LECTURE 11
CHAPTER 14

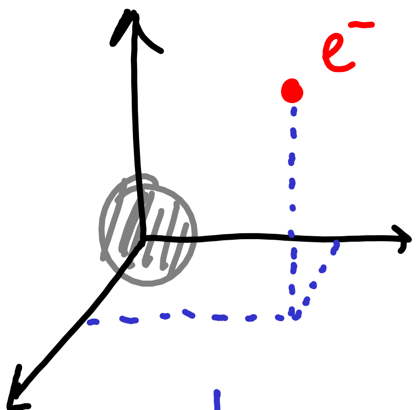
PHY 100 . CHEMISTRY, QUANTUM UNCERTAINTY

FILL IN TA SURVEY (DEADLINE FRIDAY 5)

http://data-store.pas.rochester.edu/phpQ/fillsurvey.php?sid=28

RETURN CHOICES OF PRESENTATION TOPICS

RECAP: QUANTUM MECHANICAL TREATMENT OF H ATOM (WITH A SINGLE e^-)



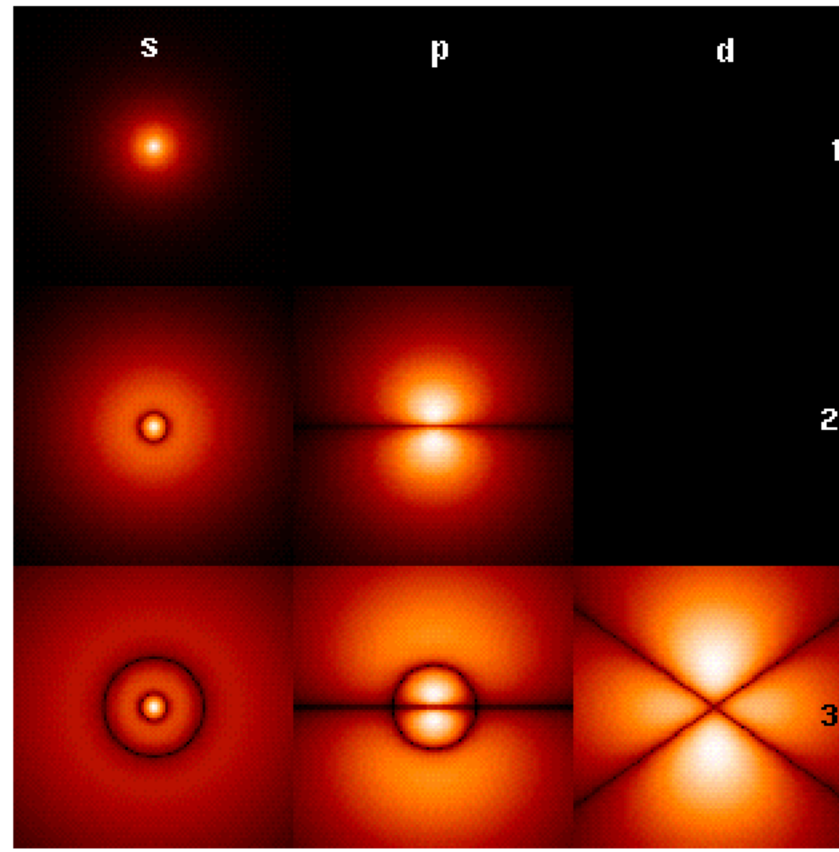
↓

SCHRÖDINGER EQ

↓

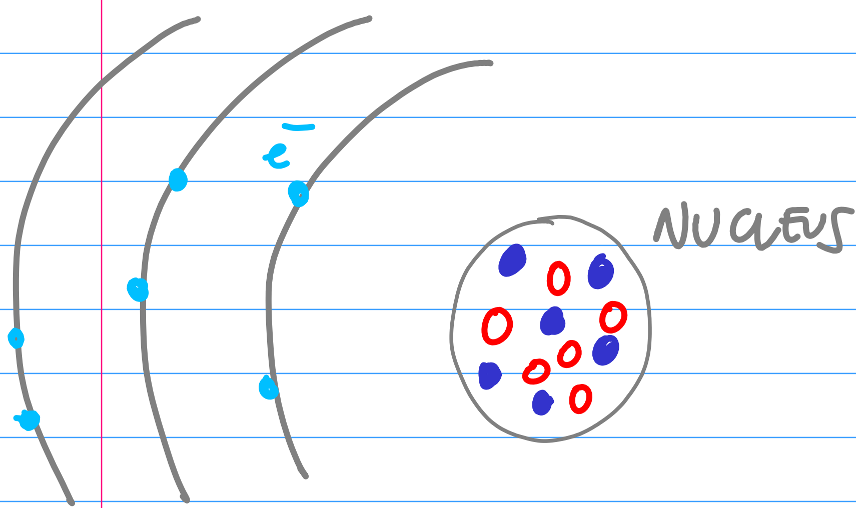
ALLOWED "QUANTUM STATES" FOR THE ELECTRON TO BE IN

