Task On Entry

1) What is meant by atomic number?

2) What is a neutron?

3) What is a proton?

4) What is meant by alpha decay?

5) What is meant by beta decay?

6) What is an isotope?

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Particle Accelerators

2 March 2024

7Cs: Collaboration, Communication & Critical thinking

Learning Objective:

Understand the working and aim of particle accelerators

Success Criteria:

- ❑ I can Explain that electrons are released in thermionic emission.
- ❑ I can describe how electrons can be accelerated by electric and magnetic fields.
- ❑ I can explain why high energies are required to investigate the structure of nucleons.

Keywords:

Thermionic emissions, High energy particles, Photoelectric effect, De Broglie wavelength

Skills developed by learning activities:

A01/A02 – Development of understanding of the particle accelerators and apply the knowledge to the context of exam questions.

A03 – Interpret scientific ideas and information to think, pair and share

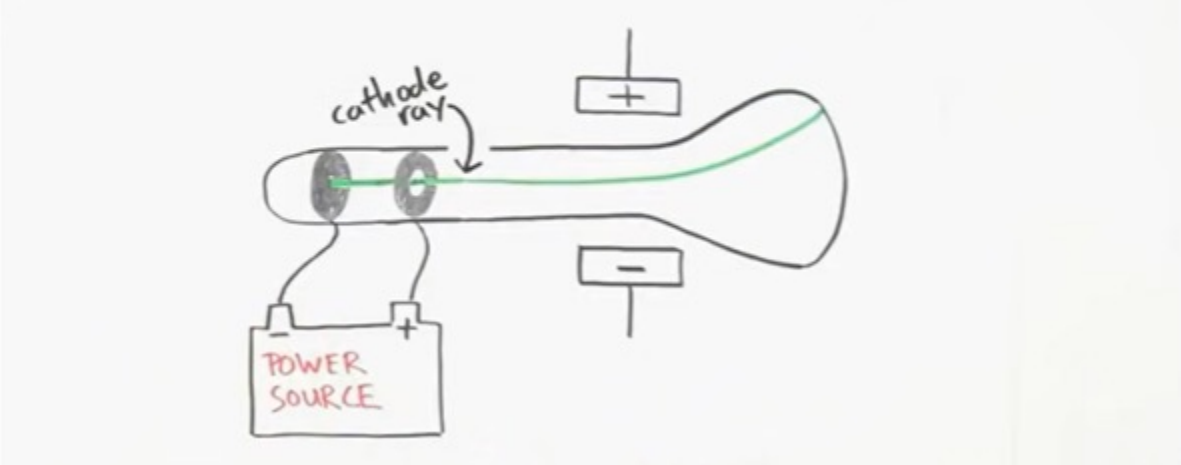
Specification

114	understand the role of electric and magnetic fields in particle accelerators (linac and cyclotron) and detectors (general principles of ionisation and deflection only)
115	be able to derive and use the equation $r = \frac{p}{BQ}$ for a charged particle in a magnetic field

