Day 1

FInish trends, a little time to work on EA questions on trends sheet

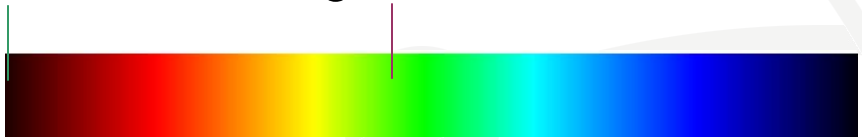
Then this quantum start, time to read quantum sheet OR its homework, come ready to summarize tomorrow.

GET WHITEBOARDS - Front of the class as always

•From B-R to Quantum Model

- Recall the equation for number of electrons in a B-R energy level
- $2n^2$
- Using this, draw Ca (think, how many go into the third orbital)
- Recall other difficulties with the B-R model!

White Light



Hydrogen

Potassium

Explain the multiple lines of nearly identical colours!

Read & Think

Read over the handout and attempt to summarize to your partner

Day 2

Sub-levels and Orbitals

Quantum and detecting explosives

Quantum dots and cancer surgery

The Quantum Model

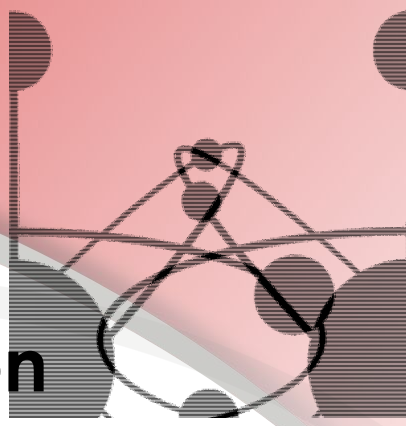
- Bohr's model was only the first step in the development of the quantum model of the atom.
- Over the course of the first half of the 20th century, the model was further refined to more precisely explain the position and behaviour of electrons in an atom

•Features of The Quantum Atom

- There are major energy levels (also called orbits or shells), similar to Bohr-Rutherford model. Major levels are represented by "***n***" and can contain a maximum number of electrons ($2n^2$).

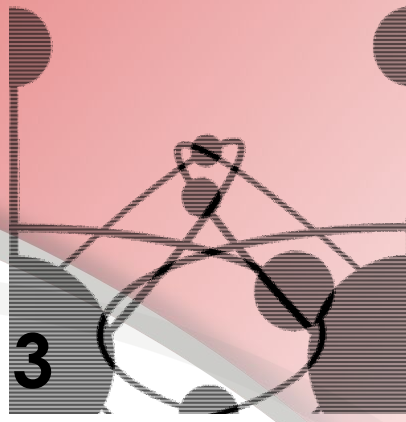
- Energy levels have overlapping subshells that are divided into 4 different types (s, p, d and f), based on the maximum number of *orbitals* (and electrons) they can have. (note that lower energy levels do not have all 4 types of subshells)

Sub-levels

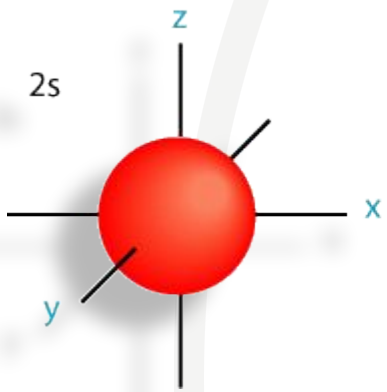


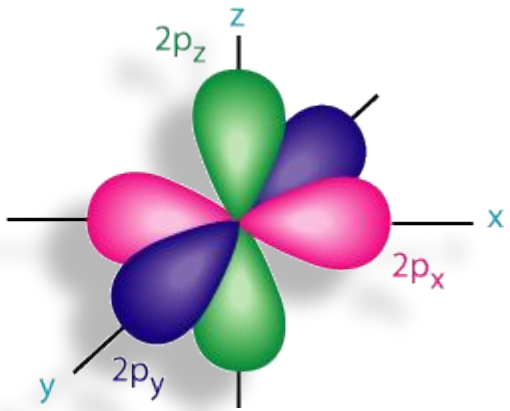
- level = distance from nucleus based on average energy
- sub-level = region in a level where there is a high probability of finding an electron
- since sub-levels can only hold 2 electrons, 2 must represent a maximum
- so how does this relate to p, d and f?