THE STATES ARE DETERMINED BY 4 "QUANTUM NUMBERS" (ENERGY + SHAPE)



The electron orbital wave functions of hydrogen. The principal quantum number is at the right of each row and the azimuthal quantum number is denoted by letter at top of each column.

ATOMIC STRUCTURE



Z = ATOMIC NUMBER = # OF PROTONS

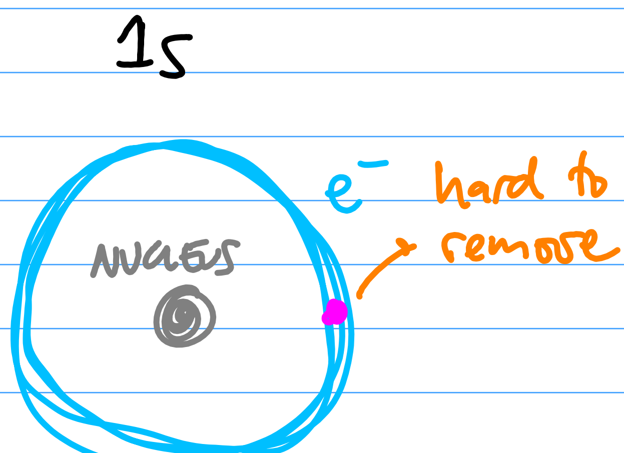
electrons = # protons = Z

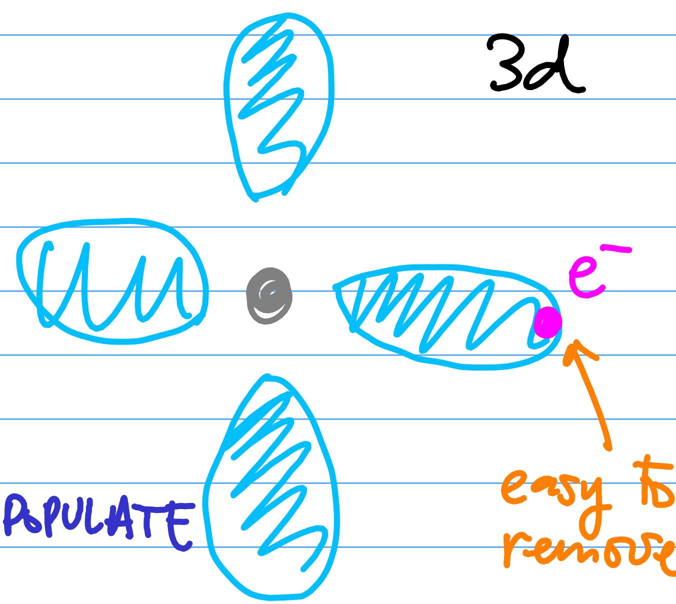
A = ATOMIC MASS

= # protons + # neutrons

- • proton (+1 electric charge)
- o neutron (0 " ")
- • electrons (−1 " ")

MULTIELECTRON ATOMS : e^- FILL LOWEST AVAILABLE ENERGY STATES, AND THE NEXT, etc...