New learning

The Very first Particle Accelerator

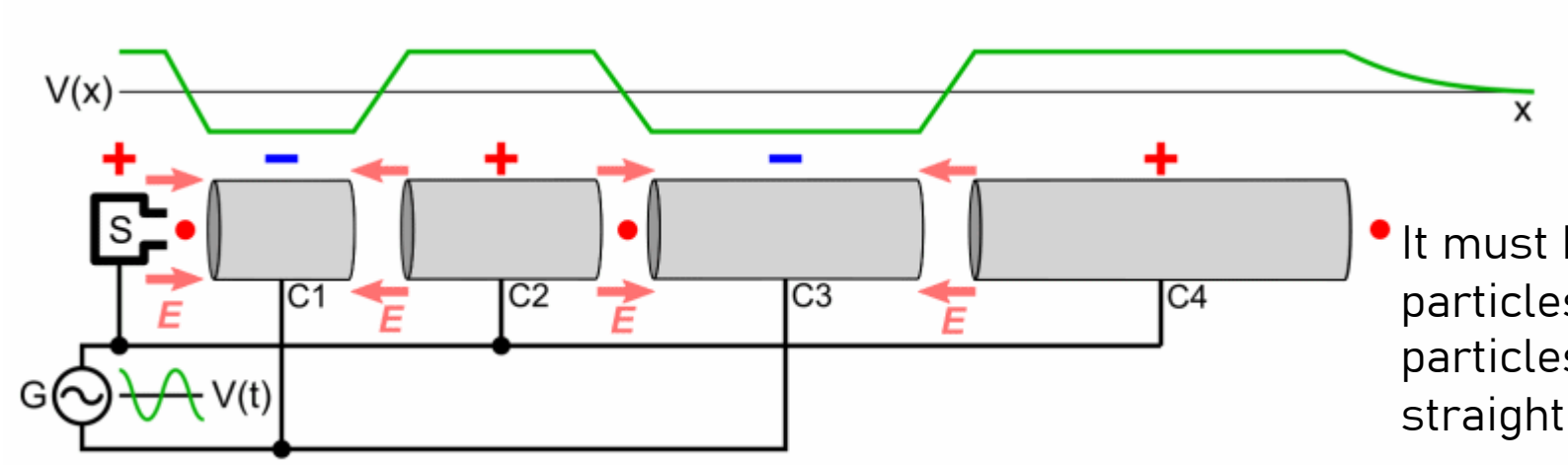
Cathode Ray Experiment – J.J. Thompson



THERMIONIC EMISSIONS !!!

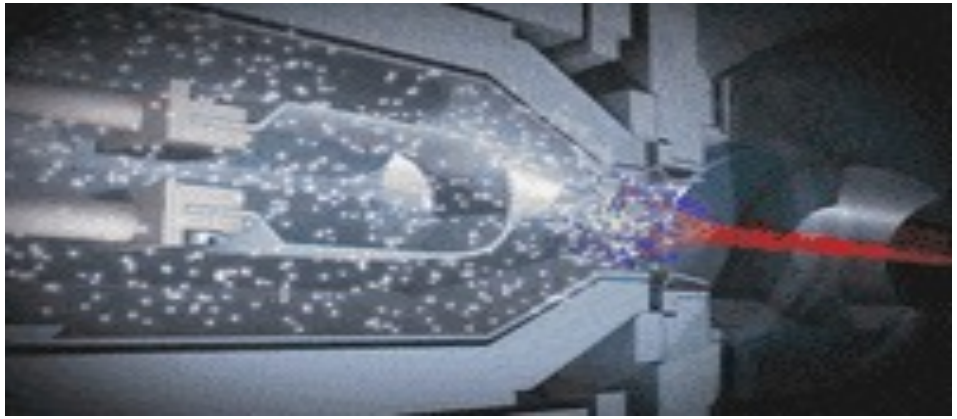
LINEAR ACCELERATOR (LINAC)

They use ac electric field



- It must be in a vacuum so that the particles do not collide with air particles and it must be perfectly straight.

As the electron gets faster, the tubes get longer so the time to pass a tube is constant.