Orbitals



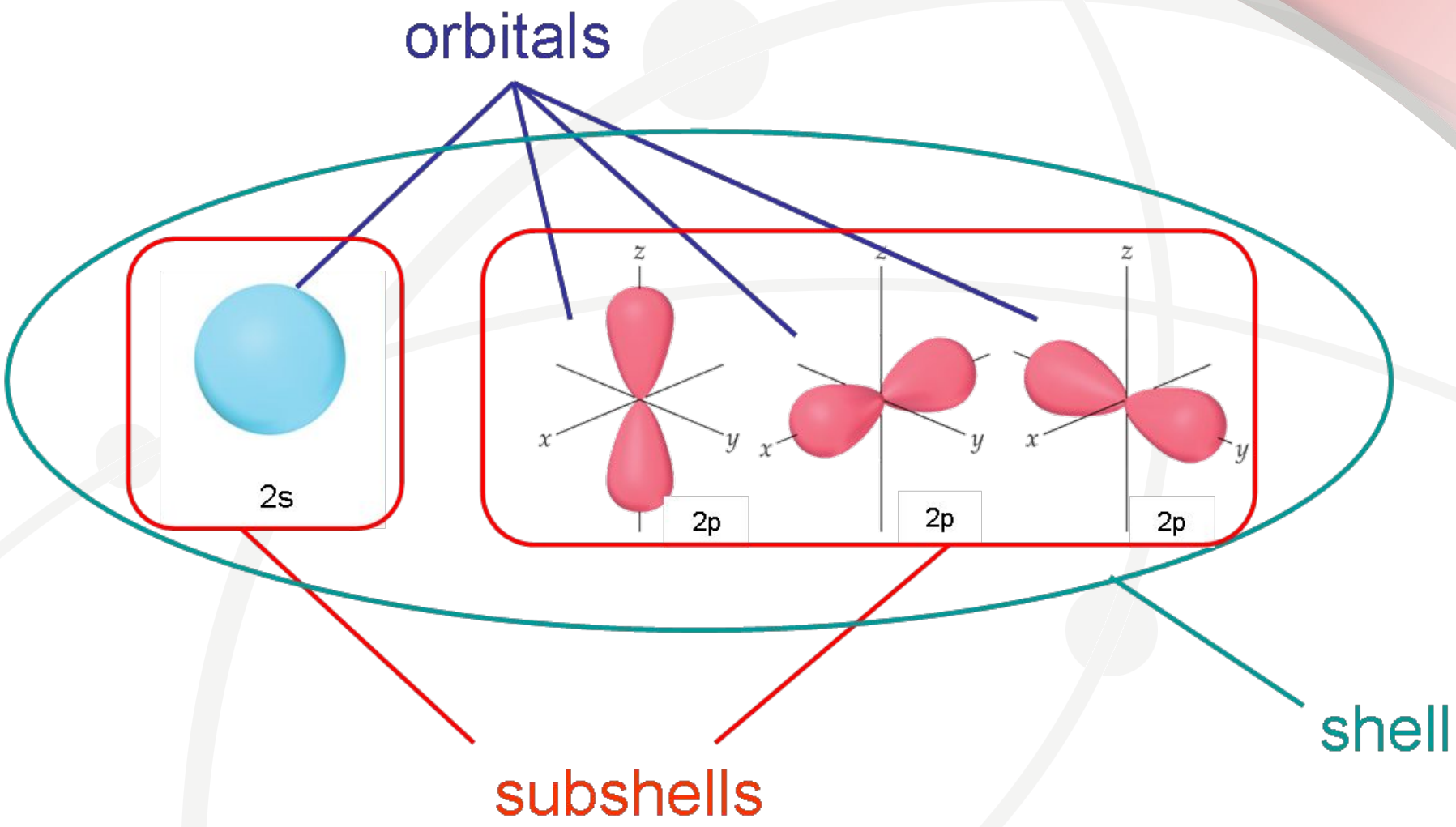
- so p sub-level places 2 electrons in its 3 orientations (2 = maximum for any orbital)
- basically, the orbital = how an electron moves in space at a location
- so s and p are really:





Explains closely spaced spectral lines! Movement between subshells that are close in energy

Another Visualization of it



•Quantum Numbers

- Chemists use Electron Energy Level Diagrams to describe the arrangement of electrons around an atom.
- These diagrams indicate which orbital energy levels are occupied by electrons for a particular ion or atom.
- Energy level Subshells are divided into 4 different types, based on the maximum number of orbitals they can have. Orbitals can hold 2 electrons each.

