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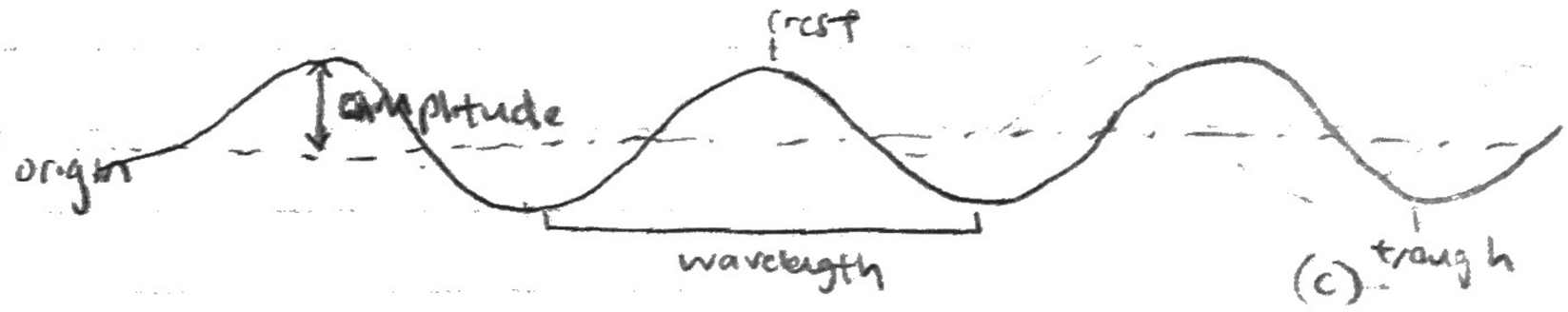
Chapter 5.1: Light and Quantized Energy

p. 116-128 Q-Notes

Questions	Answers
What did the atomic models leave unanswered?	- Rutherford's model didn't explain <u>how</u> electrons filled the space, nor why electrons were not pulled into nucleus nor the chemical properties (reactivity) of atoms
How does light behave like a wave?	- It is electromagnetic radiation, a form of wave-like energy - includes radio waves, visible light, and x-rays - all waves have certain properties: - wavelength (λ): shortest distance between equivalent points on a continuous wave (usually from crest to crest or trough to trough) (m, cm, nm) - frequency (ν): number of waves that pass per second (Hz) - amplitude: wave's height from origin to crest.



- all electromagnetic waves travel at $3.00 \times 10^8 \frac{m}{s}$ in a vacuum
  - $c = \lambda\nu$ (inverse relationship between λ and ν)

What is a "spectrum" (of light)?	- a band of colors or wavelengths (and frequencies) — visible light spectrum includes all the colors we can see - visible light spectrum is continuous because each part corresponds to a corresponding wavelength - white light has all the colors of this spectrum, can be split using a prism — electromagnetic spectrum has all forms of electromagnetic radiation - lowest to highest wavelength: radio, AM, TV/FM, microwaves, infrared, visible light, ultraviolet, x-rays, gamma rays
How does light act as a particle? - what is the "quantum concept?"	- matter can only gain or lose energy in small amounts a time - a "quantum" is the minimum amount of energy that can be gained or lost by an atom - energy of a quantum is related to frequency of emitted radiation $E = h\nu$ (h = Planck's constant of 6.626×10^{-34} J·s) - matter can only gain or lose whole number multiples of $h\nu$ (whole quantums)
- what is the photoelectric effect?	- when electrons (called photoelectrons) emitted from surface of metal if a certain frequency of light shines on it

Questions	Answers
	- photoelectric effect allows for creation of electrical energy in photovoltaic cells of electronics - if there is too little energy, then no electron will be emitted - Einstein proposed that light also acts as a particle, made up of bundles of energy (1 quantum each) called photons - $E_{photon} = h\nu$ (1 quantum = energy of photon)
what are atomic emission spectra?	- an "atomic emission spectrum" of an element is the set of frequencies of the electromagnetic waves emitted by an element - unique for every element, can be used to determine element

