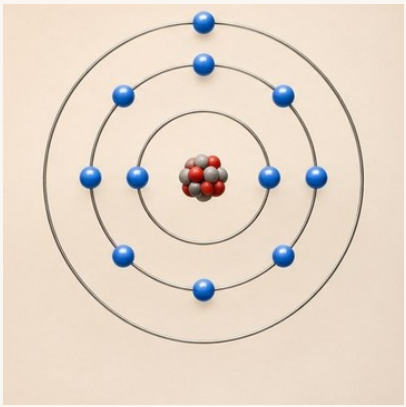
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Inside atoms







In this chapter

01 Atoms have smaller parts

02 Stable energy levels

03 Count a neutral atom

04 Same mass number, different elements

05 Valency is a combining capacity

Inside atoms

Atoms have smaller parts



THE IDEA

An atom is not an indivisible ball. Electrons carry negative charge; protons positive charge; neutrons no net charge. Protons and neutrons have similar masses, much larger than an electron's.

A neutral atom has equal numbers of protons and electrons. Particle colours in models are conventions, not literal colours.

CHECK YOUR THINKING

What balances charge in a neutral atom?

A Equal numbers of electrons and neutrons.

B Equal numbers of protons and electrons.

B. Neutrons do not balance electric charge; their net charge is zero.

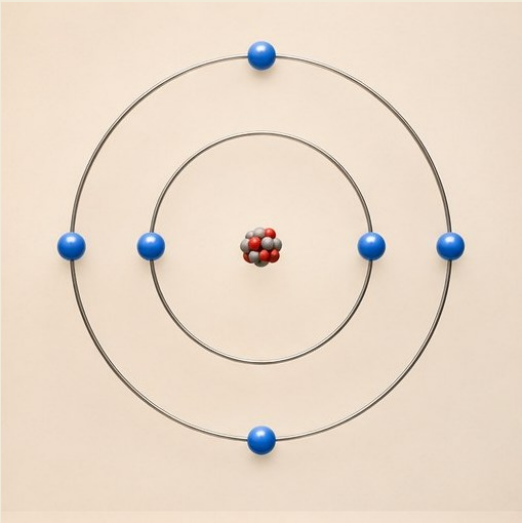
A RELATED EXAMPLE

A model must explain evidence

Thomson pictured electrons in positive matter. The discovery of the electron showed that atoms had internal parts. Thomson's model placed negative electrons within spread-out positive charge. A model can explain some observations and still fail new tests. Scientific explanations change when evidence demands it.

Inside atoms

Stable energy levels



THE IDEA

Bohr restricted the allowed electron energies. Bohr's model places electrons in permitted energy levels or shells. Electrons do not lose energy continuously while in an allowed level.

The shell picture is a useful introductory model, not a literal photograph of tiny planets following drawn wires.

CHECK YOUR THINKING

What is a shell in this model?

A An allowed electron energy level.

B A solid ring holding an electron.

A. The drawn ring represents an energy level rather than a material structure.

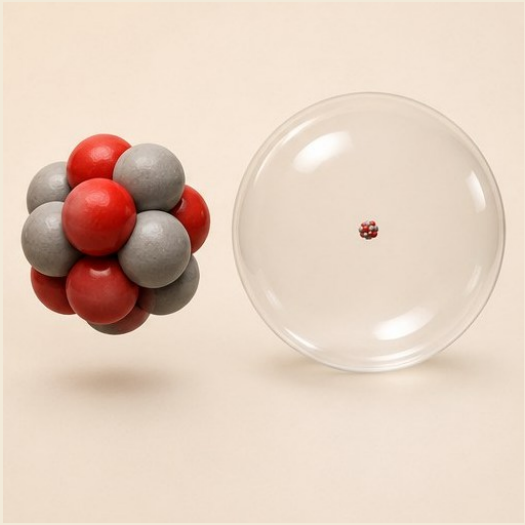
A RELATED EXAMPLE

Most passed; a few turned sharply

Scattering revealed a tiny dense nucleus. Most alpha particles crossed thin gold foil with little deflection. A small fraction turned sharply; very few returned. Rutherford inferred that most atomic volume is empty space, with positive charge and much mass concentrated in a small nucleus.

Inside atoms

Count a neutral atom



THE IDEA

An atom has Z = 11 and A = 23. Protons = 11. Neutrons = 23 − 11 = 12. A neutral atom has 11 electrons.