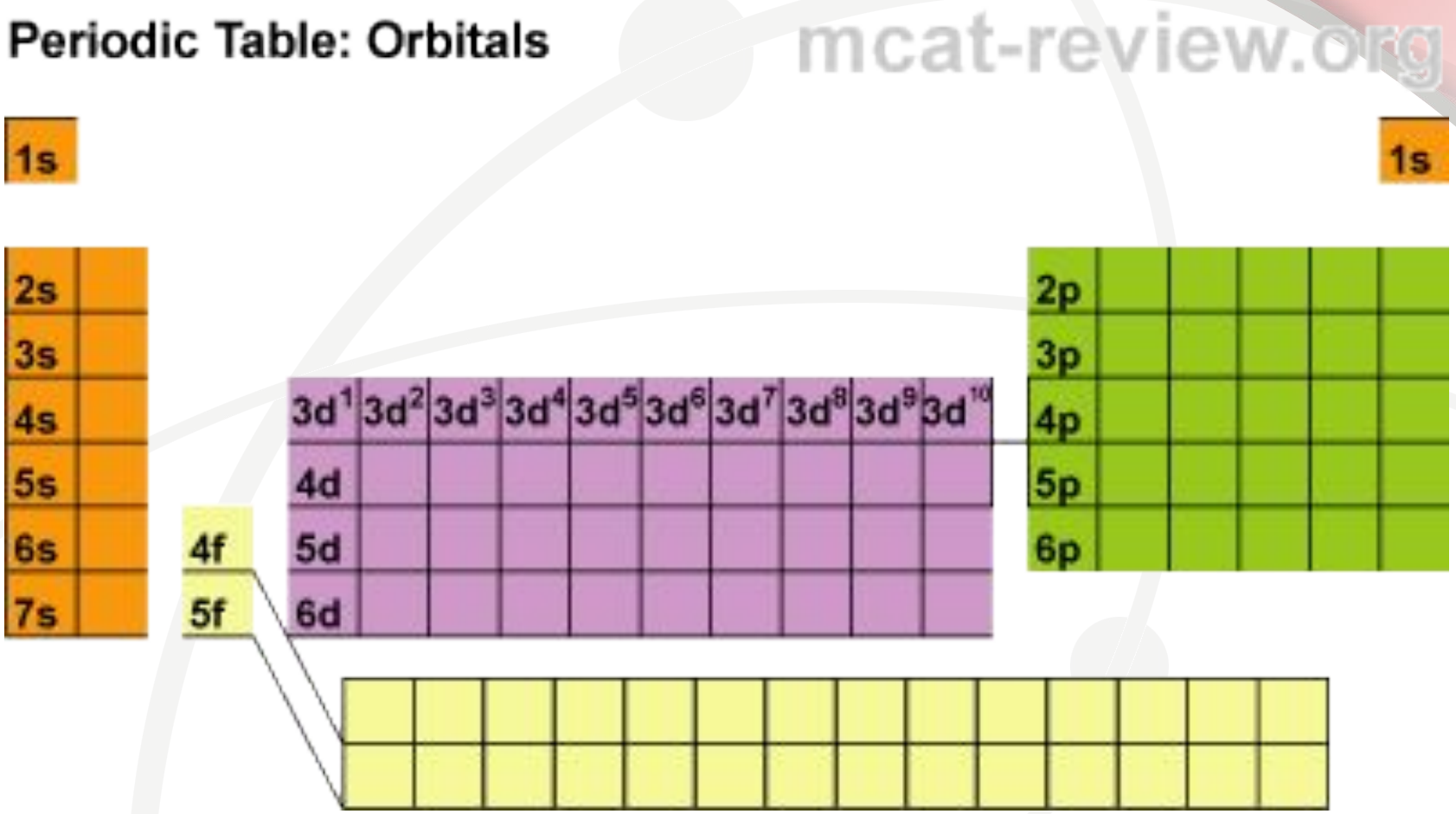
Sublevel	Number of Orbitals	Maximum number of electrons
s	1	2
p	3	6
d	5	10
f	7	14

•Blocks on the Periodic Table

- As it turns out, these sublevels are related to blocks on the periodic table.
- Complete the following table using the periodic table on the next slide

Sublevel (aka Block)	Columns of associated elements	Elements found in this "Block"
s		
p		
d		
f		

