ATOMIC AND NUCLEAR PHYSICS
ANSWERS

Atoms - The Stuff the Universe is Made of

Atoms - The Stuff the Universe is Made of
STOP AND CHECK (PAGE 6)

- The observations that led to the Thomson model of the atom included noting that atoms have negative electrons inside of them and that, overall, the atom is neutral.
- The Thomson model proposed that atoms were a spherical cloud of positive charge, with electrons embedded non-randomly inside of it. It also posited that if the atoms were blasted with tiny particles, they would mostly just pass through the positively charged cloud, only being deflected slightly.

The Rutherford Model of the Atom
STOP AND CHECK (PAGE 9)

- The first observation that made Rutherford question the Plum-Pudding model was that particles didn't only pass through the gold-foil, but that some of the alpha particles also bounced back, as if hit by an invisible barrier. The new model showed that most of the mass of the atom was concentrated in the centre and was positive, with electrons orbiting this centre. This meant that there would be something for the alpha particles to bounce off of and that they could still be deflected at an angle.
- Experiments needed to be conducted in a vacuum because when alpha particles bump into air molecules, they lose their energy and stop moving, so the air needed to be removed. Zinc sulfide was necessary as it changes colour when in contact with alpha particles (therefore letting you know where they end up), which is what was being measured.
- The key outcomes of the experiment were:

1. Most of the mass of an atom is concentrated in a small, positively charged nucleus.
2. Electrons exist in a cloud orbiting the nucleus.

The Periodic Table and Nuclear Stability

STOP AND CHECK (PAGE 11)

- Carbon:
  - Mass: 14
  - Atomic number: 6
- Radium:
  - Mass: 226
  - Atomic number: 88
- Uranium:
  - Mass: 239
  - Atomic number: 92
- Elements on the periodic table differ from each other in their proton, electron, and neutron numbers.
- If a light element has equal amounts of protons and neutrons, the isotope is likely to be stable. Alternatively, a heavy element needs more neutrons in the nucleus to be stable.

Atoms - The Stuff the Universe is Made of

QUICK QUESTIONS (PAGE 11)

- Most of the alpha particles were not deflected in the gold-foil experiment because they were passing through the empty space of the atom. They were deflected if they got close to the concentration of charges - positive in the middle and negative around the nucleus.
- The particles that were deflected by a large angle hit the nucleus of the atom, so they bounced back.
- A thin tube was pointed towards the foil to guide the alpha particles in the right direction. The experiment was done in a vacuum so that the alpha particles didn't hit or interact with air molecules, as this would have made them lose all their energy and stop moving.
- $^{32}_{15}P$. The number of neutrons is the mass number - the number of protons, so $32-15=17$.

- Because P-32 has more neutrons than protons, it can emit beta particles (radiation) that could help kill cancer cells.

Types of Radiation

Types of Particles

STOP AND CHECK (PAGE 15)

- Alpha particles have an atomic number of 2, beta particles have an atomic number of -1, and gamma rays have an atomic number of 0.
- Alpha particles have a mass number of 4, beta particles have a mass number of 0, and gamma rays have a mass number of 0.
- An alpha particle curves to the right when shot directly ahead in a magnetic field.

Types of Radiation

QUICK QUESTIONS (PAGE 15)

- In the first decay, a gamma ray is released. In the second decay, a beta particle is released. The gamma ray, because it has no charge and no mass, will not be affected by the magnetic field and so will travel straight through the field. On the other hand, a beta particle has a charge, so its direction of travel will be changed by the magnetic field. This means that you can detect which particle is which by whether or not their direction is being changed by the magnetic field.

Nuclear Equations

Nuclear Equations

STOP AND CHECK (PAGE 19)

- The conservation laws used for nuclear reactions are:
    - Conservation of mass numbers - states that the total number of nucleons (the total mass number) is the same before and after a nuclear reaction.
    - Conservation of charge - states that the total charge in an isolated system (the universe) never changes.
- When there is no change in the mass or charge number, it should still be assumed that energy is lost, so gamma radiation is released.
- A neutron can split up to create a proton and a beta particle (an electron).

Fission, Fusion, and the Applications of Nuclear Physics

STOP AND CHECK (PAGE 22)

- Alpha particles are the most dangerous coming from inside of the body.
- Gamma radiation has the best penetration power.
- Radiation is so dangerous to us because when it hits our cells, it can mess up the electron arrangement of the atoms in our cells.

Fission, Fusion, and the Applications of Nuclear Physics

QUICK QUESTIONS (PAGE 23)

- $^{236}_{92}\text{U} \rightarrow\ ^{92}_{36}\text{Kr} +\ ^{141}_{56}\text{Ba} + 3\ ^{1}_{0}\text{n}$
- $^{238}_{92}\text{U} \rightarrow\ ^{238}_{93}\text{Np} +\ ^{0}_{-1}\beta$

	Formula	Charge	Atomic Mass	Penetrating Power
Alpha (α)	${}^{4}_{2}\alpha$ or ${}^{4}_{2}He$	+2	2	Low
Beta (β)	${}^{0}_{-1}\beta$	-1	0	Average
Gamma (γ)	${}^{0}_{0}\gamma$	0	0	High

- $m = A(2^{\frac{-t}{\tau}})$

  $0.00625 = 0.025 \times 2^{\frac{-t}{10}}$

  $\frac{0.00625}{0.025} = 2^{\frac{-t}{10}}$

  $0.25 = 2^{\frac{-t}{10}}$

  $log_2(0.25) = log_2 2^{\frac{-t}{10}}$

  $log_2(0.25) = \frac{-t}{10} \times log_2 2$

  $log_2(0.25) = \frac{-t}{10}$

  $-2 = \frac{-t}{10}$

  $-2 \times 10 = -t$

  $-20 = -t$

  $t = 20\ years$
- In the magnetic field, the alpha particle and the beta particle will move in opposite directions (with the alpha particle curving to the right), which we can figure out using the right hand rule. The gamma ray will continue in a straight line.
- The alpha particle will curve to the left (or the negatively charged side) and the beta particle will curve towards the right (or the positively charged side) due to opposite charges attracting each other. The gamma ray, because it has no charge, will continue straight ahead.