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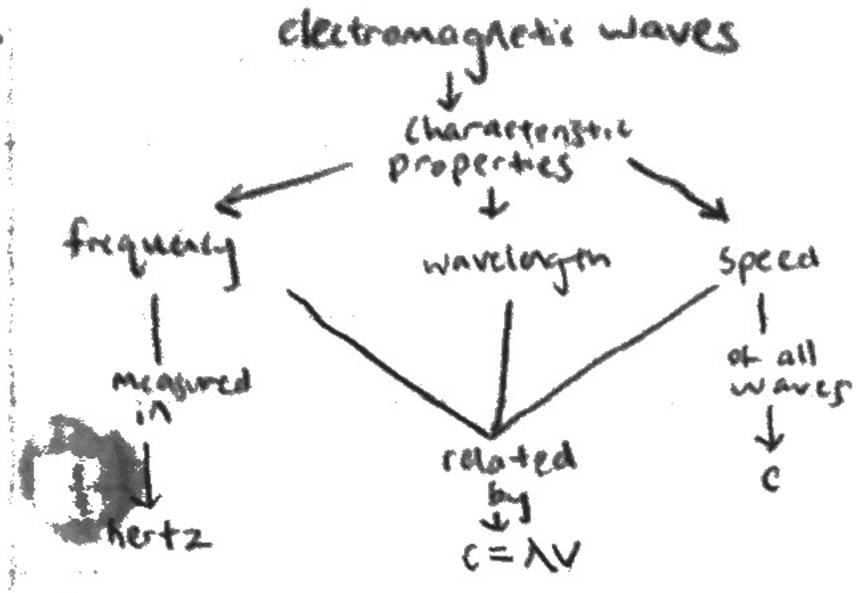

30. frequency is the number of waves that pass a given point in a certain amount of time. Usually measured in Hz (1 wave/second).
wavelength is the (shortest) distance between the corresponding parts of two (adjacent) waves. It is usually measured from trough to trough or peak to peak. Measured with regular units of length
quantum is the (tiny) minimum amount of energy that an atom can gain or lose. (so it is dependent on frequency) It is equal to $h\nu$, and is also the energy of a photon.
ground state is the lowest allowable energy state of an atom

31. It didn't explain the exact arrangement of electrons, why they didn't get pulled into the nucleus, nor an atom's chemical properties.

32. Visible light.

33. Electricity excites the electrons in the neon, pushing them up to a higher energy level. They then become unstable and have to release this energy. Their electrons drop an energy level and emit electromagnetic radiation.

34. A photon is the particle representation of light as small bundles with one quantum of light each. (this was proposed by Einstein)

35. The photoelectric effect is the observation that when a certain frequency of light is shone on a metal surface, photoelectrons are emitted.

36. Planck proposed that matter (atoms) could only lose or gain energy in tiny amounts, in whole number multiples of a quantum of energy ($h\nu$) at a time. He also said that (based on his equation) a quantum's energy is correlated with the frequency

37. Einstein proposed the idea of light as photons, small bundles of one quantum of energy

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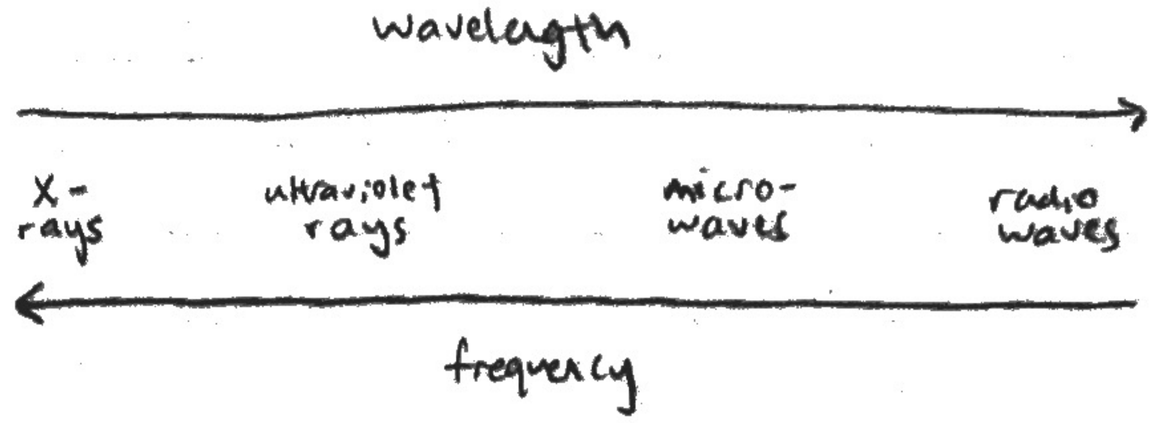

