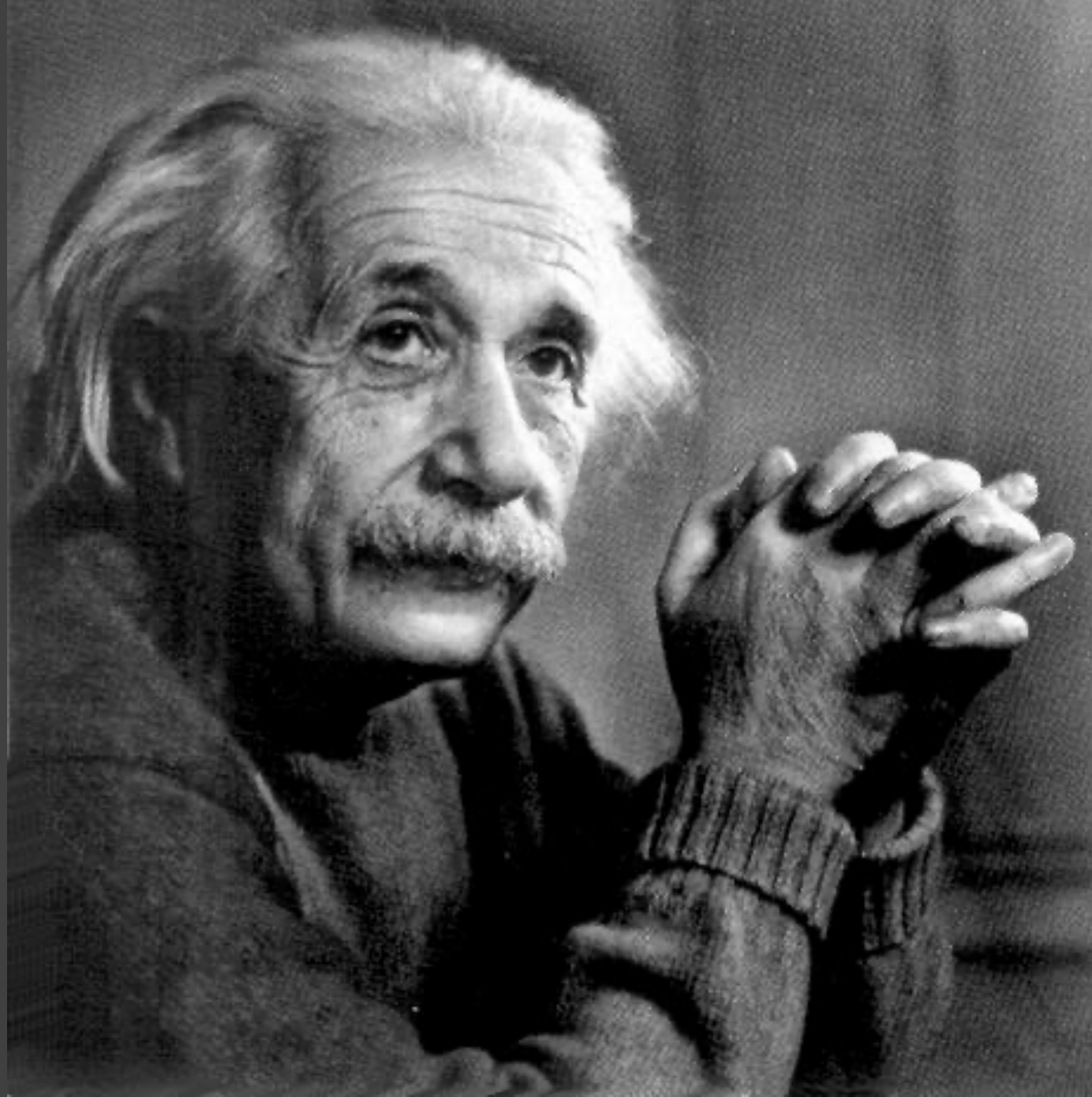


Noddy's Guide to Fission and Fusion

by

Tony Heyes





The Energy Equivalence of Mass

$$E = m_0 c^2$$

Velocity of Light

- 299,792 km/s
- 1Kg equivalent to
 - 25,000 Kwh

Einstein's Postulate

That physics should be the same in any none accelerating frame of reference.

