

Physics 100 - Fall 2007 - Recitation 5

①

In the Bohr Model of the atom, what happens to the electron when the atom absorbs a photon? What happens to the electron when the atom emits a photon?

Below is a schematic diagram of an atom with four different states (or orbits) in which the electron could exist. Next to it is a graphical representation of the electron energy in each possible STATE ... $E_1 < E_2 < E_3 < E_4$.

In terms of E_1, E_2, E_3, E_4 , what is the energy of the most energetic photon emitted by this atom?

In terms of E_1, E_2, E_3, E_4 , what is the energy of the least energetic photon?

Suppose for a moment that

$$h = 6.6 \times 10^{-34} \text{ J}\cdot\text{s}$$

or

$$4.1 \times 10^{-21} \text{ MeV}\cdot\text{s}$$

$$E_1 = -13.6 \text{ eV}$$

$$E_2 = -3.4 \text{ eV}$$

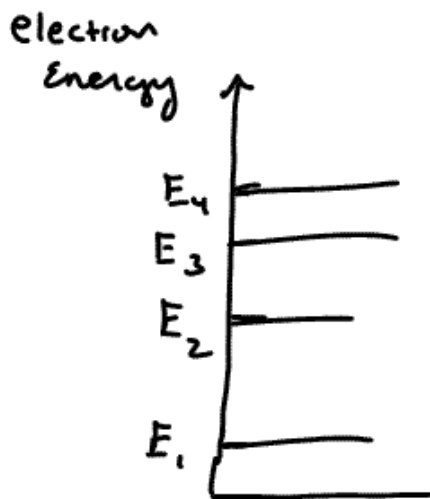
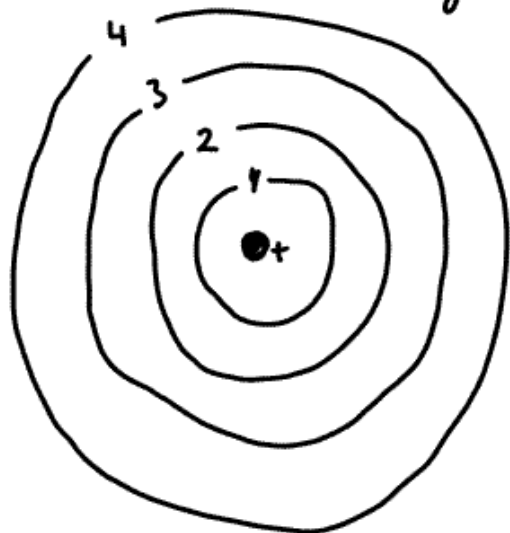
$$E_3 = -1.5 \text{ eV}$$

$$E_4 = -0.85 \text{ eV}$$

I know the "-" sign seems strange ... it means the electron is bound in the atom. Just think of scale as offset from zero.

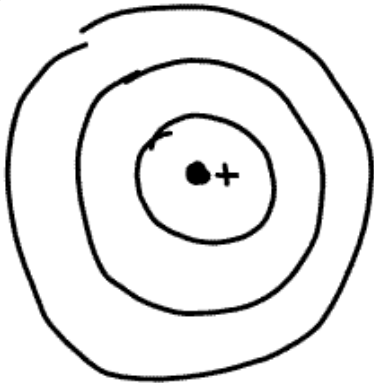
What is the highest frequency light emitted by this atom?

What is the lowest frequency light emitted by this atom?



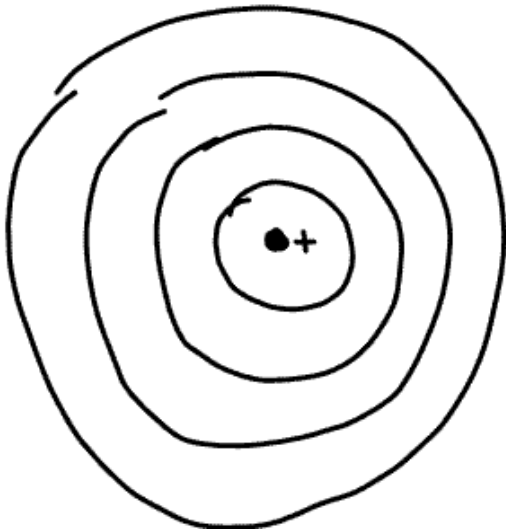
Look on p 196 of Hobson to determine the region of the electromagnetic spectrum where light of this frequency would be found.

(2)



An atom has 3 possible energy states in which the electron could exist. How many spectral lines could be emitted by this atom?

(3)



An atom has 4 possible energy states in which the electron could exist. How many spectral lines could be emitted by this atom?

4) IT happens that when you calculate the energy of a multi-electron atom using a full-blown quantum mechanical treatment, the atom is most stable if it has all the possible quantum states in its outermost energy level filled.