Q-Notes: Sections 5.2, 5.3 (pg. 127-141)

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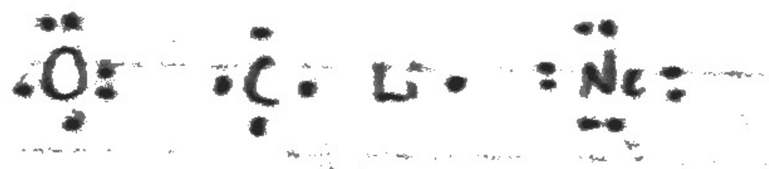
Questions	Answers / Explanations
- How did Bohr predict and calculate the energy of different energy levels? + what else did he propose with his model?	- "ground state" is lowest allowable energy levels - "excited state" is when atom gains energy - can have multiple - the lower the energy level, the closer to the nucleus (and vice versa) (and he also calculated diameters of energy levels) - $\Delta E = E_{\text{higher energy orbit}} - E_{\text{lower energy orbit}} = E_{\text{photon}} = h\nu$ - because only certain energy levels exist, only certain frequencies can be emitted - Balmer series = visible light emission spectrum of Hydrogen - Lyman " = UV " " " " - Paschen " = infrared " " " "
- How did the quantum-mechanical (wave) model of the atom differ from Bohr's model?	- model only worked for H, and was incorrect with greater atoms - Louisde Broglie proposed that electrons (orbits) were like waves - electron is only allowed certain frequencies, wavelengths, and energies if it has wave-like motion and is restricted to circular motion - de Broglie equation (λ = wavelength, m = mass, v = velocity) $\lambda = \frac{h}{mv}$
- What is the Heisenberg uncertainty principle and how does it relate to the model of the atom?	- States that it is fundamentally impossible to know precisely both the velocity and position of a particle at the same time - a photon has about the same energy as an electron, and even looking at it (implying that there's photons of light) means that there would be energy transferred and the electron may be altered.
- How did Schrödinger contribute to the model of the atom?	- derived an equation that treated the electron of the hydrogen atom as a wave, and worked well with the other elements as well - also creates limits to an electron's energy, but as a cluster of probabilities instead of a fixed path - orbital is 3D-space around nucleus that describes an electron's probable location. - because based on probability, no definite boundaries
How are Hydrogen's energy levels/orbitals described?	- often orbitals are drawn to cover 90% of probability distribution - principal quantum number (n) indicate relative sizes and energies of orbital levels - specifies principal energy levels - principal energy levels have energy sublevels (same number as energy level) - s, p, d, f, and all have different shapes 1 orbital ($2e^-$), 3 orbitals ($6e^-$), 5 orbitals ($10e^-$), 7 orbitals ($14e^-$)

questions	answers
	# of orbitals = (principle energy level or n)^2 - # of electrons = $2n^2$ - 2 electrons per orbital (max)
-How are electrons configured in their ground state? How does its guiding principles work? -aufbau principle	- electron configuration is arrangement of electrons in an atom - based on the idea that a more stable system is a (lower energy (level)) one - aufbau principle states that each electron occupies the lowest energy orbital provided - defining principles -all orbitals of same sublevel have the same energy - energy sublevels within a principal energy level have different energies - order of energy levels is: s, p, d, f - some energy sublevels of higher principal energy levels can have lower energy than those of a lower principal energy level (eg. 4s lower energy than 3d)
-pauli exclusion principle -Hund's rule	- every electron has an associated spin - can have a maximum of two electrons per orbital, but only if they have opposite spins (written as ↑↓) - electrons "fill" sublevels with one spin first (their spin reads aloud), with one per orbital, and then the second spin
-How can orbitals be represented? Electron configurations?	- orbital diagram -example: Oxygen 1s 2s $2p_x$ $2p_y$ $2p_z$ [↑↓] [↑↓] [↑↓] [↑] [↑] - electron configuration notation: -example: oxygen: $1s^2 2s^2 2p^4$ - can be expressed using the latest noble gas (eg. Oxygen = [He] $2s^2 2p^4$) - can use a sublevel diagram to easily show the order of "filling" based on aufbau principle -but some are INCORRECT because of strange filling of d and f orbitals
-How do valence electrons have an impact on reactivity / electron configuration? How can they be represented?	- valence electrons are electrons in highest energy level - can be represented with electron-dot structures -examples: 