Einstein's Postulate

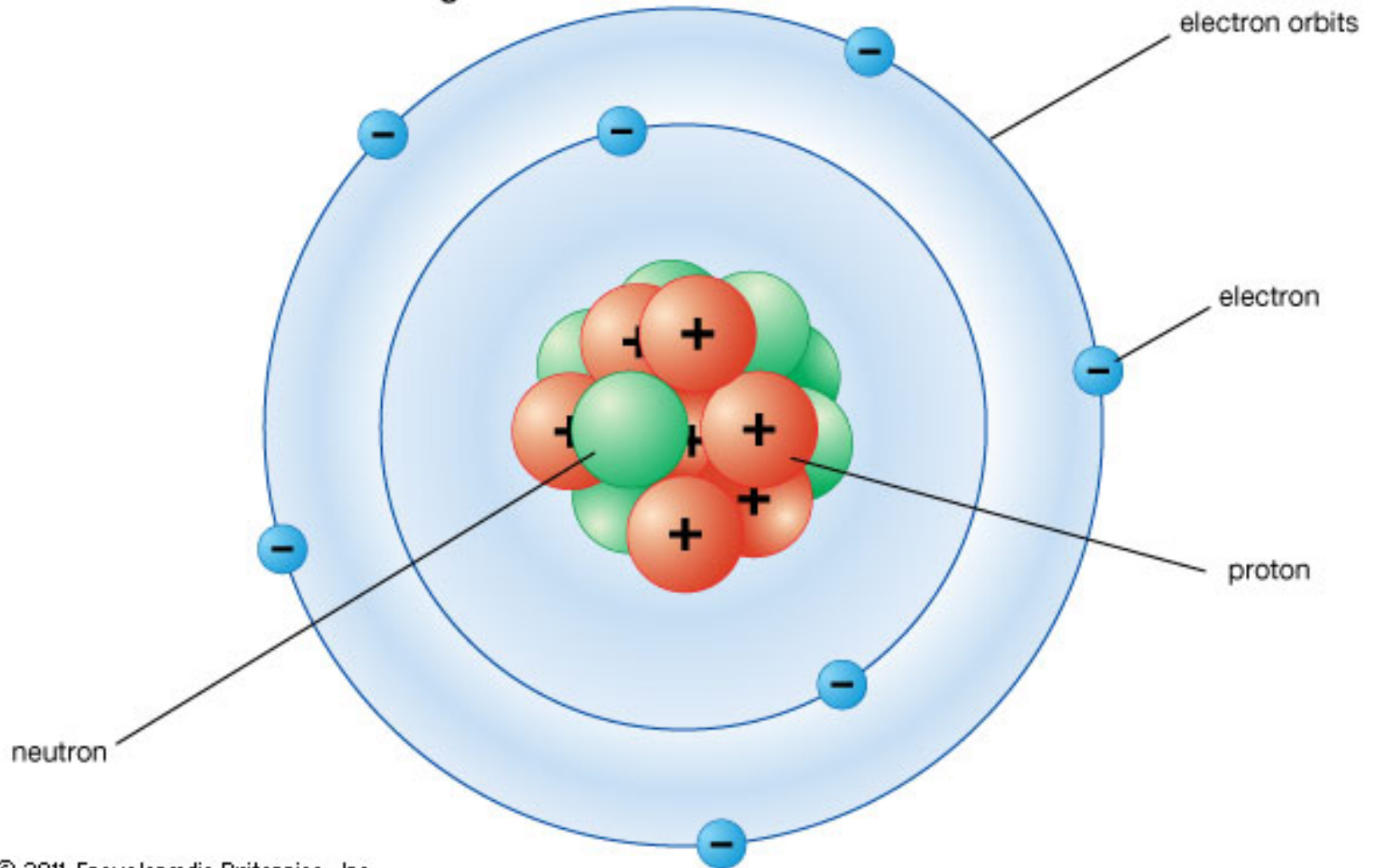
The speed of light in a vacuum is independent of the motion of both the observer and the source.

