3. Atomic Physics

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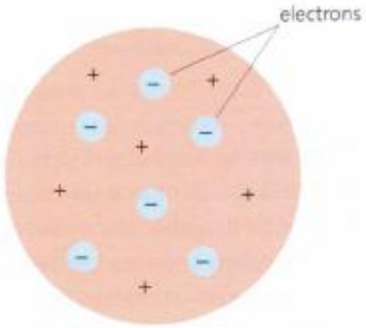
a) Early Models of the Atom

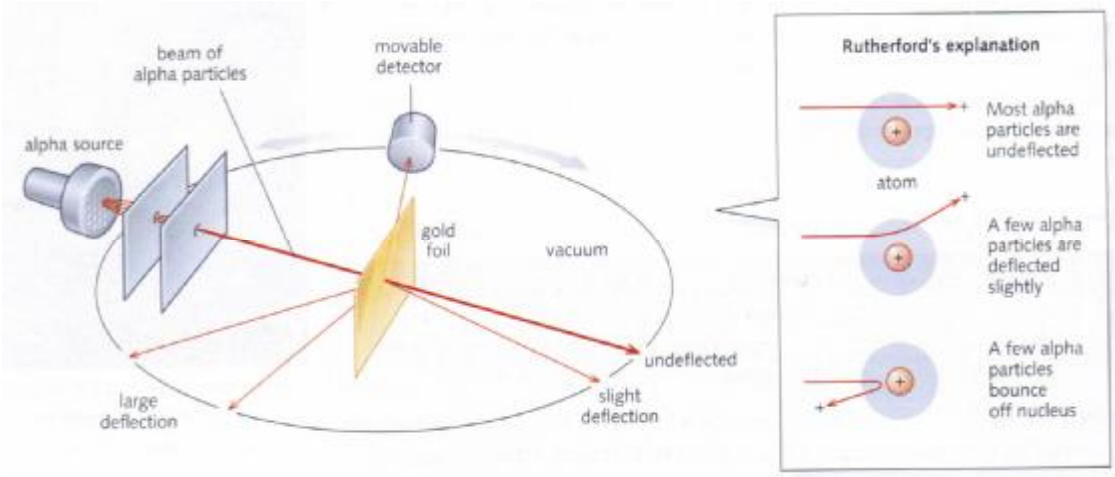
Thomson's 'plum pudding' model

The **electron** was the first atomic particle to be discovered. It was identified by J. J. Thomson in 1897. The electron has a negative (-) electric charge, so an atom with electrons in it must also contain positive (+) charge to make it electrically neutral. Thomson suggested that an atom might be a sphere of positive charge with electrons dotted about inside it rather like raisins in a pudding. This became knows as the 'plum pudding' model.

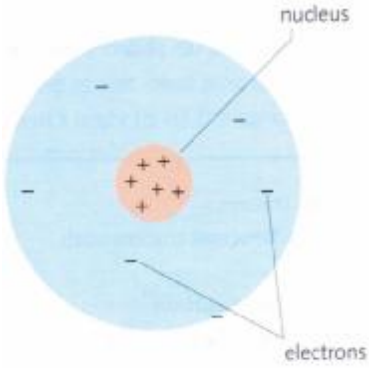


Thomson's 'plum pudding' model of the atom

Rutherford's nuclear model



The above experiment was carried out in 1911 by Geiger and Marsden under the supervision of Ernest Rutherford. It produced results which could not be explained by the plum pudding model. Thin gold foil was bombarded with alpha particles, which are positively charged. Most passed straight through the gold atoms, but a few were repelled so strongly that they bounced back or were deflected through large angles. Rutherford concluded that the atom must be largely empty space, with its positive charge and most of its mass concentrated in a tiny **nucleus** at the centre. In his model, the much lighter electrons orbited the nucleus rather like the planets around the Sun.



Rutherford's model of the atom: electrons orbit a central nucleus. (If the nucleus were correctly drawn to scale, it would be too small to see.)

Discovering particles in the nucleus

Rutherford's model said nothing about what was inside the nucleus. However, in 1919, Rutherford bombarded nitrogen gas with fast alpha particles and found that positively charged particles were being knocked out. These were **protons**. In 1932, James Chadwick discovered that the nucleus also contained uncharged particles with a similar mass to protons. He called these **neutrons**.

Elements and atomic number

All materials are made from about 100 basic substances called **elements**. An atom is the smallest 'piece' of an element you can have. Each element has a different number of protons in its atoms: it has a different **atomic number** (sometimes called the **proton number**). There are some examples on the left. The atomic number also tells you the number of electrons in the atom.

Isotopes and mass number

The atoms of any one element are not all exactly alike. Some may have more neutrons than others. These different versions of the element are called **isotopes**. They have identical chemical properties, although their atoms have different masses. Most elements are a mixture of two or more isotopes.

The total number of protons and neutrons in the nucleus is called the **mass number** (or **nucleon number**). Isotopes have the *same* atomic number but *different* mass numbers

Questions (6 points) – work in pairs

1 An atoms contains *electrons*, *protons*, and *neutrons*.
Which of these particles
a) are outside the nucleus **b)** are uncharged
c) have a negative charge **d)** are nucleons
e) are much lighter than the others?

2 An aluminium atom has an atomic number of 13 and a mass number of 27. How many
a) protons **b)** electrons **c)** neutrons does it have?

1 What is the difference between Rutherford's model of the atom and Thomson's 'plum pudding' model?

3 On the right, a beam of alpha particles is being directed at a thin piece of gold foil. How does the Rutherford model of the atom explain why
a) most of the alpha particles go straight through the foil
b) some alpha particles are deflected at large angles?

4 Why do the results of the experiment on the right suggest that the nucleus has a positive charge?