G1. John Dalton → Atomic theory (atoms)
Molly/Paul

G2. JJ Thompson → Plum pudding model
Alberto...

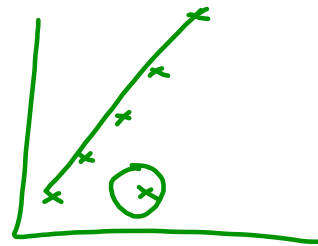G3. Rutherford → Alpha particles
Leopollo...   Gold foil
                        Nucleus   5 slide presentation

G4. Niels Bohr → Atomic spectra
Fran...   Energy levels
                  Electron movement

G5 - The Periodic Table → Mendeleev
Luis...   Atomic number
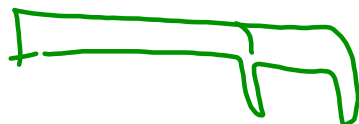   Groups/periods

Table → Title/units

Graph → Line of best fit

Conclusion → Describing the results (using graph)
             Patterns/ correlation
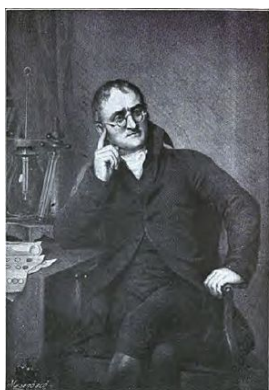
Evaluation → Measuring the diameter →

Atomic Theory

In the year 1803 scientists came up with the atomic theory

"Atom " comes from the greek: a = without   tomos = division

John Dalton proposed...

- All matter is made up of indivisible particles - atoms

- All atoms of a certain element are identical

- Atoms of different elements have a different weight and properties

- The atoms of different elements can combine with the atoms of other elements to form compounds

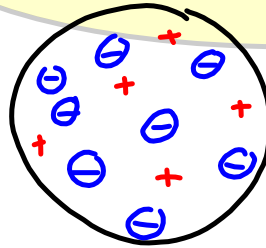- Atoms cannot be created, divided or destroyed in a chemical process.

JOHN DALTON, D.C.L., F.R.S.
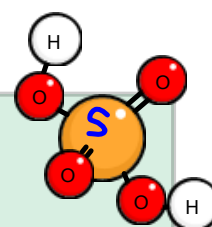
o

Subatomic particles
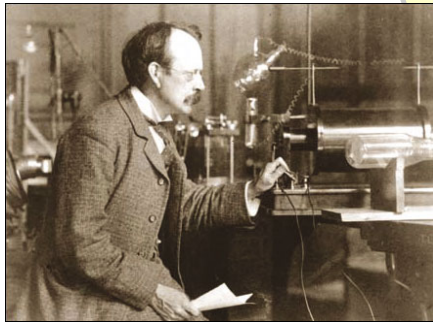
JJ Thompson discovered the <u>electron</u> in 1897
(1856 – 1940)

Plum pudding

He stated that there were negatively charged particles called electrons floating around in a positively charged cloud - plum pudding model . This was discovered by firing cathode rays (beams of electrons) through an electromagnetic field and seeing them move towards the positive side.
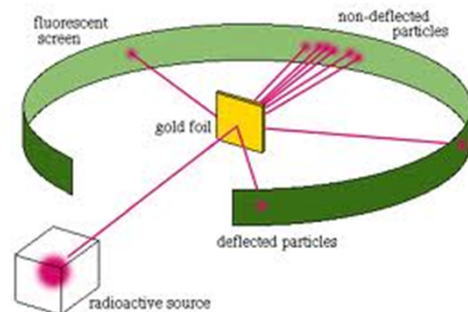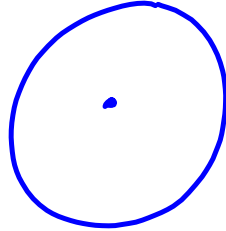
electrons

positively charged "pudding"