•Blocks on the Periodic Table

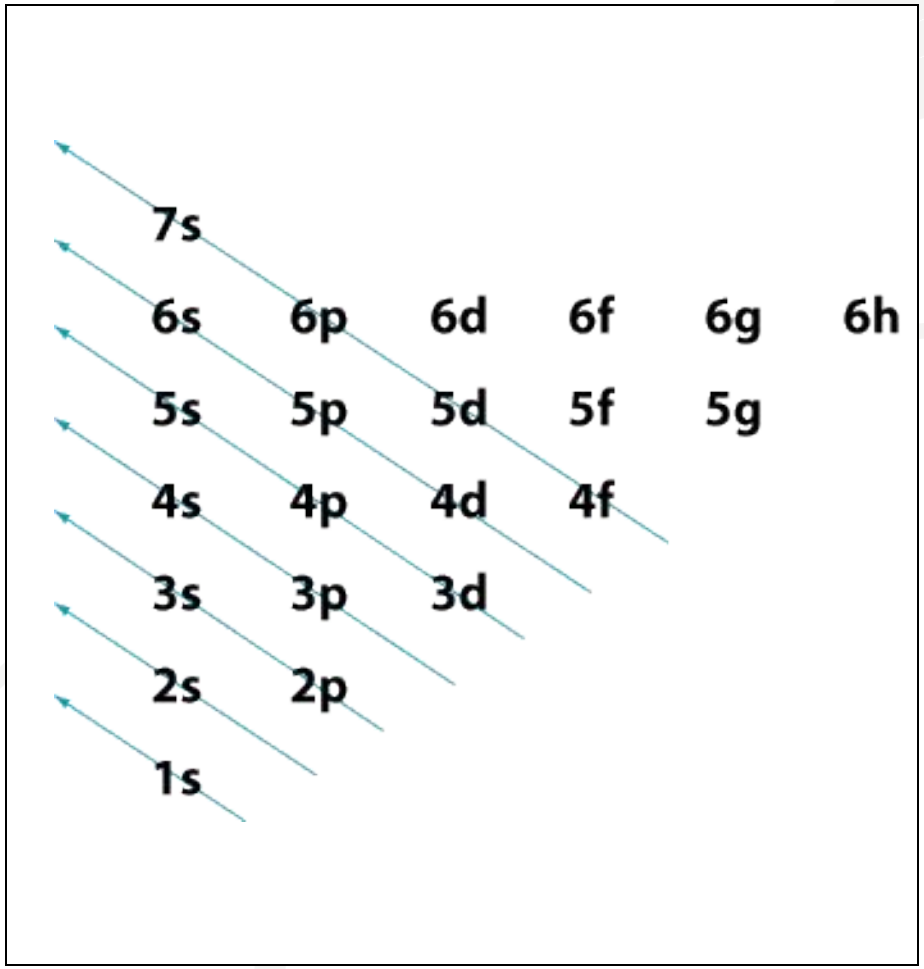


•Blocks on the Periodic Table

- As it turns out, these sublevels are related to blocks on the periodic table.
- Complete the following table using the periodic table on the next slide

Sublevel (aka Block)	Columns of associated elements	Elements found in this "Block"
s	1 & 2	Alkali & alkaline metals
p	3-8	Non-metals mostly
d	3-12 (don't confuse with above)	Transition Metals
f		lanthanides/actinides

•An “aufbau” mnemonic



- This memory aid shows the order of the orbitals as they are filled with electrons:

Electron Configuration Notation

- **What is it?**

- Drawing pictures of the quantum model is simply too complex.
- Electron configuration notation is just another way to describe where the electrons are located.
- It is a list of all the electrons in an atom

- **Determining an electron configuration**
- Use the position on the periodic table
- Period number = highest level of the atom

•The Rules

The first number indicates the principal quantum number

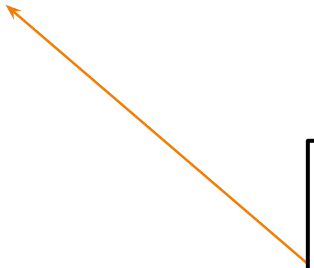
The superscript number indicates the number of electrons in that subshell

NOT to be confused with an exponent.

The letter indicates the subshell (secondary quantum number)

- **Example: Chlorine**
- Cl atom contains 17 electrons.
- Start building:

$1s^2 2s^2 p^6 3s^2 p^5$



Only write the principal quantum number once

NOTE: there is a video reviewing quantum atom on the unit plan. This is great for review at home to clear up any confusions.