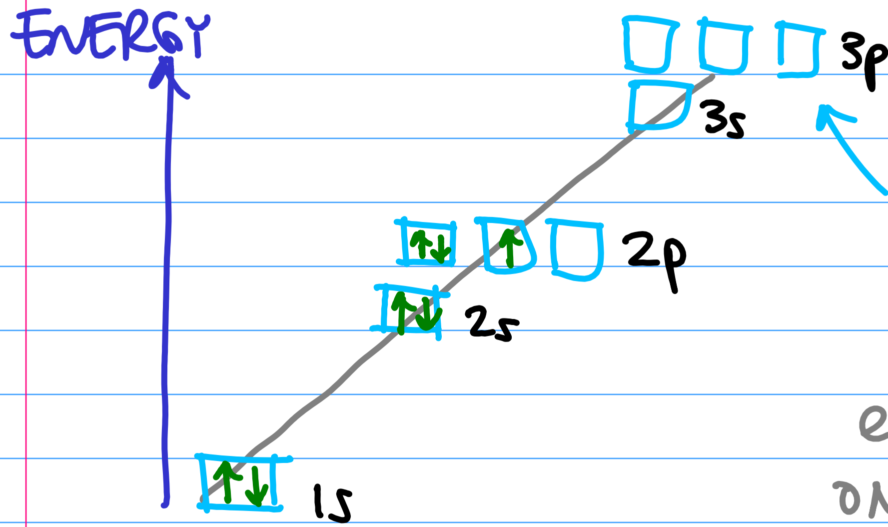




IONIZATION ENERGY: ENERGY NEEDED TO REMOVE e^- FROM ATOM

CHEMICAL CHARACTERISTICS ARE DETERMINED BY HOW ELECTRONS POPULATE AVAILABLE QUANTUM STATES.

SKY SLOPE



AVAILABLE Q. STATES = SKY CONDOS

HIGHER UP : LARGER ATOMIC RADIUS

→ EASIER TO REMOVE

e^- ARE FERMIONS:

ONLY TWO CAN OCCUPY ONE Q. STATE

ONE WITH SPIN UP ↑ AND ONE WITH SPIN DOWN ↓.

ALL ATOMS FILL THESE STATES SIMILARLY

PERIODIC STRUCTURE IN HOW e^- POPULATE AVAILABLE STATES. ⇒

" " IN ATOMIC CHARACTERISTICS

Z INCREASES → # e^- increase

↑ DETERMINES THE TYPE OF ELEMENT / ATOM

PERIODIC TABLE : DMITRI MENDELEEV (1869)

ELEMENT : SUBSTANCE THAT CANNOT BE BROKEN DOWN INTO SIMPLER SUBSTANCES THROUGH ORDINARY CHEMISTRY (ACIDS, LIGHT, HEAT, ...)

HE PREDICTED GERMANIUM, GALLIUM, SCANDIUM, BASED ON HOLES IN HIS TABLE. AND THEY WERE INDEED DISCOVERED LATER.

TABELLE II

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

Figure 2.5 Dmitri Mendeleev's 1872 periodic table. The spaces marked with blank lines represent elements that Mendeleev deduced existed but were unknown at the time, so he left places for them in the table. The symbols at the top of the columns (e.g., R^2O and RH^4) are molecular formulas written in the style of the 19th century.

Periodic Table of Elements

Wikipedia | Properties | Orbitals | Isotopes

☑ Weight ☑ Names ☑ Electrons ☐ Wide

Atomic # / Symbol / Name / Atomic Weight

C Solid · Hg Liquid · H Gas · Rf Unknown

Metalloids · Nonmetals: Other nonmetals, Halogens, Noble gases · Metals: Alkali metals, Alkaline earth metals, Lanthanoids, Actinoids, Transition metals, Post-transition metals

3984

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H Hydrogen 1.00794																	2 He Helium 4.002602
2	3 Li Lithium 6.941	4 Be Beryllium 9.012182											5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.0067	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797
3	11 Na Sodium 22.98976928	12 Mg Magnesium 24.3050											13 Al Aluminium 26.9815386	14 Si Silicon 28.0855	15 P Phosphorus 30.973762	16 S Sulfur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.948
4	19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955912	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.933195	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798
5	37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.96	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.293
6	55 Cs Caesium 132.9054519	56 Ba Barium 137.327	57–71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94788	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98040	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
7	87 Fr Francium (223)	88 Ra Radium (226)	89–103	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Sg Seaborgium (271)	107 Bh Bohrium (272)	108 Hs Hassium (270)	109 Mt Meitnerium (276)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (280)	112 Uub Ununbium (285)	113 Uut Ununtrium (284)	114 Uuq Ununquadium (289)	115 Uup Ununpentium (288)	116 Uuh Ununhexium (293)	117 Uus Ununseptium	118 Uuo Ununoctium (294)