forming a positive ion

conduction of electricity
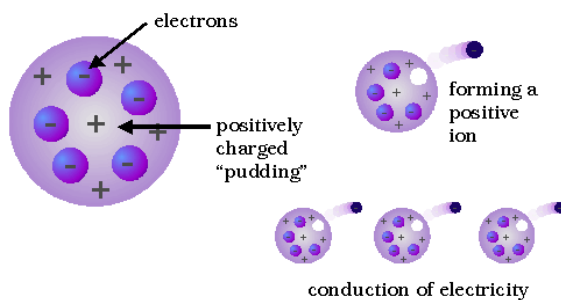
He also calculated the mass of an electron and found it to be very small compared to the total mass of an atom
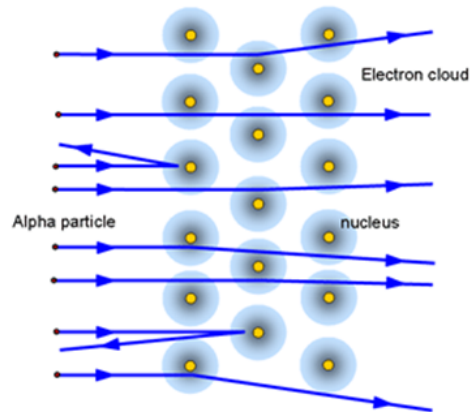
Rutherford
1871 – 1937

Observations:
1. The majority of the particles passed through the gold foil.
2. A small proportion of particles was strongly deflected.
3. One out of 10.000 particles bounched of the gold foil

Conclusions:
1. The majority of atoms is empty space
2. The atom's positive charge is found in a small dense nucleus
3. The electrons orbit around the nucleus

He also found that an electron is 1/1836 the mass of a proton.

Problems:

1.

2.
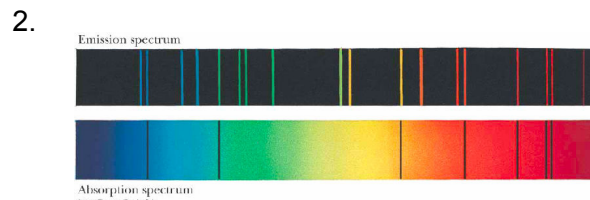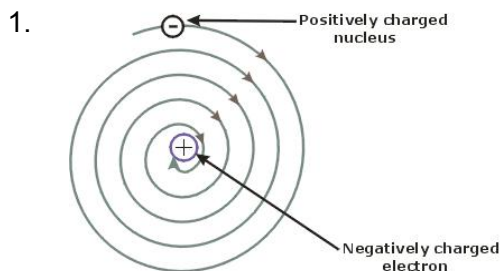
→ Emission spectrum
→ Absorption spectrum

Neils Bohr
7 October 1885 – 18 November 1962

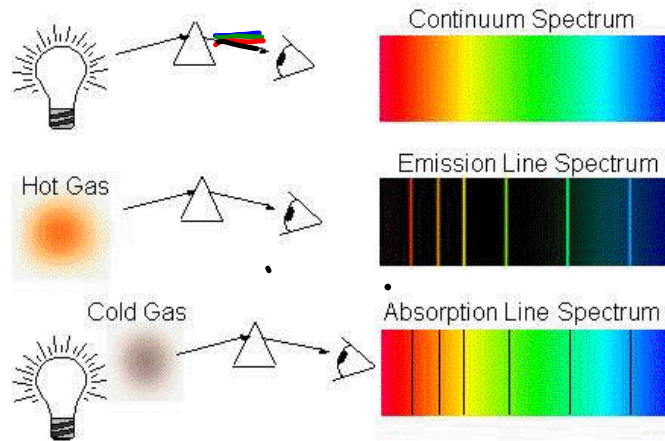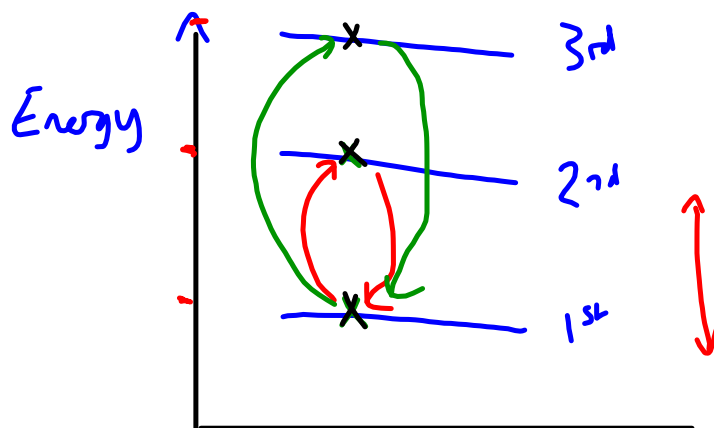Continuum Spectrum

Emission Line Spectrum

Hot Gas

Cold Gas

Absorption Line Spectrum

How did these observations lead him to the idea of set energy levels where the electrons exist?