Niels Bohr
(1885 – 1962)
Nobel Prize 1922



The Bohr Atom

Bohr atomic model of a nitrogen atom

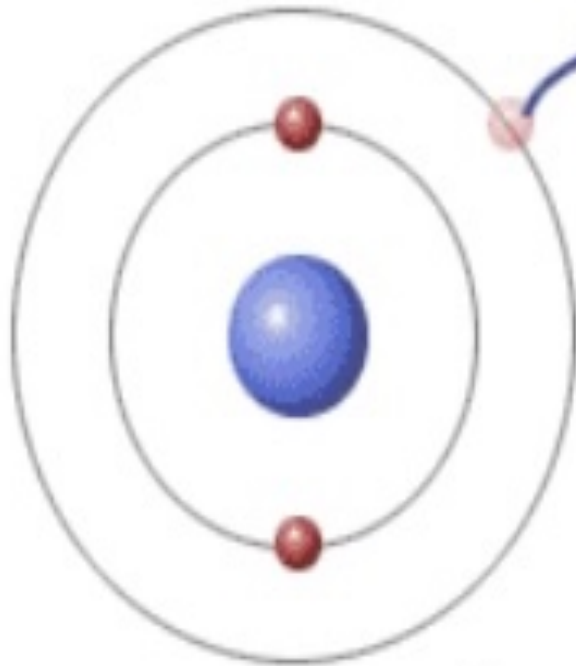


Chemistry

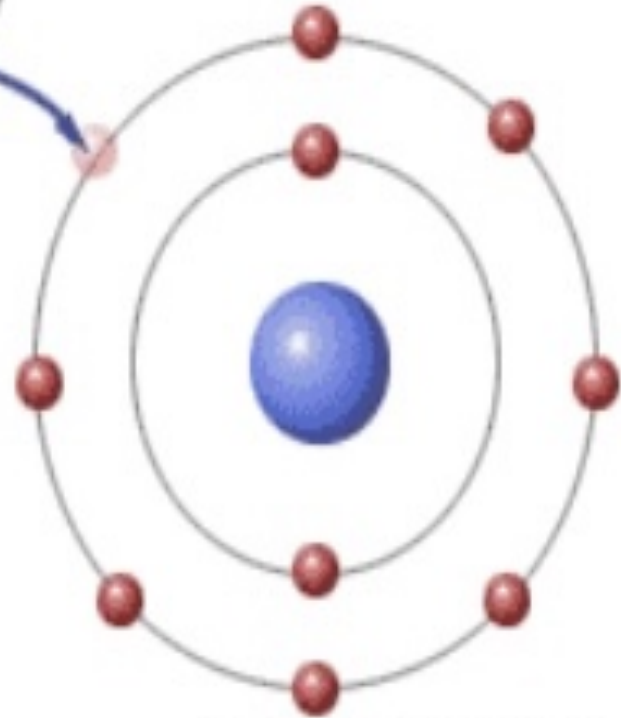
Lithium

Flourine

Electron is given away



Atom with
spare electron



Needs an electron
to become stable

Mendeleevian Table

Periodic Table

Legend:

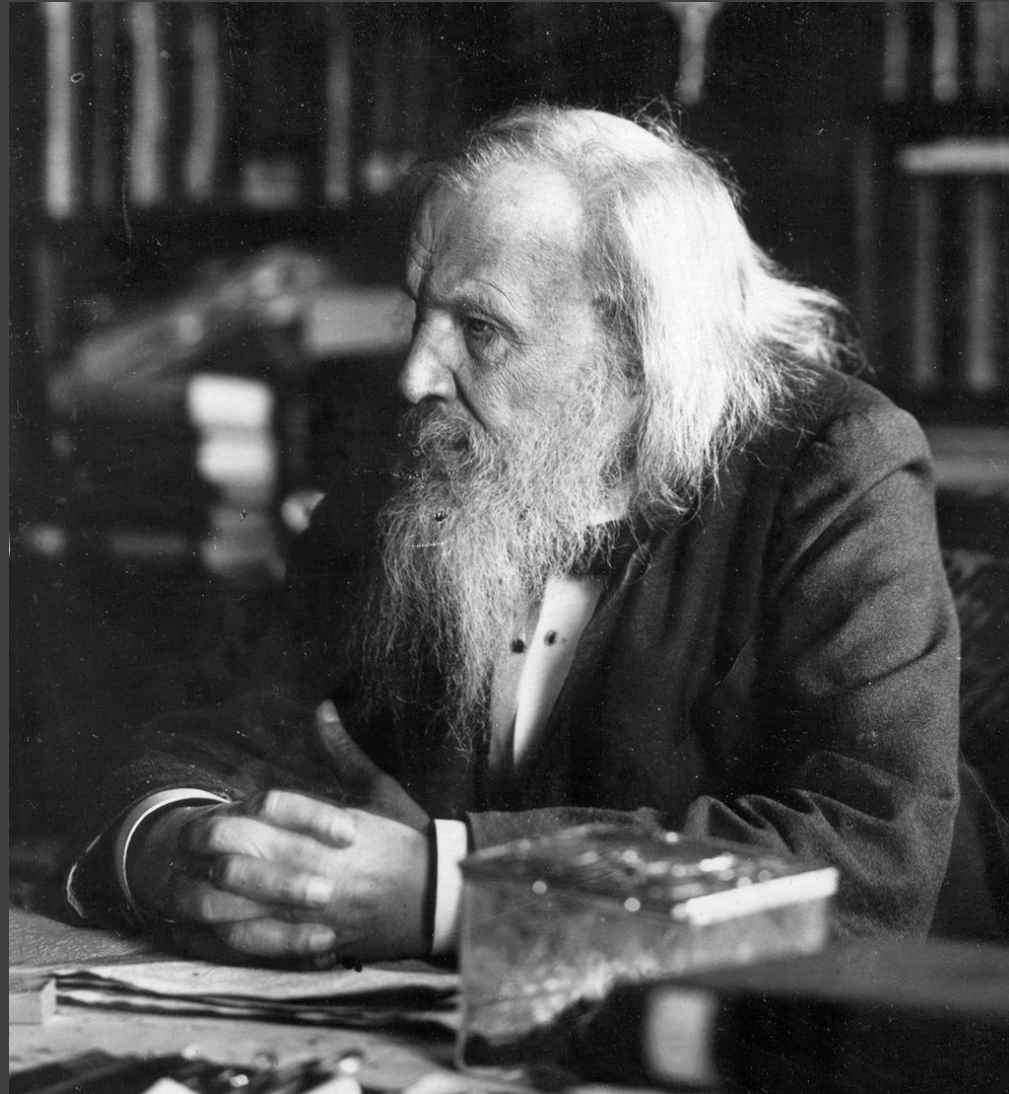
- Other nonmetals
- Alkali metals
- Alkaline earth metals
- Noble gases
- Metalloids
- Halogens
- Transition metals
- Post-transition metals
- Lanthanoids
- Actinoids