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

57 La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92535	66 Dy Dysprosium 162.500	67 Ho Holmium 164.93032	68 Er Erbium 167.259	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.054	71 Lu Lutetium 174.9668
89 Ac Actinium (227)	90 Th Thorium 232.03806	91 Pa Protactinium 231.03588	92 U Uranium 238.02891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

Search

or Name

Ptable.com

CrystalMaker Element Tables

VFI Atomic Radii

www.crystalmaker.com

This image was generated using CrystalMaker®

These data are based on interatomic distances in the structures of the elements. (Radii for metals correspond to coordination numbers of 12.) Where no radius value can be found for a particular element, its radius has been set to a default value of 1 Å and a circle is plotted instead of a rendered sphere. Data from Vainshtein et al., 1995; values for O, F, S, Cl, Br, I, At, Po, Pm, Rn have been taken from Clementi et al.1963.

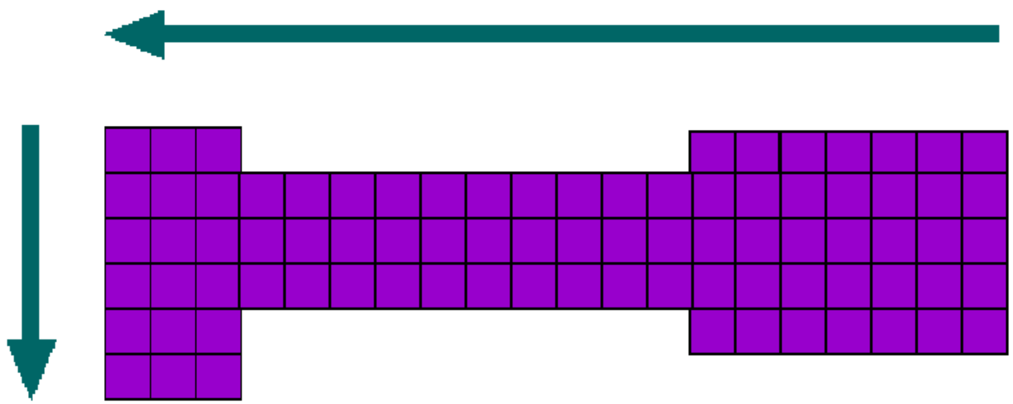
References: Vainshtein BK, Fridkin VM, Indenbom VL (1995) Structure of Crystals, 3rd Edition. Springer Verlag, Berlin.

Clementi E, Raimondi DL, Reinhardt WP (1963) Journal of Chemical Physics 38:2686-

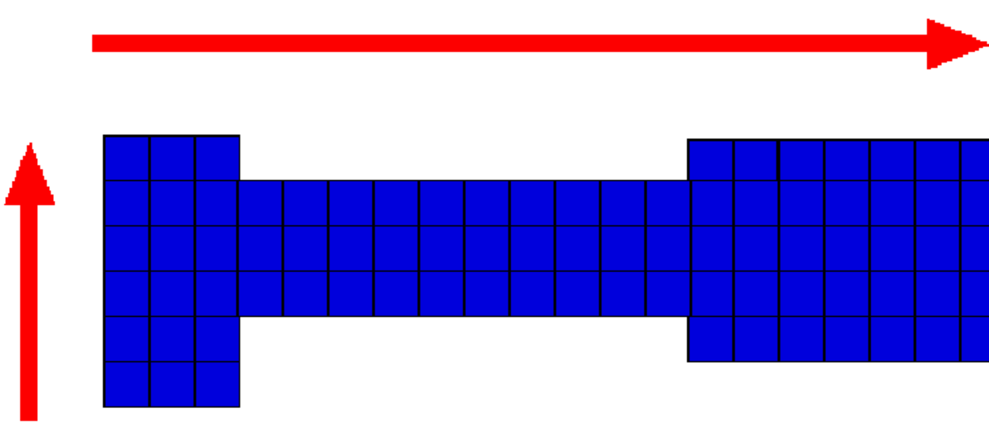
MANY DIFFERENT PROPERTIES OF THE ELEMENTS DEPEND ON THEIR POSITION IN THE TABLE