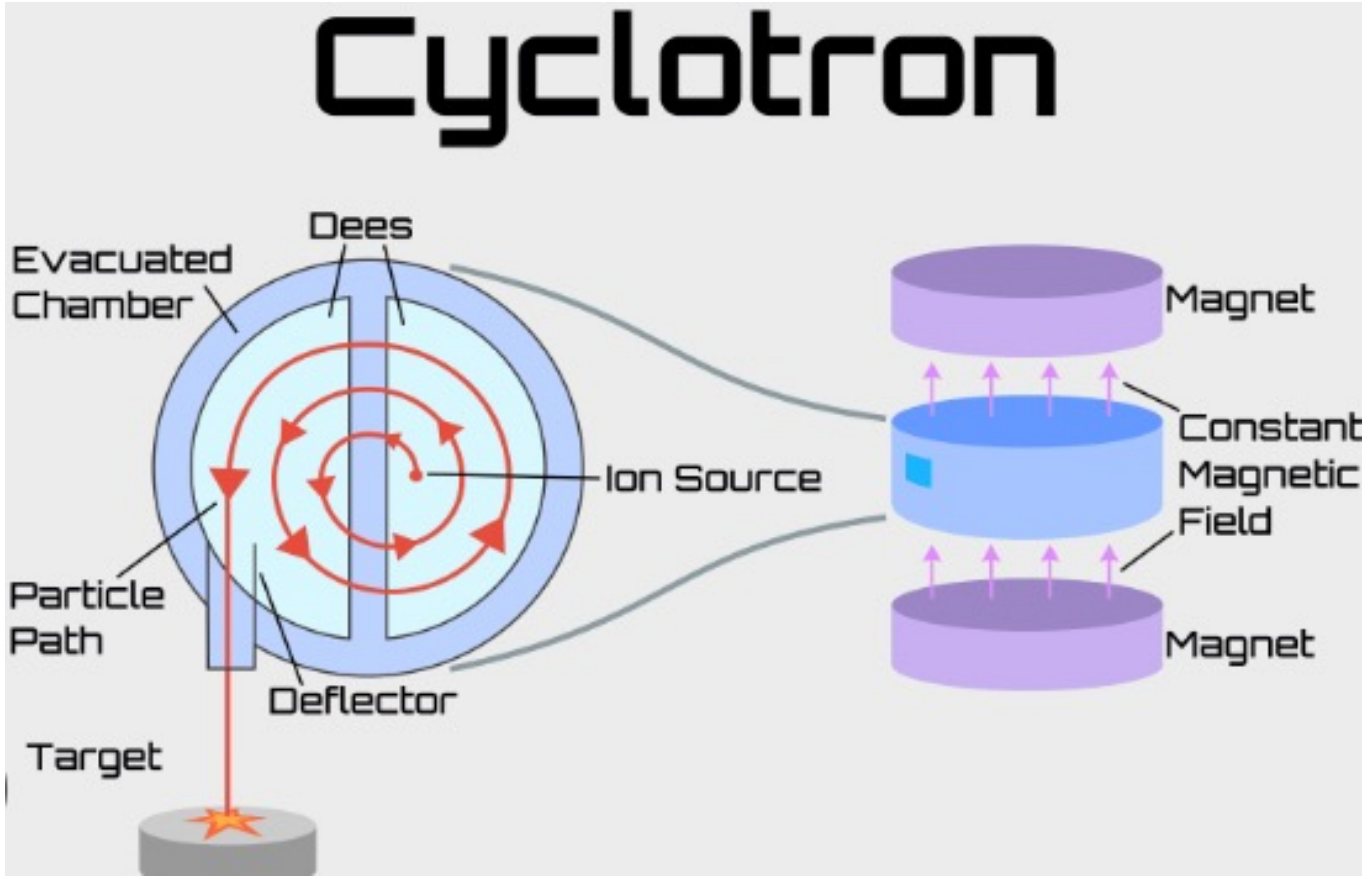


> Electrons can be accelerated to an energy of 50 GeV

> Expensive

A cyclotron is a circular accelerator that accelerates charged particles on a spiral path.

It can give protons about 1MeV of energy.