Energy

3rd

2nd

1st

Electrons can absorb energy and jump up or emit energy and drop down.

Electro

Conclusions:
- Electrons spin in shells around the nucleus, without gaining or losing energy.
- An electron can only change its orbit by emission or absorption of the energy which is equal to the difference in energy between the two orbits.
- Only shells with specific amounts of energy are permitted.

Exam style questions

Easy

1. State the 3 postulates (conclusions) of Bohr´s model.

2. Describe the results of Rutherford´s model.

3. What is the "plum pudding" model?

Medium

3. What was the major difference between Dalton´s proposal and Thompson´s plum pudding model?

4. Why did Rutherford propose that the nucleus was very small?

5. What would be the main difference in atomic spectra given by a very small atom and a very large one?
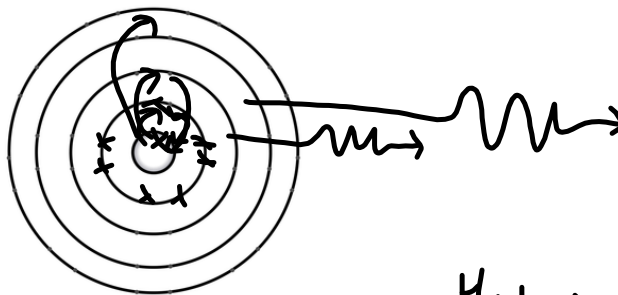
Hard

5. How does Bohr´s model support the existence of atomic emission and absorption spectra?

6. Explain 2 problems with Rutherford´s model.

7. If Rutherford had carried out his experiment and found that all radioactive alpha particles were reflected, what might he have concluded?

Atomic spectra → Emission spectra

Hydrogen

Lowest energy

Highest Energy

The Visible Spectrum

infrared light
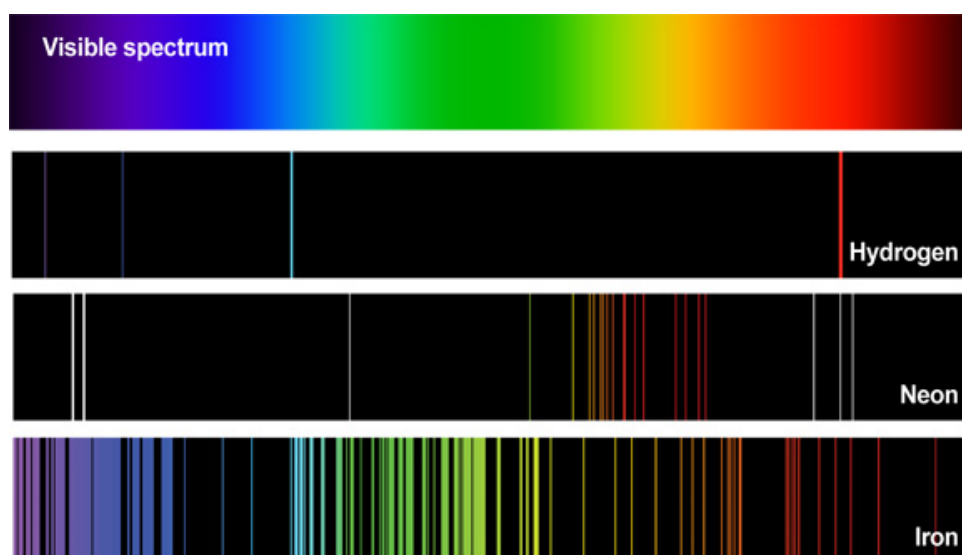
ultraviolet light

700   600   500   400

Wavelength (nm)

© 1995 CHP

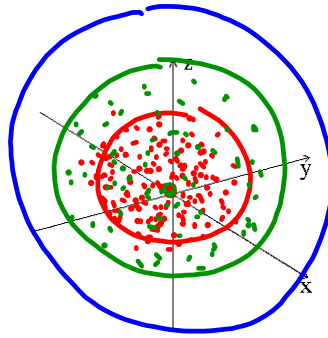# Why do different elements produce different emission spectra?