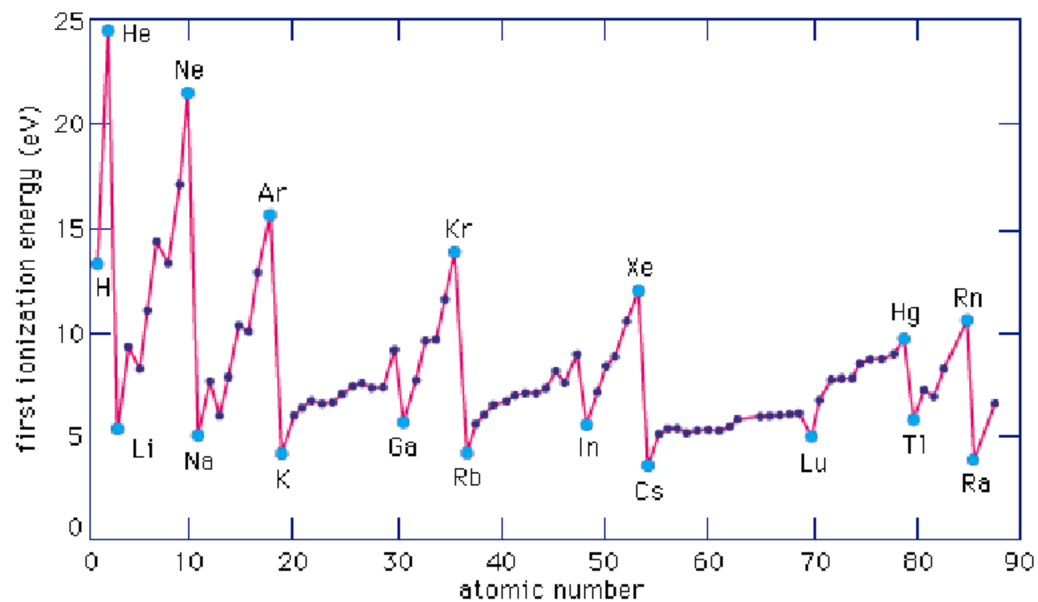
- ATOMIC NUMBER
- WEIGHT
- RADIUS
- IONIZATION ENERGY
- DENSITY
- RESISTIVITY
- MAGNETIC SUSCEPTIBILITY
- ELECTRON AFFINITY