$$\omega_{cyclotron} = \frac{qB}{m}$$

$$T = \frac{2\pi r}{v} = \frac{2\pi mv}{qBv} = \frac{2\pi m}{qB}$$

THINK-PAIR-SHARE

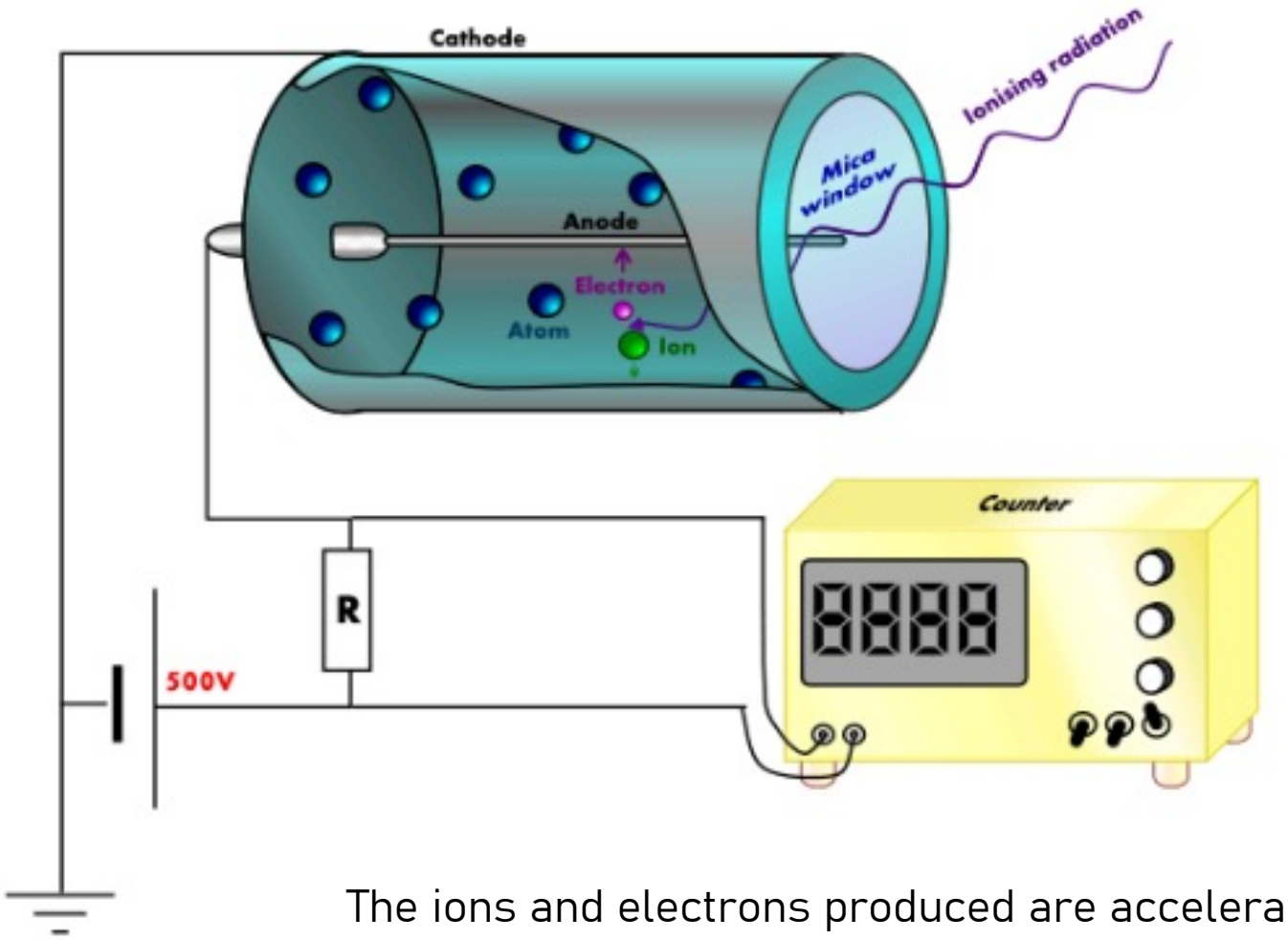
$$F = Bqv$$

$$F = mv^2 / r$$

Derive..... $$r = mv / Bq$$

$$= p / Bq$$

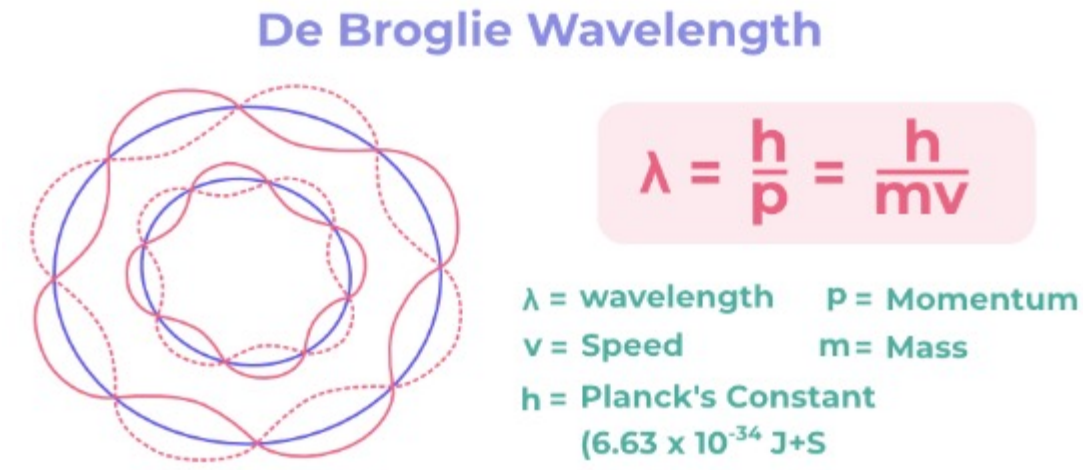
Geiger Muller tube / counter



The ions and electrons produced are accelerated by an electric field between electrodes in the tube and then discharge when they reach the electrodes, which produces a pulse of electricity which is counted by a counter.

Why are high energies are required to investigate the structure of nucleons?

1. Allow forces between particles to be overcome
2. Ensure particles have a very high momentum
3. Ensure particles have a very small de Broglie wavelength



The Physics behind Particle Accelerators

Voltage gives free e- a push - charges gain lose PE and gain KE:

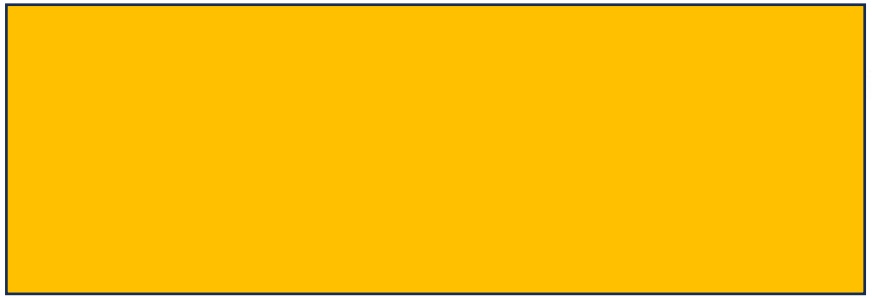
$$\Delta PE = KE$$

$$qV = 1/2\ mv^2.$$

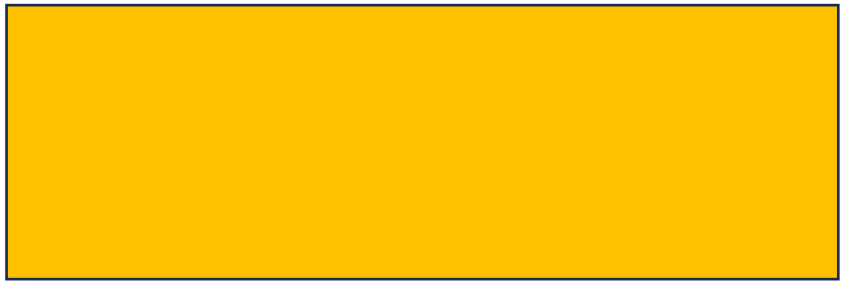
Expected Questions

Define electronvolt.

1.



2.



The final speed of the particle can be found using:

$$v = \sqrt{\frac{2QV}{m}}$$

Define electronvolt.

1 eV = the kinetic energy carried by an electron after it has been increased through a PD of 1 volt.

Progress check-

2. What is the equivalent of 1 meV?

A 1.1×10^{3} u

B 1.1×10^{-3} u

C 1.1×10^{-12} u

D 1.1×10^{-16} u

C

WORKSHEET

What does the equation $E = mc^2$ suggest?

A The mass of a substance is increased when it is heated. ⬭

B The mass of a nucleus is greater than the mass of its constituent parts. ⬭

C The total mass of a nucleus is converted into kinetic energy when the nucleus decays. ⬭

D Energy is required to initiate proton–antiproton annihilation. ⬭

Plenary : Where am I?

Stanine 2-3 (WT)	Stanine 4-5 (WA)	Stanine 6-7 (WAB)	What's your score??
❑ I can Explain that electrons are released in thermionic emission.	❑ I can describe how electrons can be accelerated by electric and magnetic	❑ I can explain why high energies are required to investigate the structure of nucleons.	

2 ★s and a ✦

1) **Stars** - ask students to write down 2 things that their peer has done well

2) **Wish**- ask students to write down one thing that they could do to improve the piece of work further

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Where am I going next?
How do I get there via the one-way system?