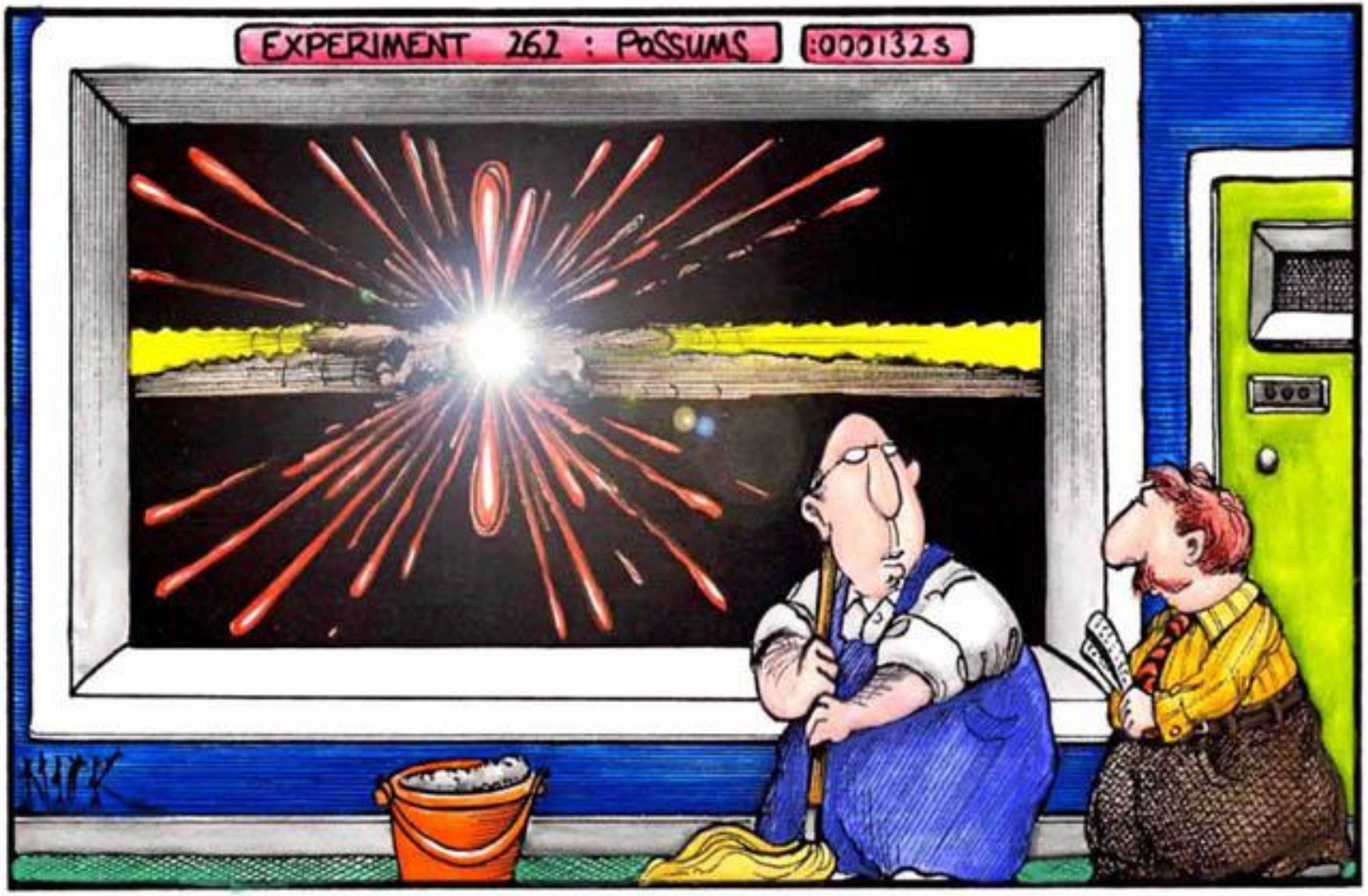
Atomic Structure



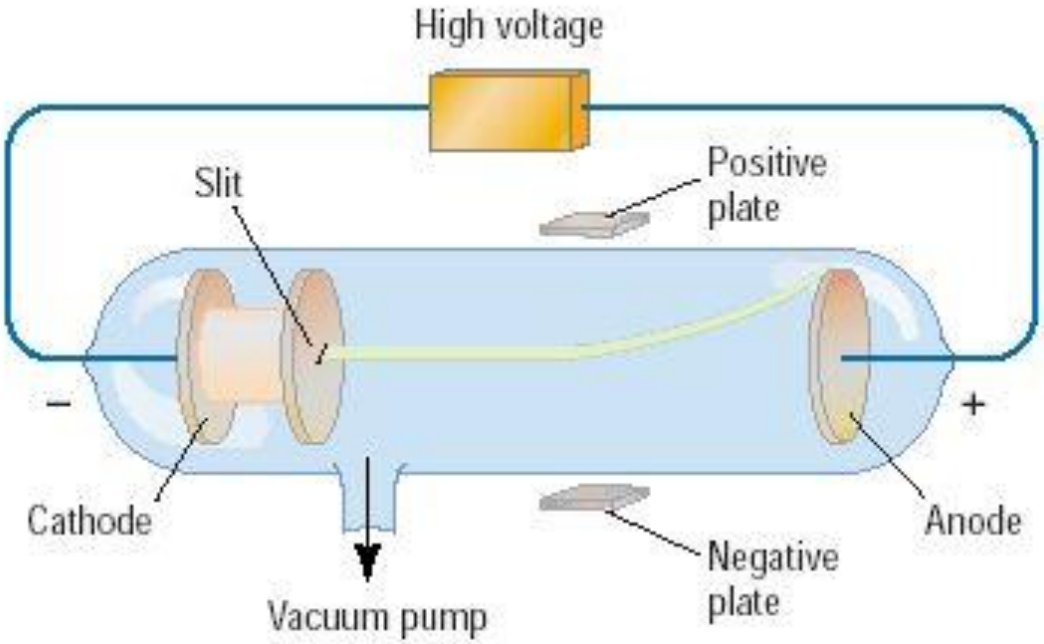
"Sure been a heap more work for ME around here since those Biologists got granted research time on the ol' Supercollider..."

Modern Atomic Theory

- All matter is composed of atoms
- Atoms cannot be subdivided, created, or destroyed in <u>ordinary chemical reactions</u>. However, these changes CAN occur in nuclear reactions!
- Atoms of an element have a characteristic average mass which is unique to that element.
- Atoms of any one element differ in properties from atoms of another element