Atomic Size Increases With Arrows

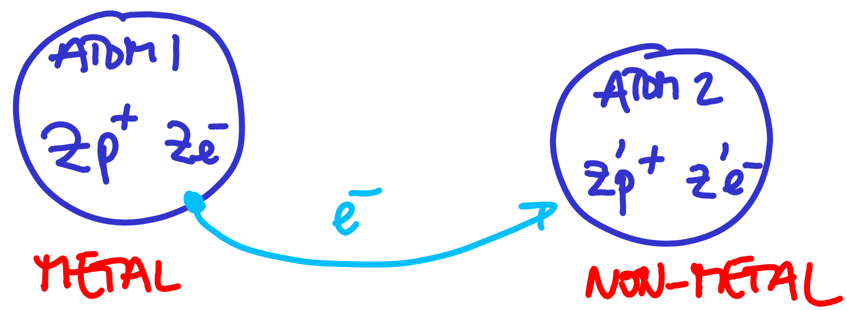


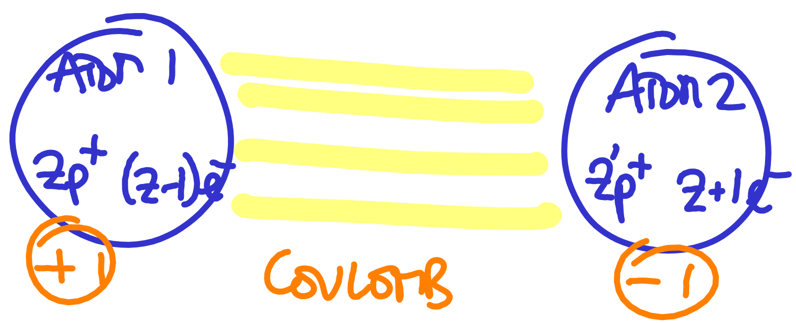
Ionization Energy Increases With Arrows





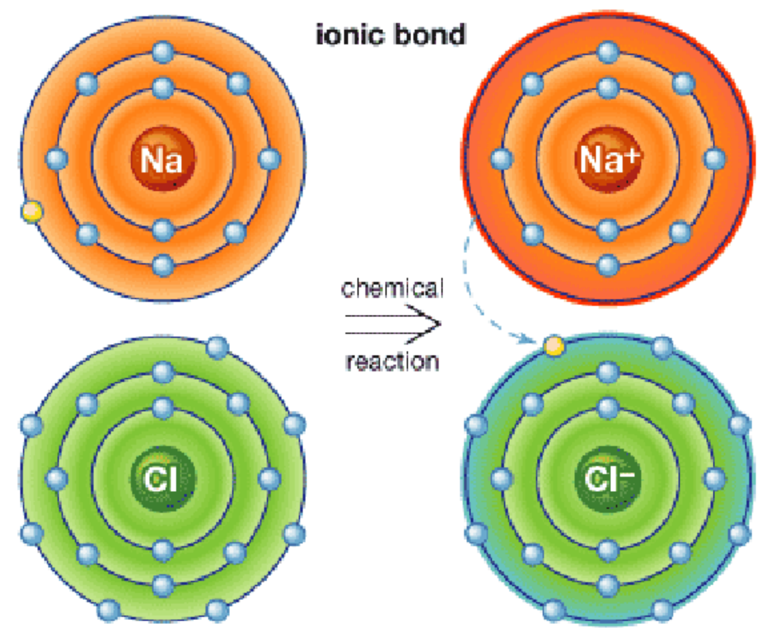
CHEMISTRY : IONIC BONDS





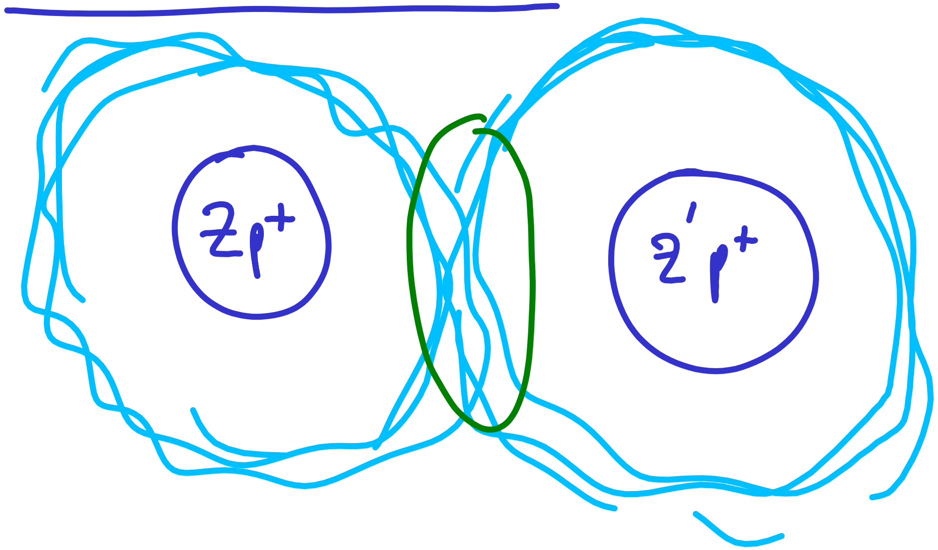
Na^+ Cl^-

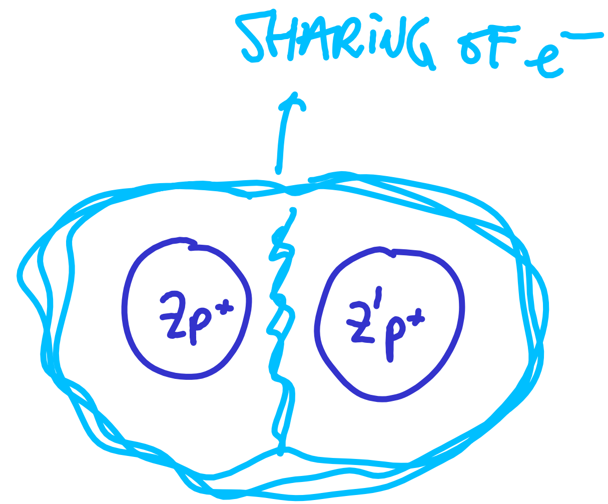
$Z = 11$ $Z = 17$



ATTRACTION BY TWO OPPOSITELY CHARGED IONS.