If it loses one electron, it has charge +1 but still has 11 protons. The nucleus has not changed.

CHECK YOUR THINKING

How many electrons are in the +1 ion?

A 12.

B 10.

B. Losing one negative electron leaves one excess positive charge.

A RELATED EXAMPLE

Name the element with Z

Atomic number counts protons. Atomic number Z identifies an element. Mass number A counts protons plus neutrons in a particular atom. Neutrons = A − Z. Electron count affects charge but does not change which element the nucleus belongs to.

Inside atoms

Same mass number, different elements



THE IDEA

Isobars are not isotopes. Argon-40 and calcium-40 both have mass number 40, but atomic numbers 18 and 20.

They are isobars. Their proton and electron arrangements differ, so shared mass number does not imply identical chemistry.

CHECK YOUR THINKING

Which pair would be isotopes?

A Same Z, different A.

B Same A, different Z.

A. Isotopes belong to the same element, so their atomic numbers match.

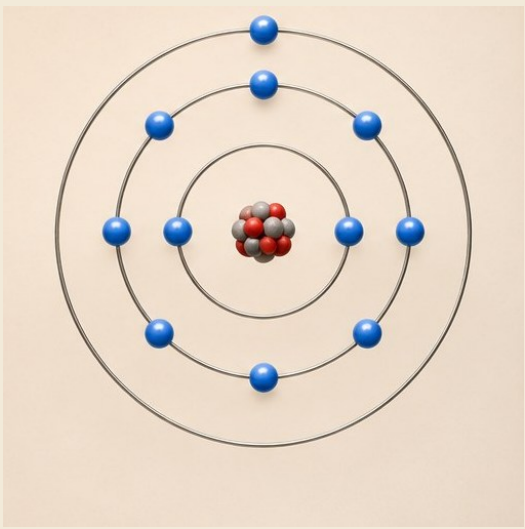
A RELATED EXAMPLE

Same element, different masses

Isotopes share protons, not neutron counts. Carbon-12 and carbon-14 both have six protons. They have six and eight neutrons respectively. Their chemical behaviour is broadly similar because electron arrangements are similar, but nuclear properties can differ. Models here are enlarged, not to scale.

Inside atoms

Valency is a combining capacity



THE IDEA

Atoms can lose, gain or share electrons. For many main-group atoms, a filled outer shell helps predict common valency. Sodium commonly loses one; chlorine gains one.

Oxygen commonly forms two bonds; carbon four. Noble gases have full outer shells and commonly zero valency at this level.

CHECK YOUR THINKING

What is oxygen's common valency?

A 6.

B 2.

B. Six outer electrons leave two needed for an octet in this introductory model.

A RELATED EXAMPLE

Fill shells with care

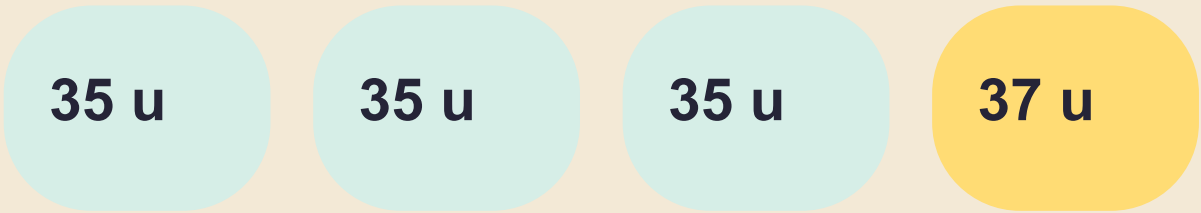
The outer electrons guide many reactions. The introductory shell capacity rule is $2n^2$: first shell up to 2, second up to 8. For the first 18 elements, arrangements build through 2,8,8. Do not treat a shell model as a complete rule for every element. Use the stated element and level of the model.

ONE LAST CHALLENGE

What is the mean mass per atom?

In a simplified sample, three atoms out of four have mass 35 u. The fourth has mass 37 u.

A SAMPLE OF FOUR ATOMS



Three atoms of 35 u for every one atom of 37 u.

THE REVEAL

35.5 u.

Total mass = 3 × 35 + 37 = 142 u. Dividing by four weights the two isotopes by their abundance.

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