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
1	H Hydrogen 1.00794	Ds Darmstadtium (271) 2-8-18-32-32-17-1											Other nonmetals		Halogens		He Helium 4.002602		
2	Li Lithium 6.941	Be Beryllium 9.012182	Ds											B Boron 10.811	C Carbon 12.0107	N Nitrogen 14.0067	O Oxygen 15.9994	F Fluorine 18.9984032	Ne Neon 20.1797
3	Na Sodium 22.98976928	Mg Magnesium 24.3050	Ds											Al Aluminium 26.9815386	Si Silicon 28.0855	P Phosphorus 30.973762	S Sulfur 32.065	Cl Chlorine 35.453	Ar Argon 39.948
4	K Potassium 39.0983	Ca Calcium 40.078	Sc Scandium 44.955912	Ti Titanium 47.867	V Vanadium 50.9415	Cr Chromium 51.9961	Mn Manganese 54.938045	Fe Iron 55.845	Co Cobalt 58.933195	Ni Nickel 58.6934	Cu Copper 63.546	Zn Zinc 65.38	Ga Gallium 69.723	Ge Germanium 72.64	As Arsenic 74.92160	Se Selenium 78.96	Br Bromine 79.904	Kr Krypton 83.798	
5	Rb Rubidium 85.4678	Sr Strontium 87.62	Y Yttrium 88.90585	Zr Zirconium 91.224	Nb Niobium 92.90638	Mo Molybdenum 95.96	Tc Technetium (97.9072)	Ru Ruthenium 101.07	Rh Rhodium 102.90550	Pd Palladium 106.42	Ag Silver 107.8682	Cd Cadmium 112.411	In Indium 114.818	Sn Tin 118.710	Sb Antimony 121.760	Te Tellurium 127.60	I Iodine 126.90447	Xe Xenon 131.293	
6	Cs Caesium 132.9054519	Ba Barium 137.327	La-Lu	Hf Hafnium 178.49	Ta Tantalum 180.94788	W Tungsten 183.84	Re Rhenium 186.207	Os Osmium 190.23	Ir Iridium 192.217	Pt Platinum 195.084	Au Gold 196.966569	Hg Mercury 200.59	Tl Thallium 204.3833	Pb Lead 207.2	Bi Bismuth 208.98040	Po Polonium (208.9824)	At Astatine (209.9871)	Rn Radon (222.0176)	
7	Fr Francium (223)	Ra Radium (226)	Ac-Lr	Rf Rutherfordium (261)	Db Dubnium (262)	Sg Seaborgium (266)	Bh Bohrium (264)	Hs Hassium (277)	Mt Meitnerium (268)	Ds Darmstadtium (271)	Rg Roentgenium (272)	Cn Copernicium (285)	Uut Ununtrium (284)	Fl Flerovium (289)	Uup Ununpentium (288)	Lv Livermorium (292)	Uus Ununseptium (294)	Uuo Ununoctium (294)	

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

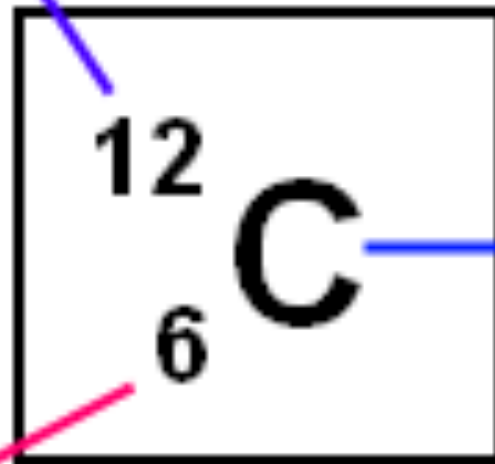
57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La Lanthanum 138.90547	Ce Cerium 140.116	Pr Praseodymium 140.90765	Nd Neodymium 144.242	Pm Promethium (145)	Sm Samarium 150.36	Eu Europium 151.964	Gd Gadolinium 157.25	Tb Terbium 158.92535	Dy Dysprosium 162.5	Ho Holmium 164.93032	Er Erbium 167.259	Tm Thulium 168.93421	Yb Ytterbium 173.054	Lu Lutetium 174.9668
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac Actinium (227)	Th Thorium 232.03806	Pa Protactinium 231.03588	U Uranium 238.02891	Np Neptunium (237)	Pu Plutonium (244)	Am Americium (243)	Cm Curium (247)	Bk Berkelium (247)	Cf Californium (251)	Es Einsteinium (252)	Fm Fermium (257)	Md Mendelevium (258)	No Nobelium (259)	Lr Lawrencium (262)

Dmitri Mendeleev (1834 – 1907)



