- Structure of the atom
  - The Bohr model proposed the existence of atomic energy levels.
  - The plum pudding model had electrons in the atom with the protons as they were neutral they were used to prove the existence of electrons.
  - In the Geiger-Marsden used high-energy alpha particles which were shot at a a thin film of gold (a few atoms thick), and it was seen that a few were repelled.
    - Alpha particles (α) are ^4_2He with no electrons.
    - Since electrons are 7000 times less massive than α particles they won't be able to scatter the protons.
    - Since protons emit a positive electromagnetic field which is uniform the alpha particles won't be affected because of the protons as the large amount of protons will almost cancel out the others electromagnetic force.
    - In the experiment it was seen that $\frac{1}{8000}$ alpha particles where shot back. The only possible way for this to occur was by having a single point where most of the mass of the atom was concentrated (the nucleus).
  - Taking this into considerations, the new atom model was:
    - Mass of atom is concentrated in the nucleus, which is positively charged, and is surrounded by negatively charged particles
    - The size of the nucleus is $10^{-4} - 10^{-5}$ times smaller than the atom (depending on the atom).
  - Using the Rutherford scattering simulation it can be observed that the (larger the alpha particles kinetic energy, the smaller the deflection angle (all other variables constant).
    - Furthermore, the greater the E_p, the closer the particle will be able to reach the atom.
  - Unless the alpha particle penetrates the nucleus, the closest approach distances must be at least the sum of the alpha particle & nucleuses radii.
    - This set an upper limit (ware) for how large the nucleus could be, 10^{-14} m, $1 \cdot 10^4$ times smaller than the atom.
  - With the volume being proportional to the cube of the radius, an atom is mostly empty space with the nucleus occupying less than 10^{-12} of the volume of an atom.
- The structures of matter
  - Bond chambers allow for the observation of the particle tracks.
  - It was predicted that there where a set of elementary particles where a combination of them would make up a certain class of particle called hadrons.
    - Quarks make up hadrons.
    - There are 6 different types of quarks
      - up : $\frac{2}{3}e$
      - down : $-\frac{1}{3}e$
      - top : $\frac{2}{3}e$
      - Bottom : $-\frac{1}{3}e$
      - strange : $-\frac{1}{3}e$, | strangeness
      - Charm : $\frac{2}{3}e$
  - In the quark model, the proton is composed out of a two up quarks and a down quarks.
    - This gives the proton a charge of $+e$.
  - The neutron is made of an up quarks and two down quarks.
    - This gives the neutron a charge of 0.
  - With the exception of a positron all anti-particles are written with a line over them
    - Antiproton : $\bar{p}$, antineutron : $\bar{n}$, antiup : $\bar{u}$.
  - The antiproton is made of two anti up quarks, and an anti-down quark giving it a charge of $-e$.
    - $\bar{u}\bar{u}\bar{d}$.
  - The antiparticles is: A particle matter the same mass, and size, but opposite spin & charge
    - They also have the opposite quantum numbers.
  - A particles and its antiparticle will annihilate of they collide with one another. known as pair annihilation
    - This process will release gamma radiation / photons (just packets of energy).
    - The energy will be equal to the energy equivalent of their masses. ($E=mc^2$)
  - Pair production is when a photon interacts with the nucleus of an atoms, and generates a particles and its anti-particle.