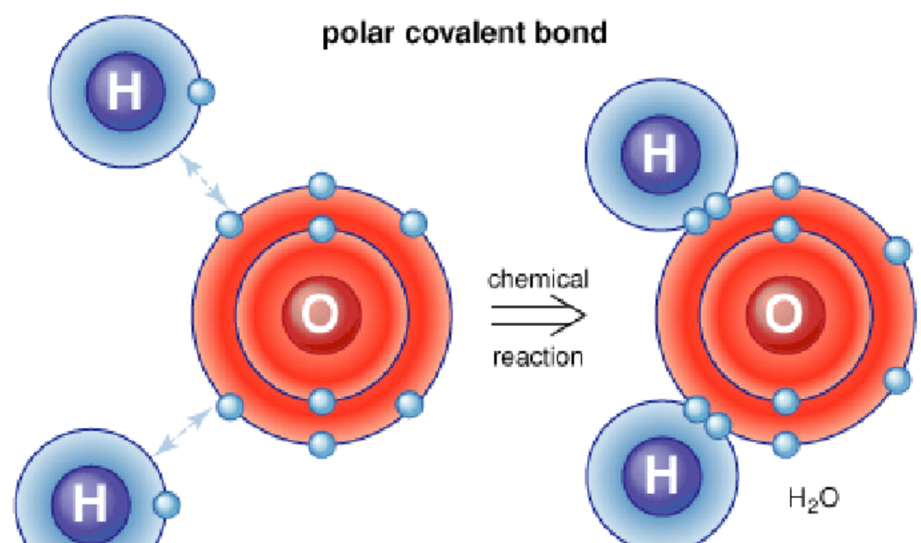
COVALENT BOND





WATER: H AND O

SHARE PAIRS OF e⁻.



QUANTUM MECHANICS + UNCERTAINTY.

$$-\frac{\hbar^2}{2m}\frac{\partial^2 \psi(x)}{\partial x^2} + V\psi(x) = E\psi(x)$$

$\psi(x)$ → WAVEFUNCTION

OBSERVER KNOWLEDGE OF THE SYSTEM

1) COPENHAGEN INTERPRETATION OF Q.M. (1927)