Q-Notes: Fireworks Article

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Questions / Answers

What are fireworks made of?

- aerial shell → gunpowder
- "stars" globs of explosives → oxidizing agent; fuel; create heat and gas
- binder — holds everything together
- metal coloring agent → COLOR
- rapidly expands → explosion

what are the steps of a firework explosion?

lift off
in mortar, lifting charge below explodes

time delay fuse → ignites bursting charge (gunpowder) and ejects stars

boom caused when air is tearing/expanding faster than speed of sound!

The SCIENCE: How are different colors produced produced in a firework explosion?

Incandescence

↓ intense heat causes glow

Luminescence

- what we did in class
- metal salts absorb heat then release it as light (electromagnetic radiation)

different metals produce different colors

- red: strontium salts, lithium salts
- orange: calcium salts
- yellow: sodium salts
- green: barium oxide
- blue: copper chloride
- purple: mix of red and blue

Are fireworks unsafe? If so, in which ways?

- If timing is off, it could explode too close to the ground and injure people
- having more than 50 mg of gunpowder in a firework can be dangerous
- often people misread labels and misuse, especially with firecrackers

What is a pyrotechnic chemist?

- "combine compounds to make a mixture that can explode to produce color, light, and audible effects," such as in fireworks
  - applications include:
    - fireworks
    - flares
    - night-vision effects