Notation

Protons + Neutrons = Atomic Mass Number

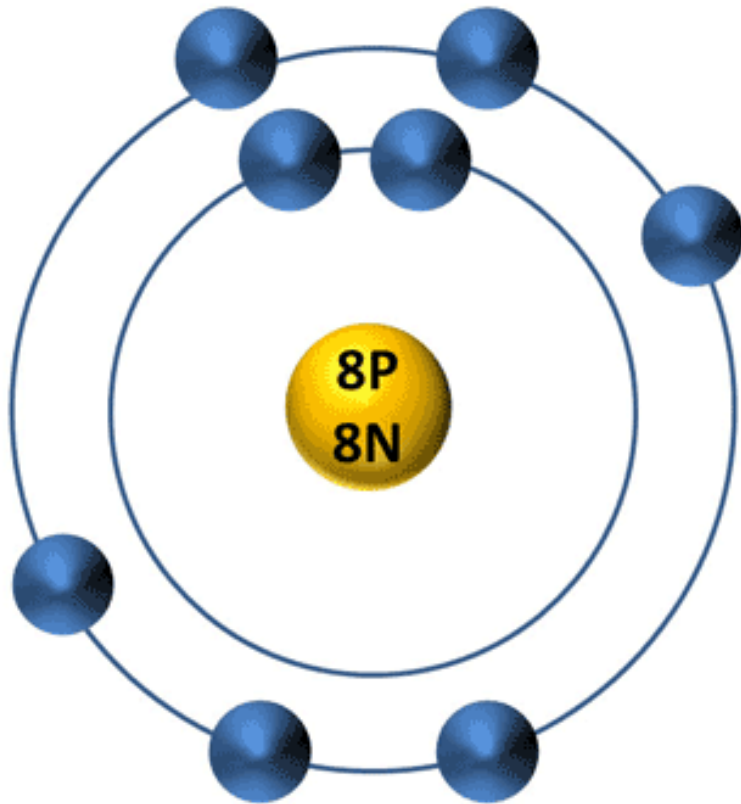


Symbol

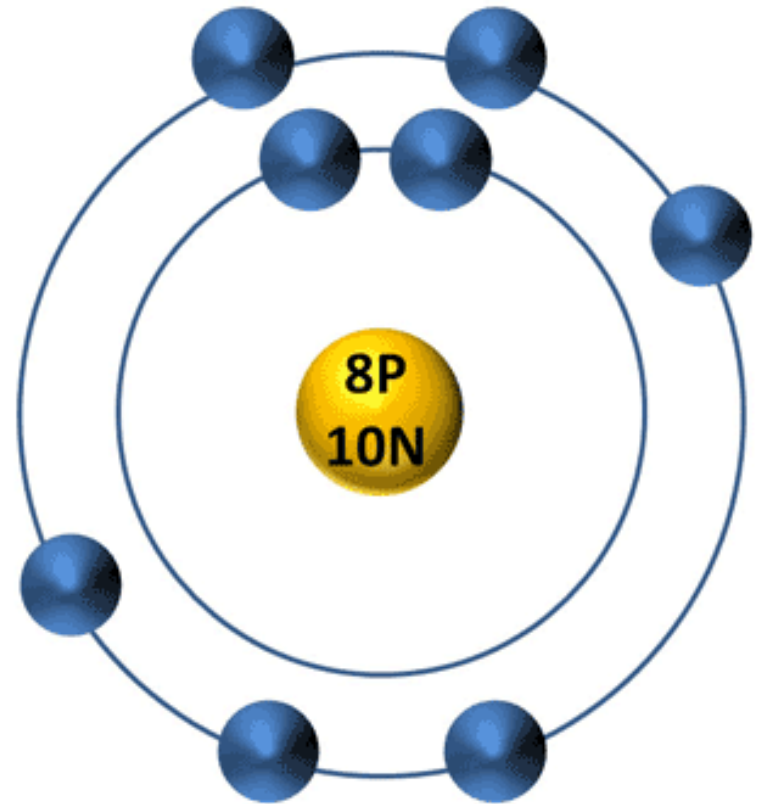
Number of Protons = Atomic Number

Isotopes

Oxygen Isotopes



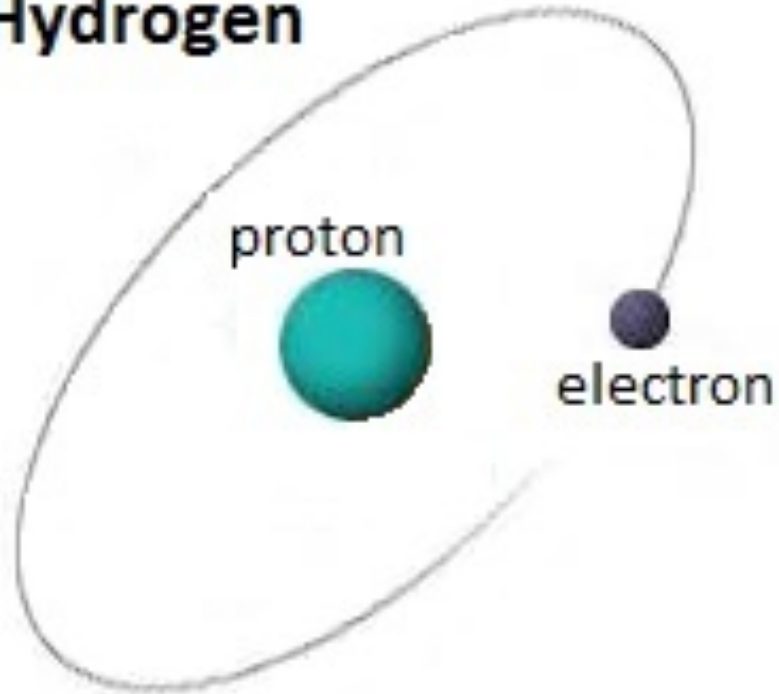
^{16}O Isotope