(a) What do I mean by the words "most stable"?

According to quantum mechanics:

	Energy level	Number of electrons Allowed
Increasing energy ↓	1S	2
	2S	2
	2P	6
	3S	2
	3P	6

Look on the periodic chart.

names of available quantum states (Don't use these in lecture)

(b) How can you tell the number of protons in each of the listed element?

(c) Elements are defined primarily by their chemical characteristics.

What do I mean by this?

(d) Considering atoms with $Z=1$ (hydrogen) through $Z=18$ (Argon \equiv Ar), which elements would you expect to be most stable (least chemically reactive)?

(e) Can you determine the number of neutrons for each element listed in the Periodic chart?

(f) Do you think the number of neutrons in an atom's nucleus has an affect on it's chemical characteristics?

(g) Which ATOM would you expect to be larger ... ?

Ne \equiv Neon or Ar \equiv Argon
 $Z=10$ $Z=18$

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Periodic Table of the Elements

1A	2A	3B	4B	5B	6B	7B	8B	11B	12B	3A	4A	5A	6A	7A	8A																																																																																				
1 H hydrogen 1.008	4 Be beryllium 9.012	21 Sc scandium 44.956	22 Ti titanium 47.88	23 V vanadium 50.94	24 Cr chromium 52.00	25 Mn manganese 54.94	26 Fe iron 55.85	27 Co cobalt 58.93	28 Ni nickel 58.69	29 Cu copper 63.55	30 Zn zinc 65.38	31 Ga gallium 69.72	32 Ge germanium 72.64	33 As arsenic 74.92	34 Se selenium 78.96	35 Br bromine 79.90	36 Kr krypton 83.80	37 Rb rubidium 85.47	38 Sr strontium 87.62	39 Y yttrium 88.91	40 Zr zirconium 91.22	41 Nb niobium 92.91	42 Mo molybdenum 95.94	43 Tc technetium (99)	44 Ru ruthenium 101.1	45 Rh rhodium 101.07	46 Pd palladium 106.42	47 Ag silver 107.87	48 Cd cadmium 112.41	49 In indium 114.82	50 Sn tin 118.71	51 Sb antimony 121.76	52 Te tellurium 127.6	53 I iodine 126.91	54 Xe xenon 131.3	55 Cs cesium 132.91	56 Ba barium 137.33	57 La* lanthanum 138.91	58 Ce cerium 140.12	59 Pr praseodymium 140.91	60 Nd neodymium 144.24	61 Pm promethium (145)	62 Sm samarium 150.36	63 Eu europium 151.96	64 Gd gadolinium 157.25	65 Tb terbium 158.93	66 Dy dysprosium 162.50	67 Ho holmium 164.93	68 Er erbium 167.26	69 Tm thulium 168.93	70 Yb ytterbium 173.05	71 Lu lutetium 174.967	72 Hf hafnium 178.49	73 Ta tantalum 180.95	74 W tungsten 183.85	75 Re rhenium 186.21	76 Os osmium 190.23	77 Ir iridium 192.22	78 Pt platinum 195.08	79 Au gold 196.97	80 Hg mercury 200.59	81 Tl thallium 204.38	82 Pb lead 207.2	83 Bi bismuth 208.98	84 Po polonium (209)	85 At astatine (210)	86 Rn radon 222	87 Fr francium 223	88 Ra radium 226	89 Ac~ actinium (227)	90 Th thorium 232.04	91 Pa protactinium 231	92 U uranium 238.03	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 260	104 Rf rutherfordium 261	105 Db dubnium 262	106 Sg seaborgium 263	107 Bh bohrium 264	108 Hs hassium 265	109 Mt meitnerium 266	110 Ds darmstadtium 271	111 Uuu unnilium 272	112 Uub ununium 277	113 Nh nihonium 284	114 Fl flerovium 289	115 Mc moscovium 288	116 Lv livermorium 293	117 Ts tennessine 294	118 Og oganesson 294

element names in **blue** are liquids at room temperature
 element names in **red** are gases at room temperature
 element names in **black** are solids at room temperature

Lanthanide Series*

Actinide Series**



(5)

hydrogen ($Z=1, H$) reacts with chlorine ($Z=17, Cl$) to form hydrogen chloride molecules which consist of 1 H and 1 Cl atom, written as HCl

From what you know about quantum stability and its dependence on the electron configuration (how the electrons fill the available orbitals),

can you motivate why H and Cl join in a 1-to-1 ratio?

What other atoms would you expect to join with chlorine in a 1-to-1 ratio in a chemical reaction?

What do you suppose might be the ratio of magnesium (Mg) to chlorine (Cl) after a chemical reaction?