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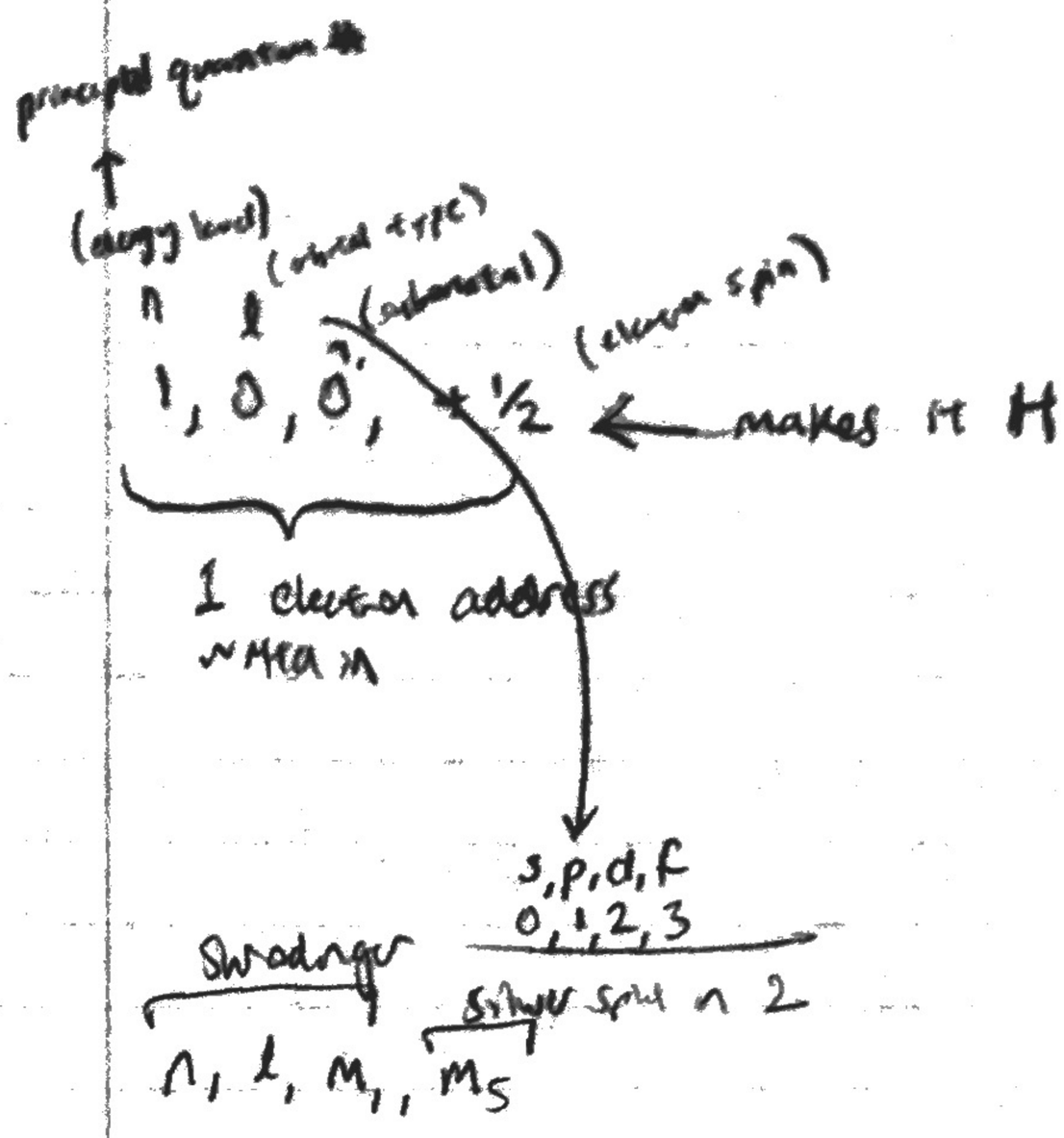
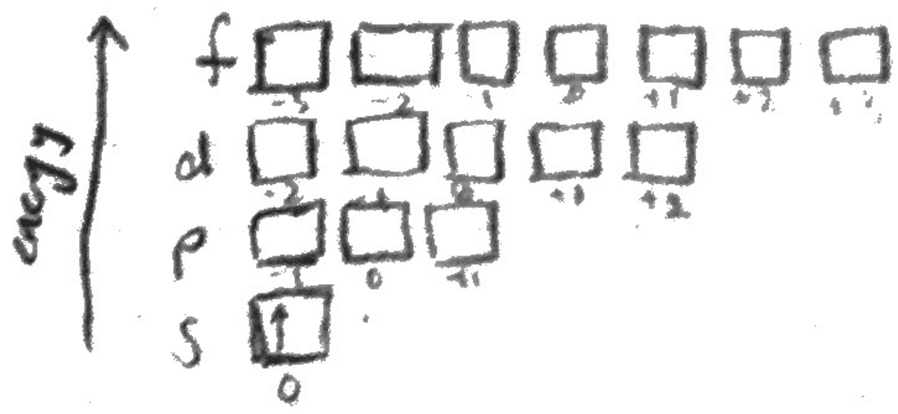
QUANTUM NUMBERS





No two electrons can have the same four quantum numbers.
Only the last electron's position of an atom/element

electrons fill by lowest energy first (aufbau principle)

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^2\ 4f^{14}\ 5d^{10}\ 6p^6\ 7s^2\ 5f^{14}\ 6d^{10}\ 7p^6$

$8s^2\ 5g^{18}\ 6f^{14}\ 7d^{10}\ 8p^6\ 9s^2\ 6g^{18}\ 7f^{14}\ 8d^{10}\ 9p^6\ 10s^2\ 6h^{22}\ 7g^{18}\ 8f^{14}\ 9d^{10}\ 10p^6\ 11s^2\ 7h^{22}\ 8g^{18}\ 9f^{14}\ 10d^{10}$
$11p^6\ 12s^2\ 7i^{26}\ 8h^{22}\ 9g^{18}\ 10f^{14}\ 11d^{10}\ 12p^6\ 13s^2\ 8i^{26}\ 9h^{22}\ 10g^{18}\ 11f^{14}\ 12d^{10}\ 13p^6\ 14s^2$