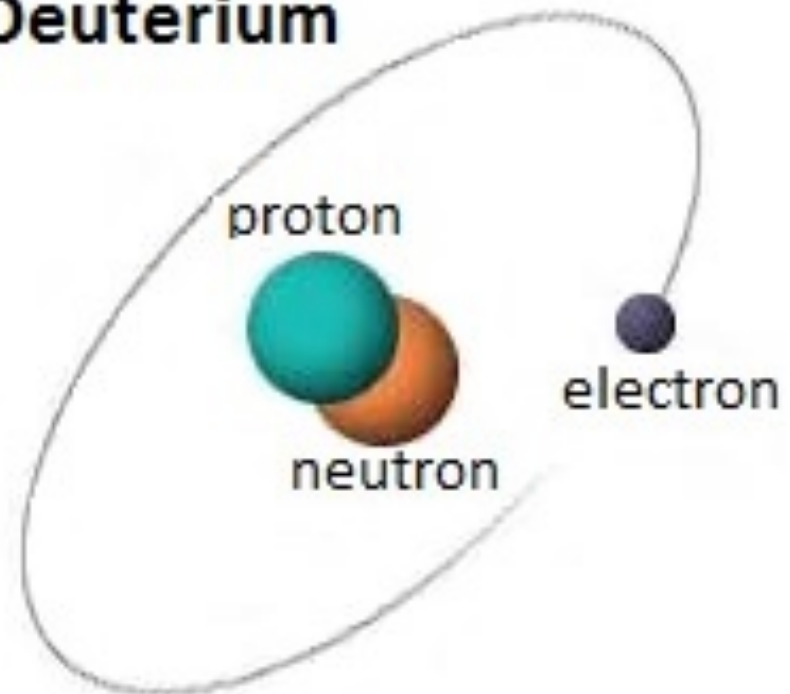
^{18}O Isotope

Deuterium

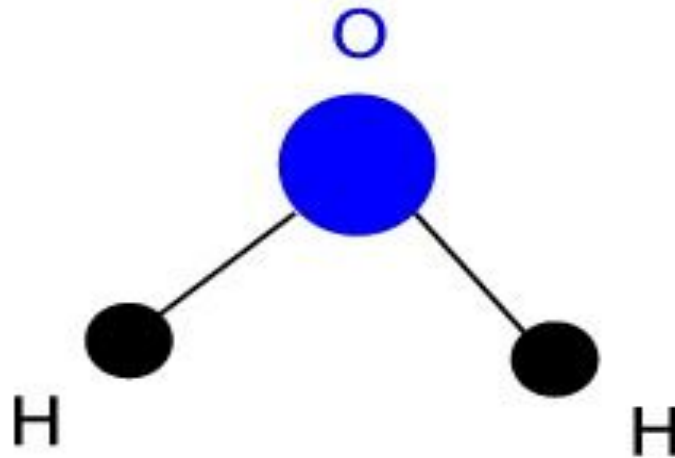
Hydrogen



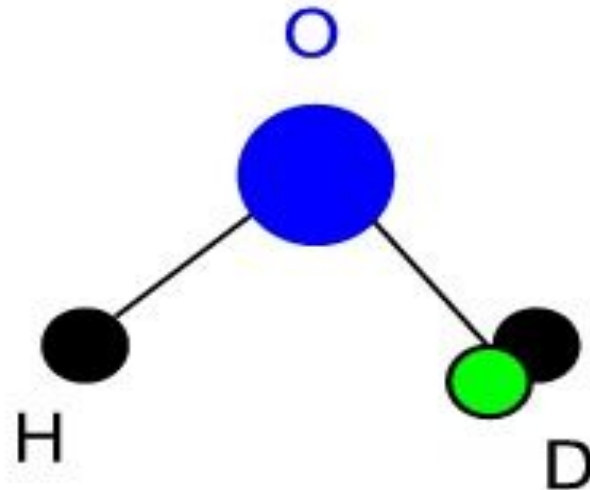
Deuterium



Semi-heavy Water

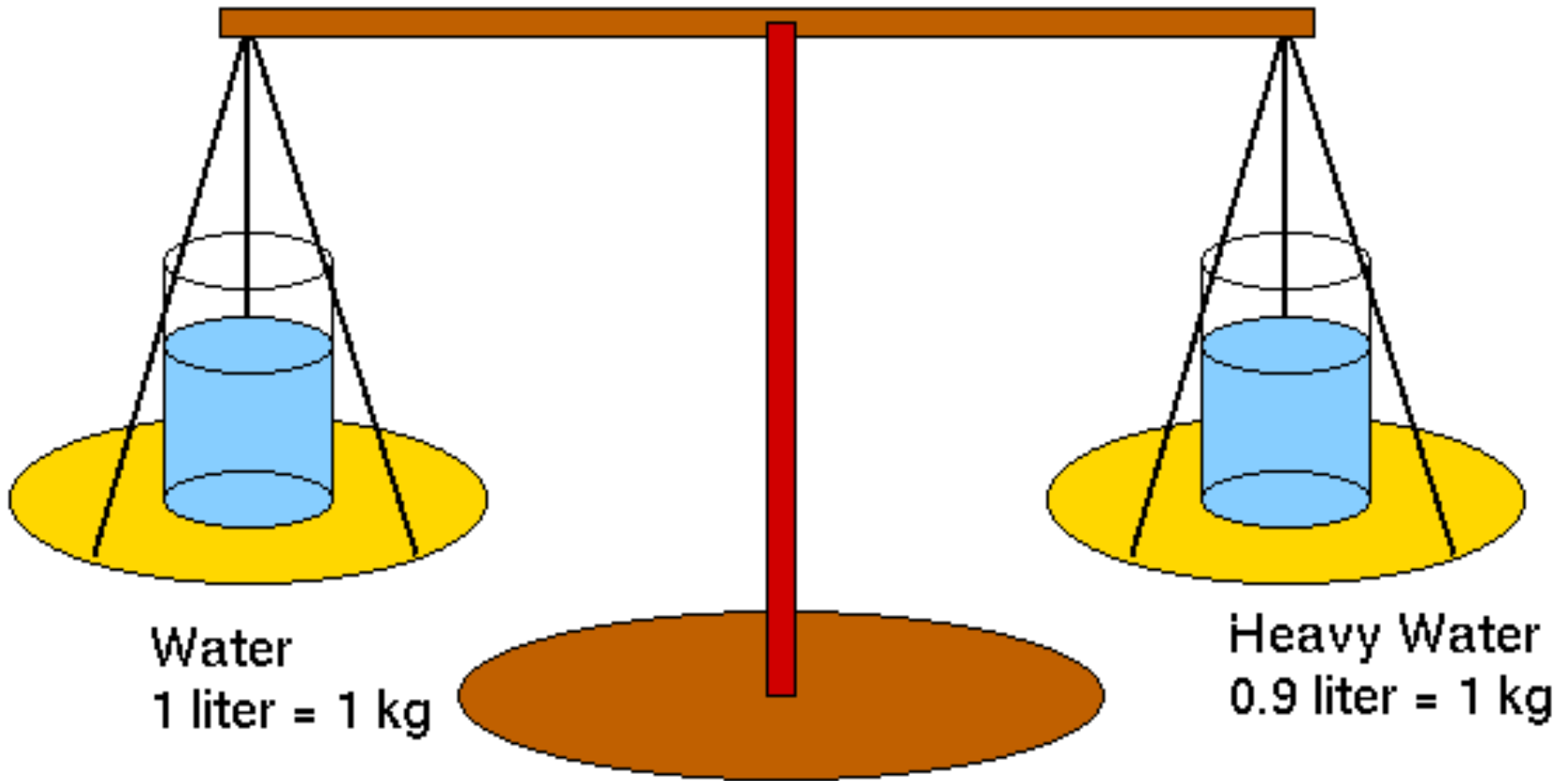


ordinary water



"heavy" water