- **Subshell order**
  - Subshells of the same primary quantum number must be kept together even though they may fill in a different order.

Example: zinc (period 4, group 12)

$1s^2 2s^2 p^6 3s^2 p^6 d^{10} 4s^2$

3d fills after 4s, however it is not written in that order

3 Minute voyage into an atom

STOP HERE FOR TODAY

Day 2 Quantum Bellwork

On your whiteboards, write the electron configurations for:

Be

S

Cr

Leave all three on your board for use in shortcut method we're going to learn.

- **Let's save time:**

NOBLE GAS shortcut:

1. Find the noble gas at one period below on the periodic table.
2. Start your notation by writing the noble gas symbol in square brackets: [__]
3. Continue the electron configuration from there.

- **Example: Yttrium**

1. Find the noble gas

   [Kr]

2. Start writing the electron configuration:

2. Yttrium is in group 3 and period 5

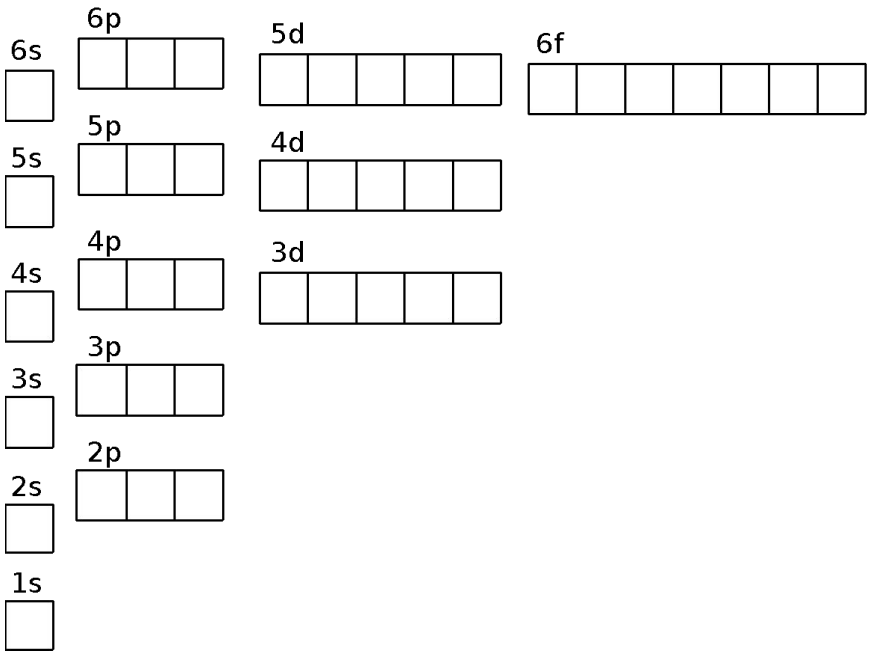
   [Kr] $4d^1 5s^2$

See Quantum Review Video on website

Day 3

•Example Energy Level Diagram:

Example: Barium Atom



Electrons are placed in these diagrams following these rules:

The aufbau principle:

Electrons always fill lower energy levels before moving to higher energy orbitals.

Hund's Rule:

