### 1. Atomic Structure

- **N**: Symbol of the element
  - **S**: Symbol of the element
  - **N**: Nucleon Number is the number of nucleons (protons plus neutrons).
  - **P**: Proton Number is the number of protons

- An atom has the same number of protons as electrons (otherwise it would be an ion)

- If an atom has 3 protons how many electrons are there? (3)

### 2. Isotopes

- An isotope of an element has a different number of neutrons.
  - As it is the same element the proton number is the same
  - e.g. Carbon 14 has 6 protons (because its carbon) and so it must have 8 neutrons and Carbon 12 has 6 protons and so it must have 6 neutrons.

### 3. Alpha

- Alpha particles are made of 2 protons and 2 neutrons that are given out during radioactive decay. (Helium nucleus).
- This causes the parent atom to go through radioactive decay, giving out radioactive substances. One of which are alpha particles.
  - i.e. $^{237}_{92}$Np $\rightarrow ^{233}_{90}$Pa $+ ^{4}_{2}$α
  - Least penetrating: can be stopped by 3cm of air or paper
  - Most ionizing (due to the presence of protons)
  - Can damage the inside of the body once consumed.

- What is an alpha particle? *(a positively charged helium ion or nucleus)*
- How do you write an alpha particle in an equation $(^{2}_{2}$α)*

### 4. Beta

- Beta particles are composed of electrons that are given out by radioactive decay.
  - A neutron in the parent atom decays to become a proton and an electron.
  - The electron cannot remain in the nucleus and is expelled.
  - This causes the parent atom to change element (atomic number goes up 1) although the nucleon number stays the same
  - $^{233}_{92}$Pa $\rightarrow ^{233}_{91}$U $+ ^{0}_{-1}$β
  - penetration: stopped by 8m of air or thin Aluminium
  - Ionizing (due to -1 charge)

- What is a beta particle? *(high energy electron)*
- How do you write a beta particle in an equation? $(^{0}_{-1}$β)*
- What changes inside the atom when a beta particle is released? *(a neutron becomes a proton + an electron)*

### 5. Gamma

- Type of radioactive decay emitted from radioactive nuclei.
- In the form of an electromagnetic wave with short wave length and high frequency (no mass, no charge).
  - No effect on mass number or atomic number, but makes the nucleus more stable.
  - Most penetrating ability as the rays are not easily absorbed due to its speed (light speed) and is very unlikely to collide with another atom.
  - The radiation is reduced by a few cm of lead or 30ft of concrete.

- What is the charge on a gamma ray? *(0)*
- Does a gamma ray have more mass than an alpha particle? *(no)*

### 6. Detecting Radiation

- Radioactivity is invisible, has no smell, makes no sound - in fact it cannot be detected by any of our senses.
  - A Geiger counter is used to detect and measure radiation.
  - Photographic paper can also be used as it turns darker (fogs) in the presence of radiation.

- What does radioactivity do to photographic film? *(fog it)*
- What does a Geiger-Muller tube detect? *(radiation)*
### 7. Background Radiation
- Background radiation is the radiation being constantly emitted from the surroundings.
- It will vary depending on your environment.
- In radioactivity experiments the experiment is shielded the background count is subtracted from the results.
- Examples: soil, radioactive waste, cosmic rays from space, rocks, air, medical X-Rays.
- Radon gas is a large source of background radiation (e.g. in Cornwall).

**Why are houses well ventilated in Cornwall? (to disperse the radon gas)**

**When performing a radioactivity experiment what must you do to your measurements? (subtract the background radiation)**

### 8. Activity
- Activity is the number of radioactive counts per second.
- Units: Becquerels (Bq) = Counts per second

### 9. Half Life
- Half life is the amount of time a radioactive material takes to lose half its radioactivity.
- It can be measured using the activity (Becquerel) or percentage of atoms remaining.
- For example, if caesium-137 has a half life of 30 years, this means that in 30 years its radioactivity has dropped by half in 30 years, a quarter by 60 years, an eighth in 90 years etc.

