

(a) i) alpha decay in a Wilson cloud chamber shows traces of the path they take as with beta decay. The paths differ from one another as alpha ~~traces~~ <sup>traces</sup>.

ii)  $^{218}_{84}\text{Po} \rightarrow ^{214}_{82}\text{Pb} + ^4_2\text{He}$

$= 218.00897 \rightarrow 213.99981 \quad 4.00260$

~~Answer~~  $E = mc^2$

$$E = (4.00260 \times 3.0 \times 10^8)^2$$

$$1.4418 \dots \times 10^{18}$$

$$\downarrow$$

$$1.4 \times 10^{18} \text{ J (2 sig fig)}$$

(b) i)  $0.2 \text{ nm} \rightarrow 2^{-9}$   
 $\downarrow \lambda$

~~De Broglie~~  $2^{-9}$   
 $1.675 \times 10^{-27} \times 6.626 \times 10^{-34}$

$$\lambda = \frac{h}{mv}$$

$$= \text{and } 1.8 \times 10^{57} \text{ m/s.}$$

$$\frac{h}{\lambda} = mv$$

$$\frac{h}{m\lambda} = v$$

ii) Beam of neutrons are used as a probe to determine structure due to their neutral charge, allowing it to penetrate the atom ~~with~~ structure without being affected by fields. Also its size allows for it to be small enough to enter a structure but large enough to be monitored. Its wavelength and speed allows for it to go into the nucleus of an atom which likewise makes it useful for determining structure.

(c) The spectroscopy allowed for different electron levels to be proposed as picked up <sup>by Bohr</sup>. The different levels led Bohr to ~~predicts~~ <sup>hypothesis</sup> that electrons orbited in shells around the nucleus, thus accounting for the stability of the atom from the Rutherford model where electrons ~~where~~ orbits had the shortcoming of potentially gathering velocity. The spectroscopy allowed for a merging of Planck's hypothesis to be merged with the energy shells in attempting to explain the stability of the atom despite electron orbits. The spectroscopy led to the understanding of electron orbits around a nucleus: as stable shells.

If you require more space to answer parts (a), (b) and (c) of the question, you may ask for an extra writing booklet.

If you have used an extra writing booklet for parts (a), (b) and (c) of the question, tick here.

(d) i) Davison and Germer concluded that the interference pattern as deflected meant that electron orbits were actually ~~propagating~~ waves as the interference pattern matched wave / x-ray lengths.  
→ as suggested by de Broglie.

ii) The Davison & Germer experiment was significant to the Bohr / Rutherford model of the atom in verifying Bohr's postulates regarding stable electron shells. The experiment verified de Broglie's hypothesis regarding electron waves and thus gave credibility to the Rutherford-Bohr model. The explanation of electrons as waves accounts for the stability of the atom in not collapsing on itself. Verified Bohr's postulates regarding his model.

(e) Advances in knowledge about particles and forces include:

Wolfgang Pauli's exclusion principle and proposal of the neutrino which hypothesised accounted for the missing energy in beta decay. The discovery of the smaller particles, including different types of quarks and Bosons has led to advances in understanding the composition of the atomic nucleus.

This has been furthered by the advancements in cyclotrons and colliders where particles are accelerated and collided. This collision and aftermaths can give information regarding the structure of atoms, and the atomic nucleus.

Advancements regarding force have included the understanding of the strong nuclear force used to bond the nucleus together. The strong force accounts for the ability of the atomic nucleus to remain together.

Advancements in the understanding of binding energy ~~and mass defect~~ have accounted for the mass defect of an atom.