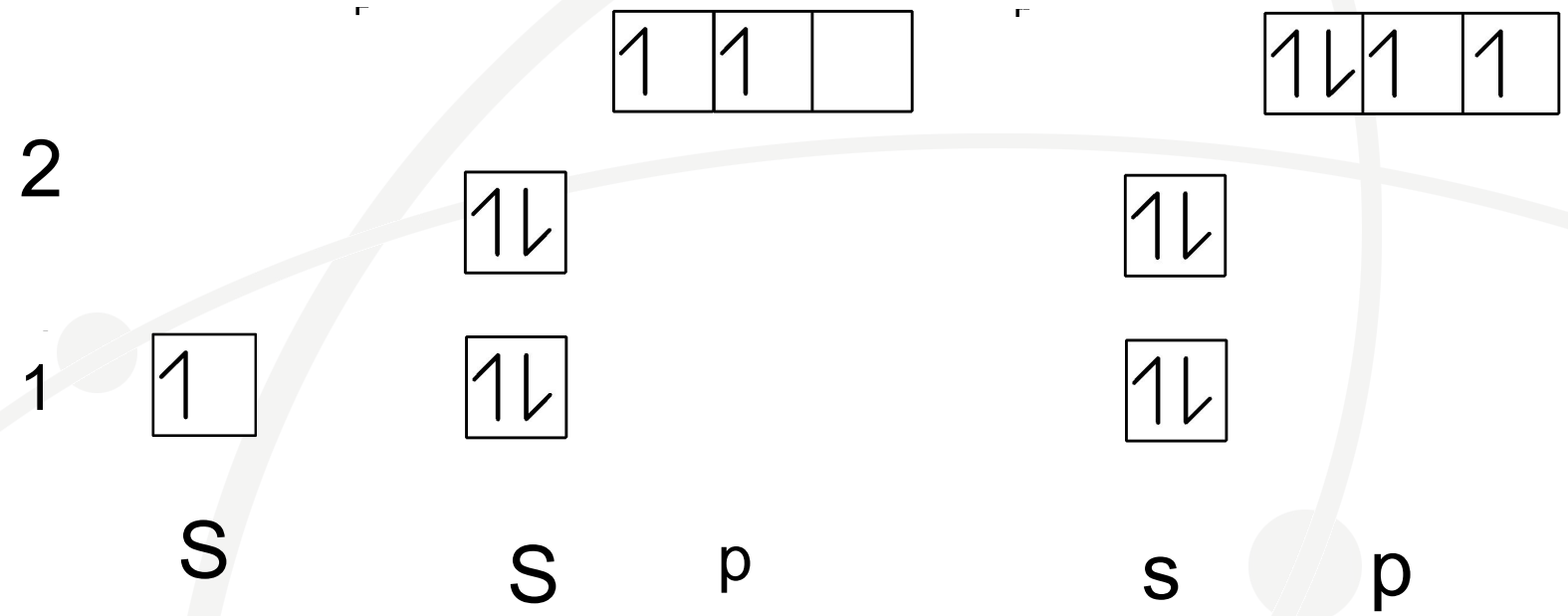
Electrons are filled into empty orbitals so that each orbital gets one electron before you start doubling up.

Pauli Exclusion Principle:

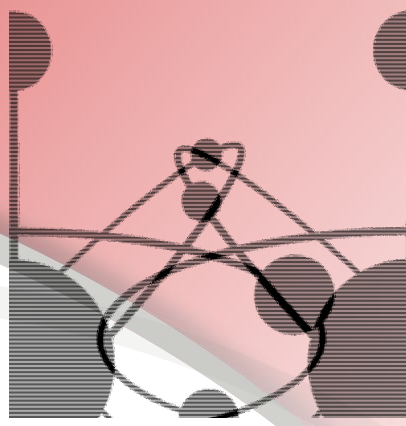
No two electrons can be in the same place at the same time. This means that electrons in the same orbital spin in opposite directions and are indicated with arrows in different directions.

