

# Particles

## 1 Constituents of the atom

**Specific charge** - The charge to mass ratio

**Isotope** - An atom with the same number of protons as an element but a different number of neutrons

## 2 Stable and unstable nuclei

### 2.1 The strong nuclear force

$0fm - 0.5fm$  - **Repulsion**

$0.5fm - 3fm$  - **Attraction**

$3fm+$  - **No force**

### 2.2 Alpha decay

An atom emits an alpha particle (Helium Nucleus/2 protons and 2 neutrons)

Reduces *Mass Number* by **4** and *proton number* by **2**

### 2.3 Beta decay

Neutron  $\rightarrow$  Proton + Electron + Neutrino

The neutrino was hypothesised to conserve energy

## 3 Particles, antiparticles and photons

For every particle there is a corresponding antiparticle (can be itself)

Property	Particle	Antiparticle
Mass	x	x
Charge	x	-x
Rest Energy	x	x
Baryon Number	x	-x
Lepton Number	x	-x
Strangeness	x	-x

When a particle and antiparticle collide they annihilate each other

A particle-antiparticle pair can be produced from energy

## 4 Particle interactions

Fundamental interactions:

Force	Affects	Gauge Boson	Range
Gravitational	Mass	Graviton	Infinite
Electromagnetic	Charge	Photon	Infinite
Nuclear Strong	Quarks	Gluon(Pion)	$10^{-15}\text{m}$
Nuclear Weak	Leptons+Quarks	$W^+, W^-, Z^0$	$10^{-18}\text{m}$

The exchange particles provide the forces between elementary particles  
Virtual photons are the exchange particle of the electromagnetic force  
Examples of the weak interaction:

- $\beta^+$  Decay
- $\beta^-$  Decay
- Electron capture
- Electron-proton collisions

## 5 Classification of particles

### 5.1 Hadrons

Hadrons are subject to the strong interaction  
There are two types of hadrons:

- Baryon(3 Quarks)
- Meson (Quark-Antiquark pair)

The baryon number is conserved in an interaction  
All baryons will eventually decay into protons  
Kaons can decay into pions

### 5.2 Leptons

Types of lepton(All have a lepton number of 1):

- Electron
- Muon
- Electron Neutrino (Approximated to massless)
- Muon Neutrino (Approximated to massless)

Lepton number is conserved during an interaction  
Muons decay into electrons

### 5.3 Strange particles

Produced through the strong interaction  
Decay through the weak interaction

## 6 Quarks and antiquarks

### 6.1 Baryons

Proton	UUD
Neutron	DUD

### 6.2 Mesons

#### 6.2.1 Pions(All 0 Strangeness)

$\pi^0$	$U\bar{U}$ or $D\bar{D}$
$\pi^+$	$U\bar{D}$
$\pi^-$	$D\bar{U}$

#### 6.2.2 Kaons (All strange)

$K^+$	$U\bar{S}$
$K^-$	$\bar{U}S$
$K^0$	$D\bar{S}$
$\bar{K}^0$	$\bar{D}S$