Atomic orbital theory
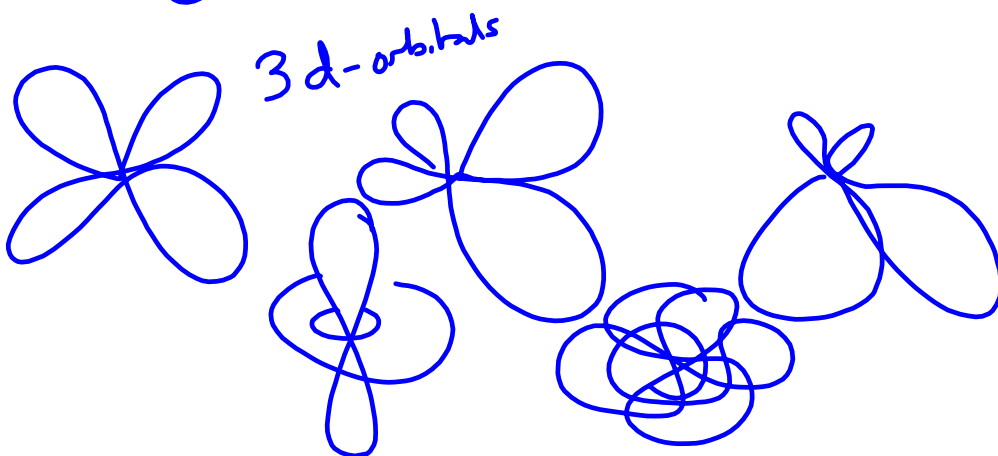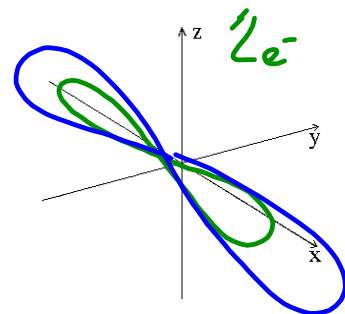
$$\Delta\chi\Delta\rho \geq \frac{\hbar}{2}$$

95%

1st energy 2
level

2nd energy 8
level

3rd energy 18
level

1 s-orbital
2 s-orbital
3 s-orbital

2 p-orbitals
3 p-orbitals

$2e^-$

$2e^-$

$2e^-$

1
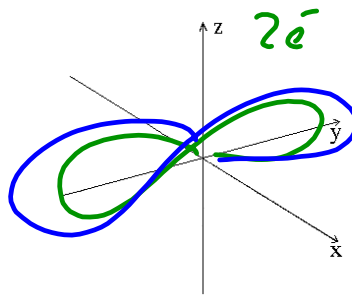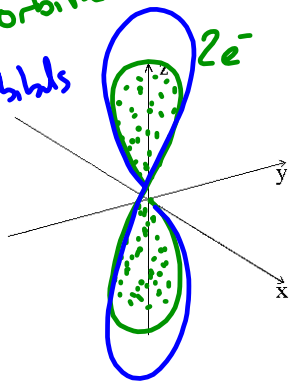
3 d-orbitals

Task 2b:

1. For each of the "shells" (energy levels) that you have seen before, there are a particular number of orbitals (above) that are possible. Find a 3d diagram for the shapes of:

> An s-orbital

> The three types of p-orbital

> The five types of d-orbital

2. The first energy level (shell) contains just one s-orbital . Find out which types of orbital are found in the second and third energy level.

10
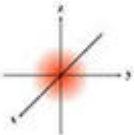
1. H
2. S
3. Ar
4. O^{2-}
5. Fe
6. Fe^{2+}
7. Fe^{3+}
8. Cl^-
9. H^+
10. Zn^{2+}
11. Cu and Cr (*Can you remember why they are different?*)

n = principal l = angular m = magnetic s = spin

distance   shape   orientation   electron
from nucleus   of orbital   in space   spin

$\ell = 0$ $\ell = 1$ $\ell = 2$
s p d

s=
   0

p=
   -1   0   1

d=
   -2   -1   0   1   2

f=
   -3   -2   -1   0   1   2   3

+1/2   -1/2
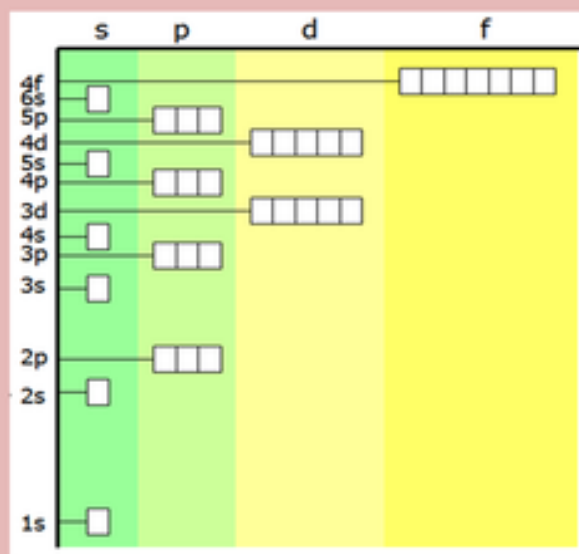
n = principal	l = angular	m = magnetic	s = spin
distance from nucleus	shape of orbital	orientation in space	electron spin

$n \rightarrow$ Which energy level (shell) the $\bar{e}$ is in.