Energy Level Diagrams

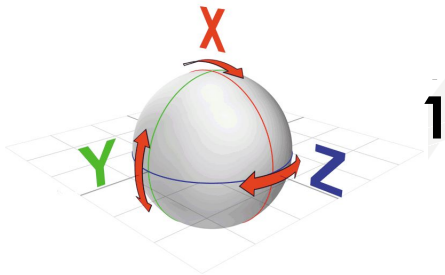
- draw H, C and O



- note energy increases moving up and note spacing/labelling



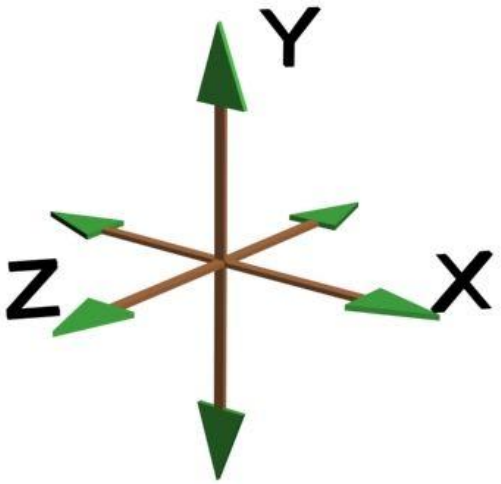
❖try He and Ne



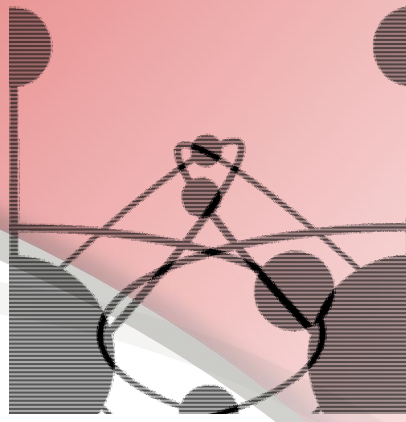
2

1

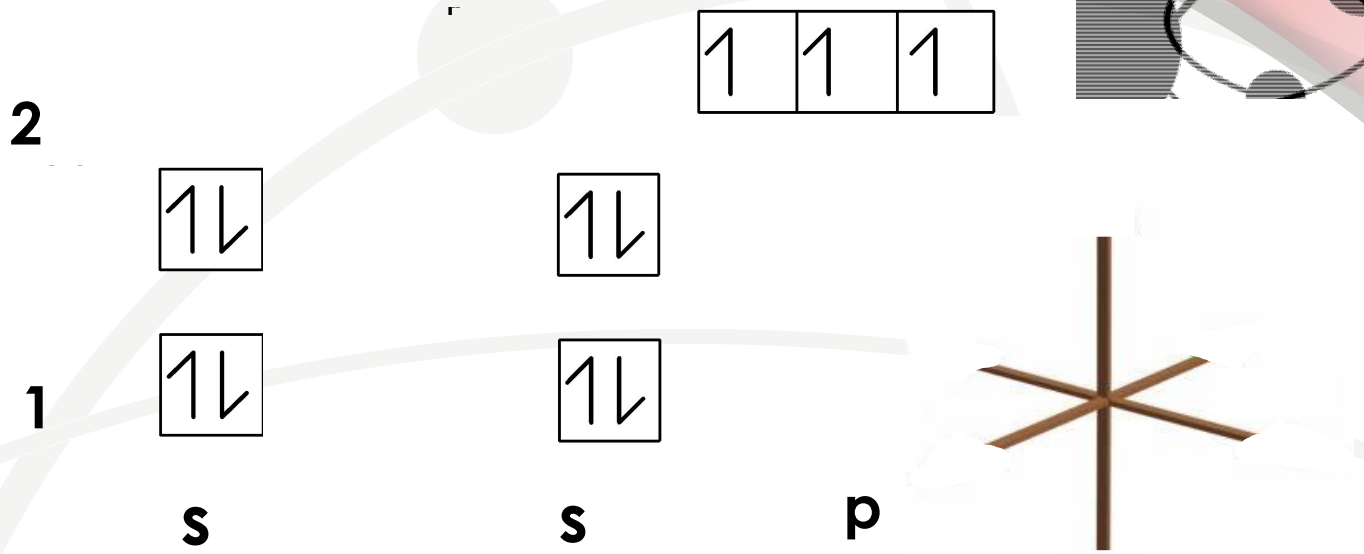
s s p



❖so stability means full orbitals as this cancels magnetic forces created by spinning electrons in all directions