Discovery of the Electron

In 1897, J.J. Thomson used a cathode ray tube to deduce the presence of a negatively charged particle.



Cathode ray tubes pass electricity through a gas that is contained at a very low pressure.

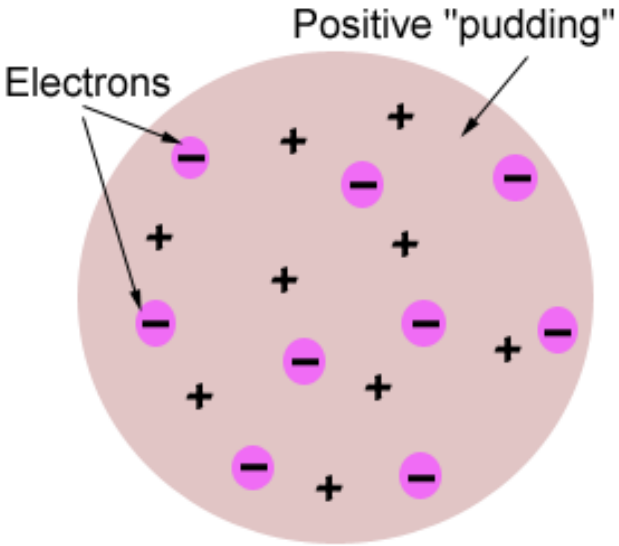
Conclusions from the Study of the Electron

- Cathode rays have identical properties regardless of the element used to produce them. All elements must contain identically charged electrons.

- Atoms are neutral, so there must be positive particles in the atom to balance the negative charge of the electrons