Heavy Water



Lise Meitner

(1878 - 1968)



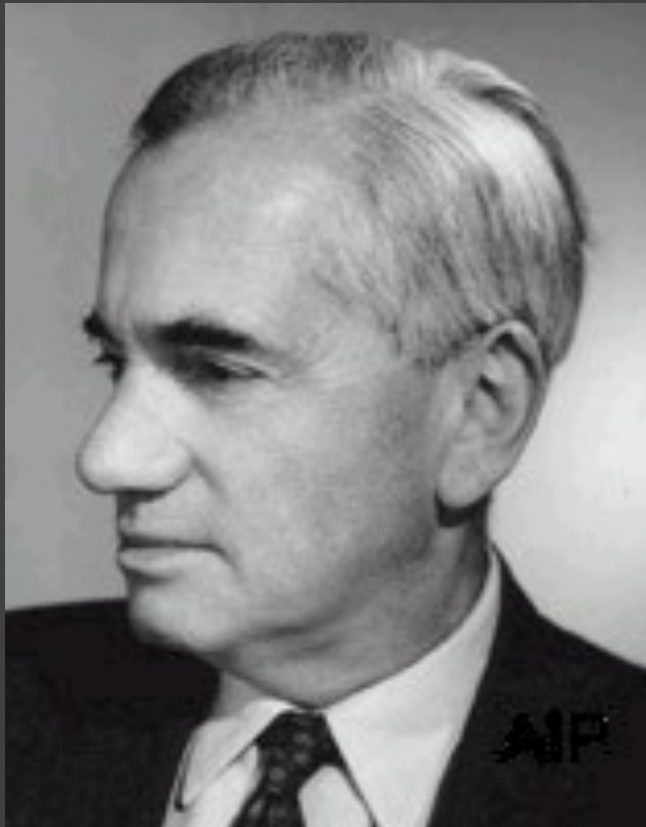
Lise Meitner

- An Austrian, later Swedish, physicist.
- She was praised by Albert Einstein as the "German Marie Curie".
- July, 1938 escaped to Sweden via the Holland.