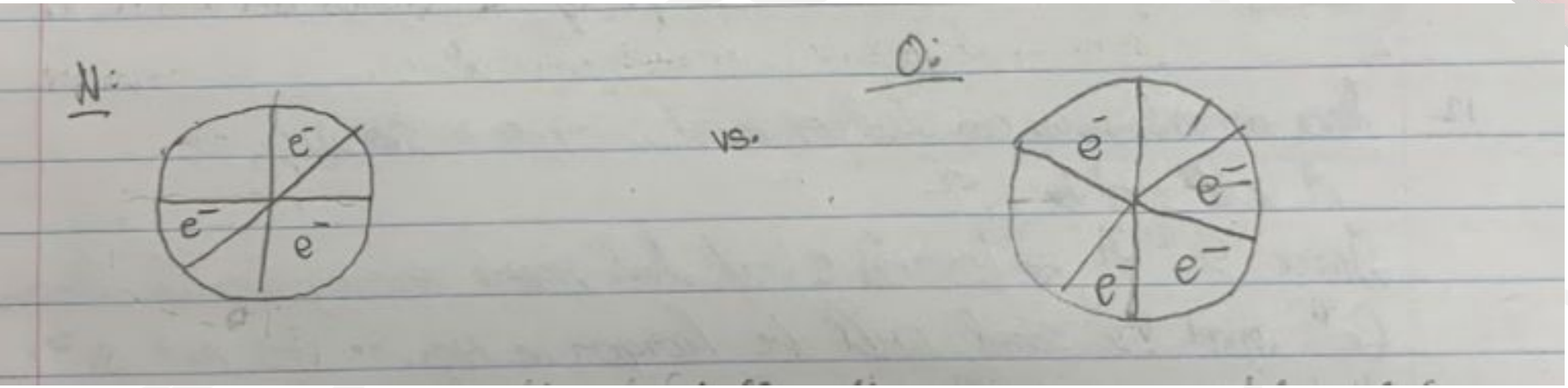


- try Be and N

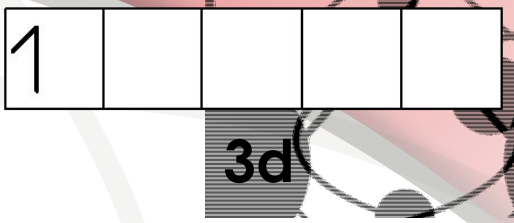


- see partial stability created as incomplete filling but magnetic forces are balanced in all directions due to rapid motion

Another way of visualizing the partial stability balance



❖try K and Sc



4

3

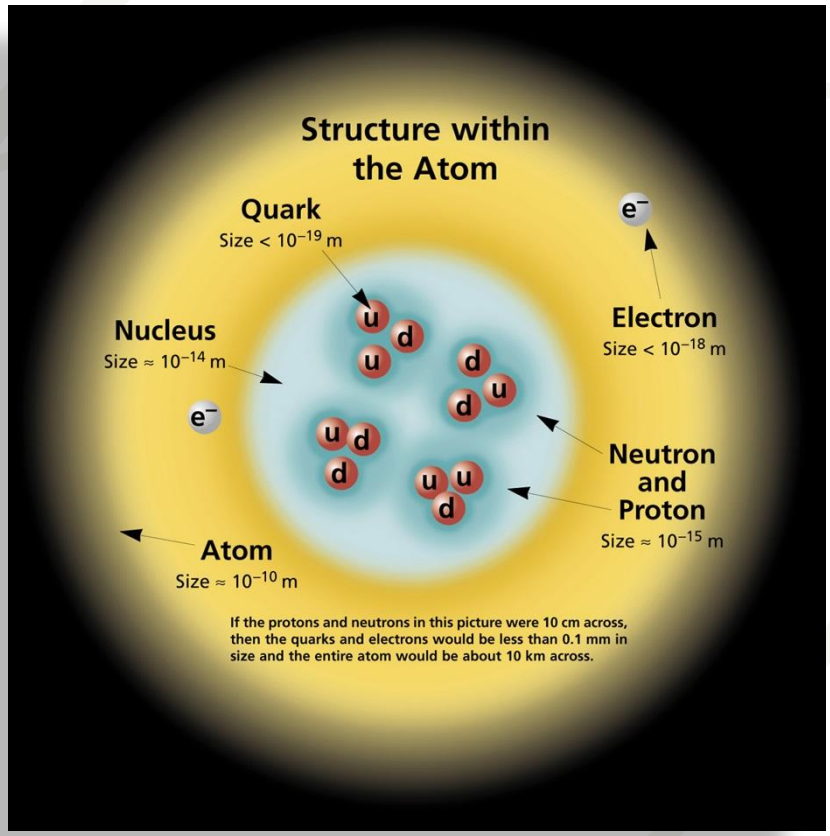
2

1

s p

s p d

- now all the anomalies can be explained
- except why protons can't repel within the nucleus



Extra Notes

When EMPTY the 3d orbital is higher energy than the 4s, so electrons are in 4s before 3d. Once electrons are IN the 3d orbital, they ARE closer average distance to the nucleus than 4s AND then push the 4s level further away by repulsion resulting in those electrons having a higher energy than 3d.

Quantum Battleship - one partner should know regular Battleship rules :)

ON YOUR TABLE: STAY IN TOP 5 PERIODS

- NO crossing lines, NO diagonals
-ONE 5 element lines
- TWO 4 element lines
- ONE 2 element line
- COMPLETE FULL configurations for all elements (can line them up and "reuse" parts of above

TO PLAY: Guess locations using the noble gas shortcuts. Confirm partners guesses by stating the matching element. Once confirmed, if its a HIT let them know and mark it.

- **Quantum and Per Table Trends**
  - Cover partial stability and electron promotion (4s → 3d)