Hydrogen $\rightarrow n = 1$

$\boxed{\uparrow}$ 1s $n = 1, l = 0$

$E \uparrow$ $2s$ $\boxed{\uparrow\downarrow}$ $\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}$ Nitrogen
   $1s$ $\boxed{\uparrow\downarrow}$

$n = 2, l = 1$

$l \rightarrow$ angular

S   P   d

$\begin{array}{ccc} \ell=0 & \ell=1 & \ell=2 \\ s & p & d \end{array}$

$m \rightarrow$ magnetic

s= $\boxed{\uparrow\downarrow}$
      0

p= $\boxed{}\boxed{}\boxed{}$
    -1 0 1

d= $\boxed{}\boxed{}\boxed{}\boxed{}\boxed{}$
   -2 -1 0 1 2

f= $\boxed{}\boxed{}\boxed{}\boxed{}\boxed{}\boxed{}\boxed{}$
   -3 -2 -1 0 1 2 3

$S \rightarrow$ Spin

Energy $\uparrow$ $\uparrow$ $\downarrow$

$\boxed{\uparrow\downarrow}$ 1s $\boxed{+1/2}$ $\boxed{-1/2}$

$He \rightarrow 2\bar{e}$

$\begin{array}{ll} n = 1 & n = 1 \\ l = 0 & l = 0 \\ M = 0 & M = 0 \\ S = +\frac{1}{2} & S = -\frac{1}{2} \end{array}$