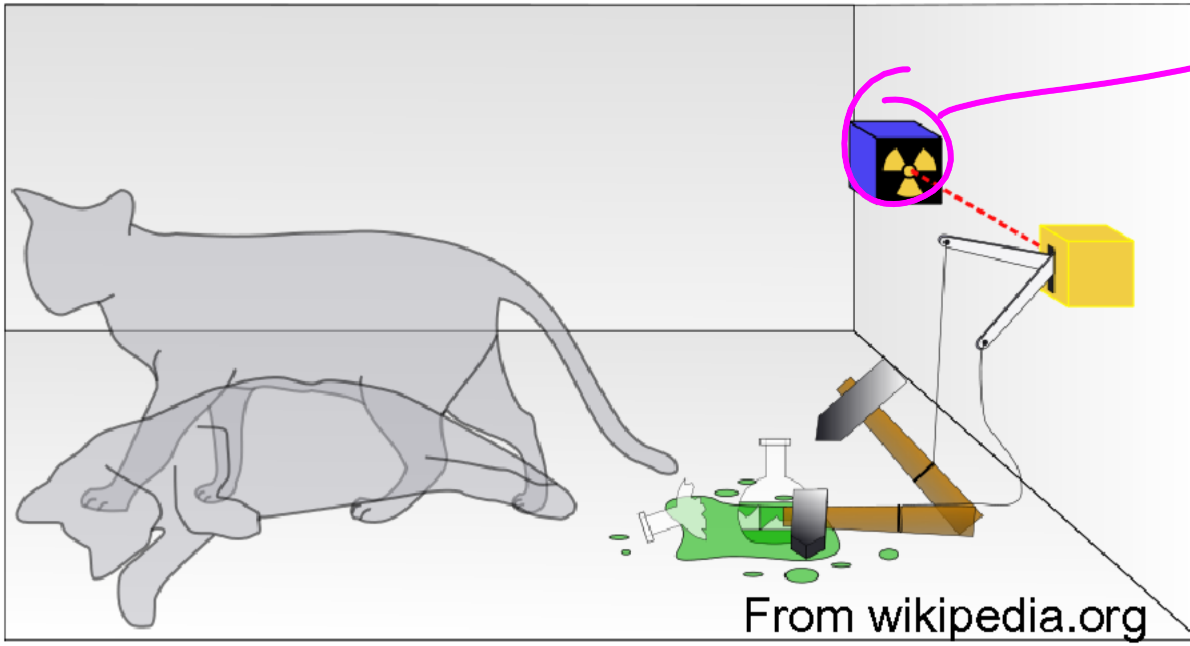
BOHR, HEISENBERG, BORN

$\psi(x)$ is NOT WELL DEFINED → TOOL FOR CALCULATION

$\psi^2(x)$ is WELL DEFINED = MEASURES THE PROBABILITY OF FINDING THE PARTICLE AT POSITION x.

↳ DESCRIPTION OF NATURE → PROBABILISTIC

SCHRÖDINGER CAT (THOUGHT EXPERIMENT)



RADIOACTIVE SOURCE

50/50 PROB. OF DECAYING

IF IT DECAYS → TRIGGERS POISON → CAT IS DEAD

IF NOT → CAT ALIVE

IS CAT DEAD OR ALIVE?

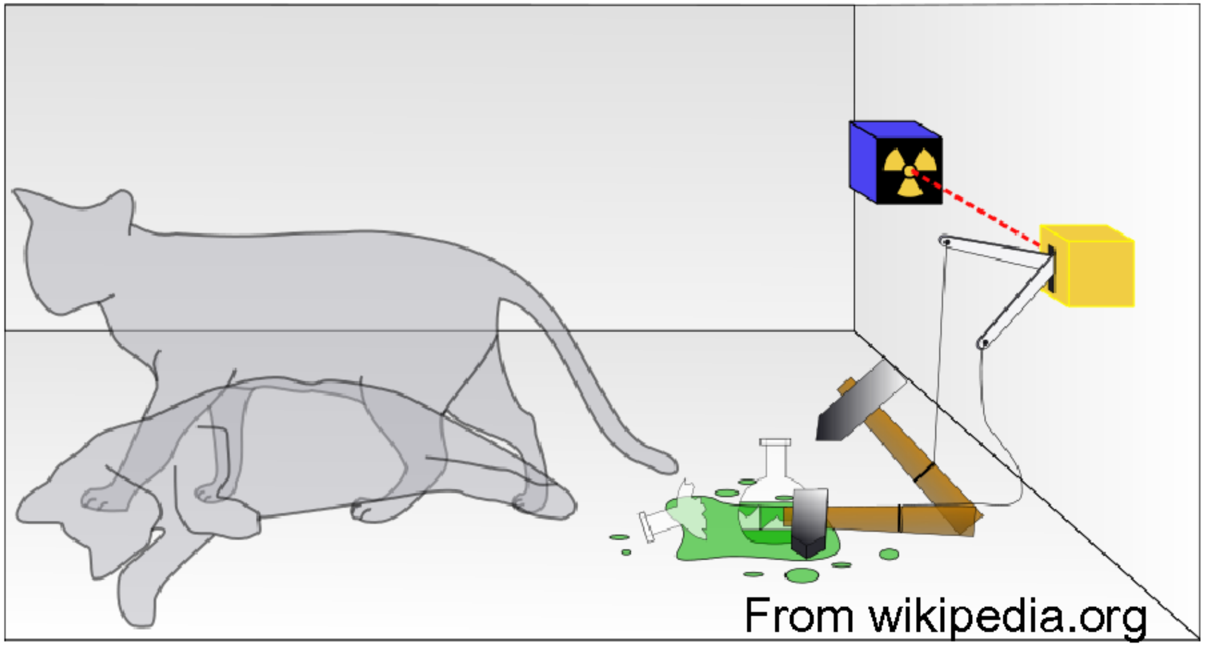
COPENHAGEN:

$$CAT = \frac{1}{2}\left(|DEAD\rangle + |ALIVE\rangle\right)$$

QUANTUM SUPERPOSITION (LIKE ADDING TWO WAVES)

CAT IS BOTH DEATH AND ALIVE

ONLY WHEN YOU OPEN THE BOX THE "WAVEFUNCTION COLLAPSES" AND YOU CAN TELL IF CAT IS DEAD/ALIVE



② MANY WORLDS INT. OF Q.M.