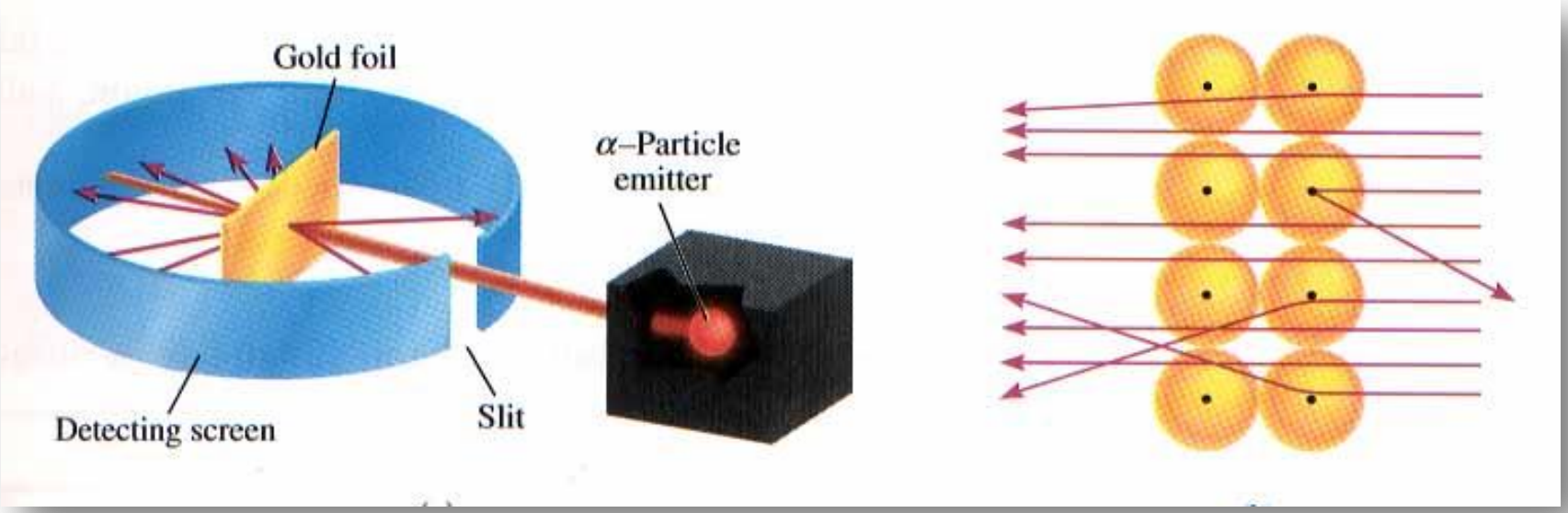
- Electrons have so little mass that atoms must contain other particles that account for most of the mass

Thomson's Atomic Model



Thomson believed that the electrons were like plums embedded in a positively charged "pudding," thus it was called the "plum pudding" model.

Rutherford's Gold Foil Experiment



- Alpha (α) particles are helium nuclei
- Particles were fired at a thin sheet of gold foil
- Particle hits on the detecting screen (film) are recorded

Rutherford's Findings

- Most of the particles passed right through
- A few particles were deflected
- VERY FEW were greatly deflected

"Like howitzer shells bouncing off of tissue paper!"

Conclusions:

- The nucleus is small
- The nucleus is dense
- The nucleus is positively charged

Atomic Particles

Particle	Charge	Mass #	Location
Electron	-1	0	Electron cloud
Proton	+1	1	Nucleus
Neutron	0	1	Nucleus

Atomic Number

Atomic number (Z) of an element is the number of protons in the nucleus of each atom of that element.

Element	# of protons	Atomic # (Z)
Carbon	6	6
Phosphorus	15	15
Gold	79	79

Mass Number

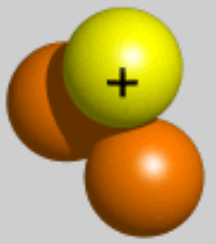
Mass number is the number of protons and neutrons in the nucleus of an isotope.

$$\text{Mass \#} = p^+ + n^0$$

Nuclide	p^+	n^0	e^-	Mass #
Oxygen - 18	8	10	8	18
Arsenic - 75	33	42	33	75
Phosphorus - 31	15	16	15	31

Isotopes

Isotopes are atoms of the same element having different masses due to varying numbers of neutrons.

Isotope	Protons	Electrons	Neutrons	Nucleus
Hydrogen-1 (protium)	1	1	0	
Hydrogen-2 (deuterium)	1	1	1	
Hydrogen-3 (tritium)	1	1	2	

Atomic Masses

Atomic mass is the average of all the naturally occurring isotopes of that element.

Isotope	Symbol	Composition of the nucleus	% in nature
Carbon-12	^{12}C	6 protons 6 neutrons	98.89%
Carbon-13	^{13}C	6 protons 7 neutrons	1.11%
Carbon-14	^{14}C	6 protons 8 neutrons	<0.01%

Carbon = 12.011