**100g of a radioactive substance has a half-life of 2 hours. How much of the substance will remain after 6 hours have passed? (12.5g)**

### 10. Uses of Radioactivity
- Some devices use radioactivity to function
  - A smoke detector uses alpha radiation.
  - Beta radiation is used in a paper thickness machine.
  - Gamma rays can kill bacteria, so they are used to sterilize medical equipment and food.
- Tracers
  - Radioactivity can also be used to identify leaks in underground water pipes.
  - Beta sources with short half lives are used to examine the inside of human bodies.

**Name and describe a device that uses radioactivity? (above)**

### 11. Dangers of Radioactivity
- Affects in different ways depending on dosage.
- Large doses - skin burns, radiation sickness
- Very large doses - can cause changes in DNA it may kill the cell or affect the way it multiplies - mutations and cancer
- Genetic mutations - if reproductive cells are damaged, there can be mutations in children

**How does radiation cause cancer? (damages the DNA of cells)**

**Which type of radiation is worse if it is inside our body? (Alpha)**

### 12. Rutherford’s Experiment (H)
- Alpha particles were fired at a gold foil in a vacuum.
- Most went straight through or were deflected through small angles.
- Thus, an atom was mostly empty space.
- Some were deflected through large angles or were reflected back.
- He concluded that there was a small nucleus with all the mass
- As alpha particles are positive, he concluded that the nucleus is also positively charged.

**Why did he conclude that the atom was mostly space (because most alpha particles went straight through)**
### 13. Fission of U235 (H)
- The nucleus of U-235 can be split by collision with a neutron (Nuclear fission)
- Stages of a chain reaction:
  - A nucleus absorbs a neutron
  - The nucleus splits into 2 daughter nuclei releasing neutrons
  - The nuclei split, all releasing neutrons
  - More neutrons are released than are absorbed
- You are not expected to learn the equation but you are expected to complete one:
  - $^{235}_{92}U + ^1_{0}n \rightarrow ^{236}_{92}U$
  - $^{236}_{92}U \rightarrow ^{141}_{56}Ba + ^{96}_{36}Kr + ^1_{0}n + ^1_{0}n + ^1_{0}n$

- What are the stages of a chain reaction?
- What is the definition of nuclear fission?

### 14. Nuclear Power (H)
- Nuclear power is formed through fission (Splitting of a nucleus) and fusion (Joining of two nuclei).
- A chain reaction is uncontrolled so:
  - Control rods are used to absorb some of the neutrons so the rate of fission can be constantly altered to provide constant heat to generate electricity.
  - Moderator slows down the neutrons to increase the chance of a neutron being absorbed by a nucleus each collision.

- What is the use of a moderator?
- What do control rods do?

### 1. Graph Drawing
- Use the SLAP method
  - Scale: multiples of 1, 2 or 5
  - Line of best fit: unless it is a motion/time graph
  - Axis: units and labels
  - Points: x not blobs
- Note:
  - more than half the graph paper should be used
  - Lines of best fit can be curved or straight
  - No line should be thicker than 1mm

- When should you use a bar graph in physics? *(never unless specifically told to)*
- When should you not use a line of best fit? *(on a velocity time or distance time graph)*

### 2. Graph Questions
- If it says use the graph you either have to:
  - work out the area under it
    (v/t graph it is the d, l/t graph it is Q ...)
  - work out the gradient
    (x/t graph it is v, v/t graph it is a ...)
- If it says calculate it normally involves taking readings and using a formula
- Show what you are doing on the graph, draw lines, write the numbers in the squares ...

### 3. Multipliers
- Always convert to base units
- Except for kg
  - $m = milli = /1000$ (e.g. mW)
  - $k = kilo = x 1000$ (e.g. kBq)
  - $M = mega = x1000000$ (e.g. MHz)
- minutes to seconds ($x60$)
- hours to seconds ($x3600$)

- Convert 0.5 hours ($1800s$)
- Convert 11.5 mW (0.0115W)
- Convert 13.2 kg (13.2 kg)
- Convert 0.87 MPa (870000 Pa)

### 4. Calculations
Follow the 5 Step Method:
1. Write down the variables in the question
2. Write down the equation
3. Substitute into the equation
4. Show your working
5. Add the unit