$Oxygen \rightarrow 8\bar{e}$

Energy $\uparrow$
   $2p$ $\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}$
   $2s$ $\boxed{\uparrow\downarrow}$ $\leftarrow n = 2$ $l = 0$ $M = 0$ $S = +\frac{1}{2}$ or $-\frac{1}{2}$
   $1s$ $\boxed{\uparrow\downarrow}$
        $n = 1$ $l = 0$ $M = 0$ $s = +\frac{1}{2}$ or $-\frac{1}{2}$
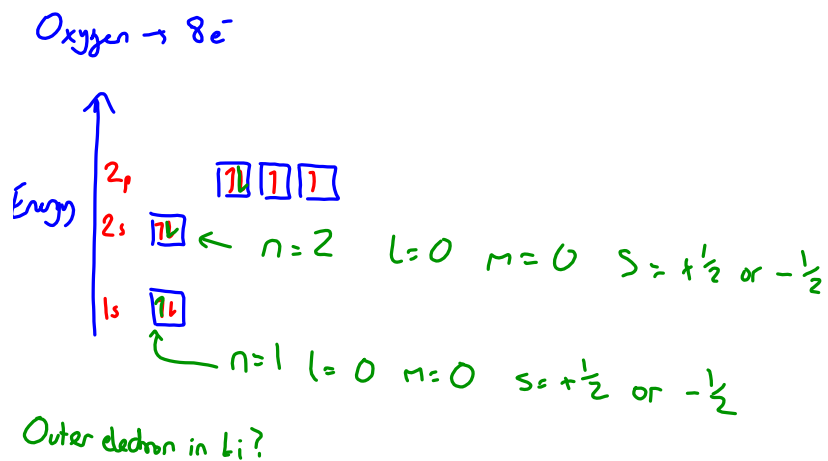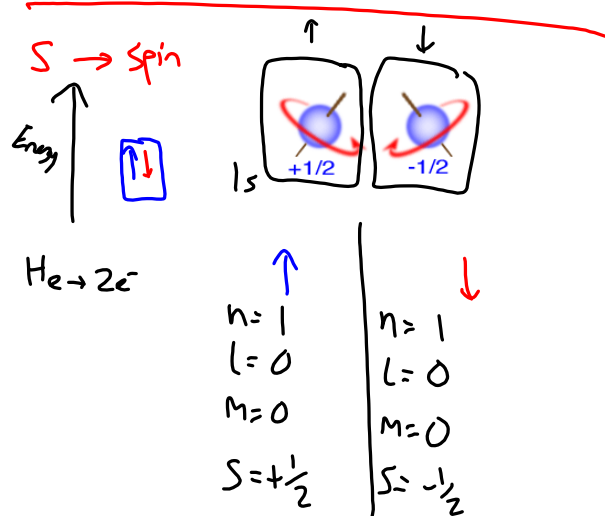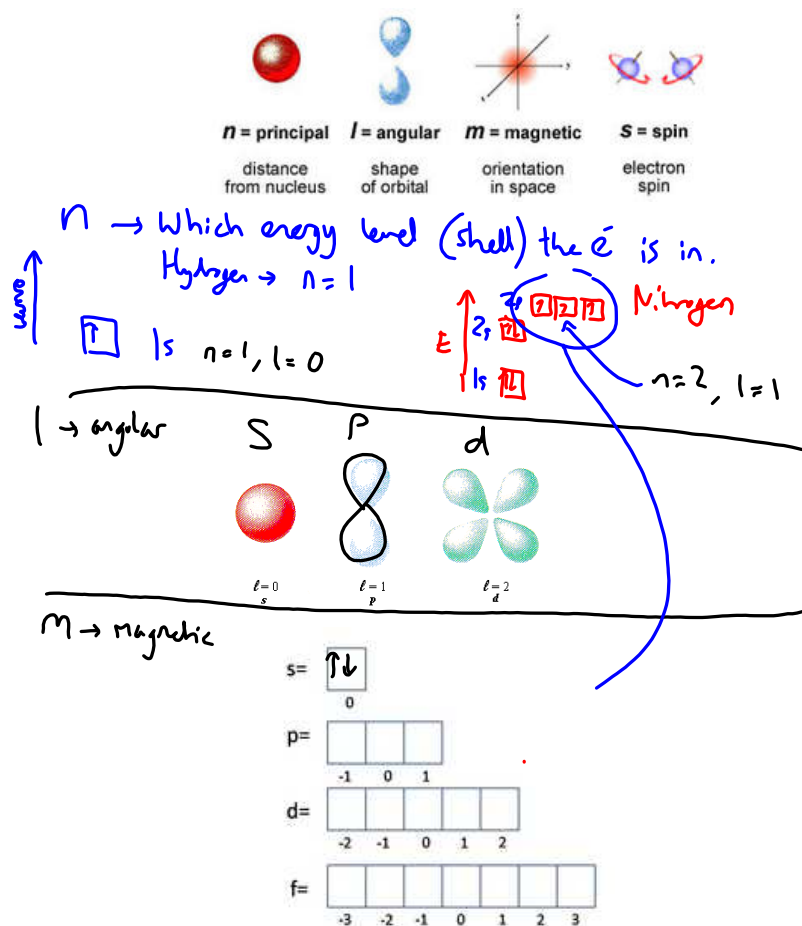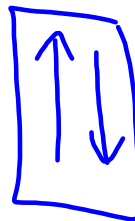
Outer electron in Li?

13

Quantum numbers

n = principal

The energy level (shell) that the e^- is in.

$2s \rightarrow n = 2$

$4d \rightarrow n = 4$

---

l = angular

The shape of the orbital

| s | p | d | f |
| $l=0$ | $l=1$ | $l=2$ | $l=3$ |

M = magnetic

$s \rightarrow$ ☐
 0

$p \rightarrow$ ☐☐☐
 -1 0 1

$d \rightarrow$ ☐☐☐☐☐
 -2 -1 0 1 2

$S \rightarrow$ spin

$+\dfrac{1}{2}$ or $-\dfrac{1}{2}$

Quantum numbers

n = principal
The main energy level (shell) where the e⁻ is.

2s   n = 2
4p   n = 4
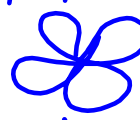1s   n = 1

l = angular
Describes the shape of the orbital

s   p   d   f
l = 0   l = 1   l = 2   l = 3

M = Magnetic

s   ☐
      0

p   ☐☐☐
     -1 0 1

d   ☐☐☐☐☐
    -2 -1 0 1 2

f   ☐☐☐☐☐☐☐
    -3 -2 -1 0 1 2 3

S = spin

$+\frac{1}{2}$ or $-\frac{1}{2}$

⬆⬇

M = 0   M = 0
S = $+\frac{1}{2}$ S = $-\frac{1}{2}$

2, 0, 0, $+\frac{1}{2}$