Lise Meitner

- Worked closely with her nephew Otto Frisch.
- Kept in touch with her old boss in German, Otto Hahn.

Otto Frisch
(1904 – 1979)



Otto Hahn
(1879 – 1968)



Their problem

- Atoms heavier than Iron weigh more than the sum of their parts.
- Atoms lighter than Iron weigh less than the sum of their parts.

- The discrepancy is known as the mass defect.
- Now known as Binding Energy
- Binding energy is released when heavy nuclei split (fission) or when light atoms fuse.
- The Energy is huge!

$$E = Mc^2$$

And c is VERY large

Lise Meitner and Otto Frisch

- Explained why Uranium was the heaviest stable atom.
- Explained nuclear fission.
- Uranium \rightarrow Barium, Krypton + neutrons + Energy
- Were the first to realise that the Energy came from the missing Mass.

Lise Meitner and Otto Frisch

- Frisch experimentally confirmed the predictions by bombarding Uranium with Neutrons (1939).
- Together they realised the possibility of a chain reaction.
- Kept Otto Hahn informed of their progress.

Otto Hahn

(1879 – 1968)

- Nobel Prize in Chemistry (1944).
- For the discovery of the fission of heavy nuclei.
- A solo winner!!!!

Lise Meitner

(1878 - 1968)

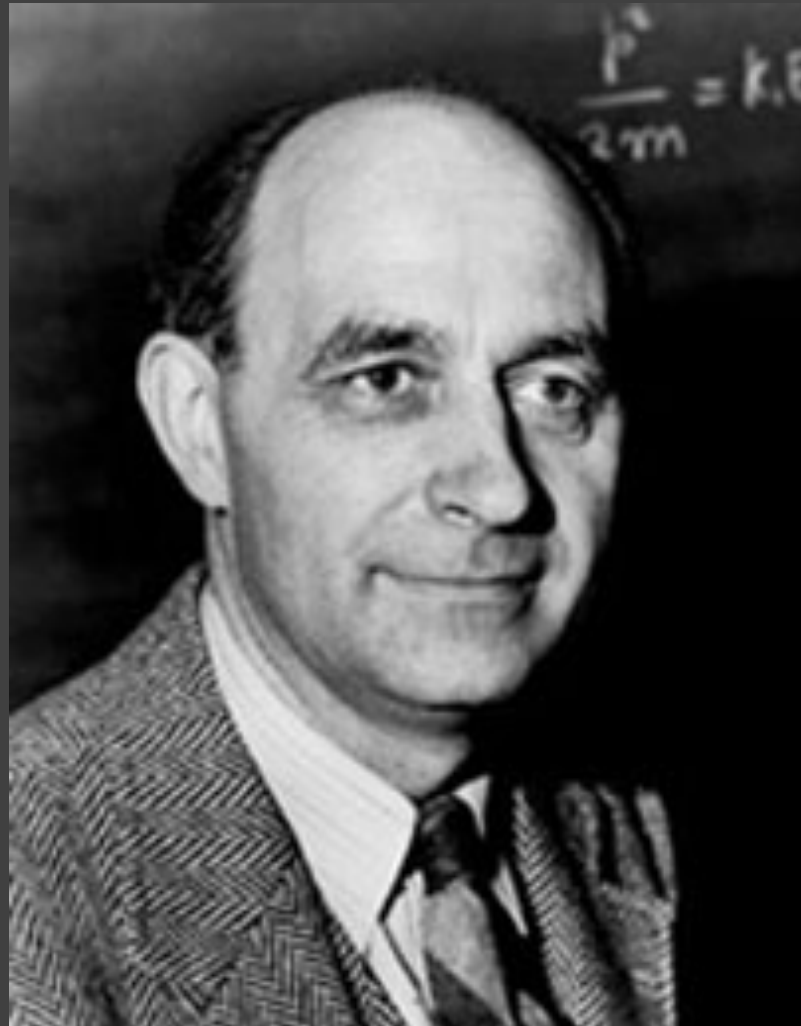
- Had an element named after her
- Element 109
- Meitnerium (Mt)
- Mt 278 half life of 7.6 secs

Chain Reaction

- Hit a Uranium nucleus with a neutron and it will fission to produce:
- Fission products eg Barium, Krypton
- But also Gamma rays, Neutrons and Energy.
- Critical Mass
- Frisch and Meitner were correct: the Energy came from the missing Mass.

Enrico Fermi

(1901 – 1954)



What about Fusion?

Fusion reactors

- Abundant fuel
- No radioactive waste
- Its how the sun works
- International Thermonuclear Experimental Reactor (ITER) – 90 MW in, 500 MW out - France (2019)

The End