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An analogy for the atom

Target level

This probe is designed for students on post-16 courses, or for students in the 14–16 age range who have already studied the topic of atomic structure.

Topics

The structure of the atom, intra-atomic forces, the 'the atom is a tiny solar system' comparison.

Rationale

Teachers and textbooks often use analogies to introduce unfamiliar ideas. One analogy that is commonly used is that 'the atom is like a tiny solar system'. However, without help, many students have difficulties recognising which aspects of an analogy they are meant to attend to. Students may also be less familiar with the analogue (*eg* the solar system) than is assumed.

This probe will elicit students' ideas about the forces acting in an atom, and in a solar system. It will also provide students with the opportunity to demonstrate their appreciation of the ways in which atoms and solar systems are similar, and the ways they differ. This is to some extent an open-ended task, as there is room for students to use their imagination and creativity to suggest comparisons.

These ideas are discussed in Chapter 7 of the Teachers' notes.

During piloting it was found that some 14–16 year old students find this type of activity very difficult. Some found it difficult to relate what they saw as their physics knowledge to their chemistry knowledge. Some students could not see the point of the exercise - 'they prefer to think of the two things as quite different'. As teachers commonly use analogies and metaphors to help students understand abstract ideas, this exercise could be useful for initiating a discussion of how we use such comparisons in teaching and learning science.

Teachers found that the exercise was fascinating. They were 'amazed' how difficult the exercise was for students, and were surprised by some of the misunderstandings revealed (with post-16 students as well as 14–16 year olds). It was also found that even able students were generally only able to suggest a small number of points when comparing the two systems.

Instructions

Comparing the atom with the solar system is designed to be distributed once students have tackled the questions on **The atom and the solar system** worksheet.

Resources

- Student worksheets
  - The atom and the solar system
  - Comparing the atom with the solar system

Feedback for students

An answer sheet for teachers is provided.

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An analogy for the atom – answers

The atom and the solar system

1. Electrical
2. The force attracting electron 3 is weaker – as it is a greater distance from the nucleus.
3. The force attracting the nucleus to the electron is the same size as the force attracting the electron to the nucleus – the forces between two bodies always act with the same magnitude (size) on both ('action' = 'reaction').
4. Yes (electrical) – they repel as they both have negative charges.
5. Gravitational
6. The force attracting planet C is weaker – as it is a greater distance from the sun.
7. The force attracting the sun to the planet is the same size as the force attracting the planet to the sun – the forces between two bodies always act with the same magnitude (size) on both ('action' = 'reaction').
8. Yes (gravitational) – they attract as they both have mass.

Comparing the atom with the solar system

Note: that as this is an open-ended activity, other valid ideas should be welcomed. Post-16 students will normally be expected to offer more sophisticated suggestions than younger students (indicated by *). Suggested answers might include:

Similarities
Central body; 'orbiting' * bodies (3 in the examples given); most of mass of system at centre; orbiting bodies attract central body; orbiting bodies attracted by central body; forces act between orbiting bodies; nuclei and sun may have a 'shell' type structure ...

Differences
Size!; nature of attraction (electrical/gravitational); planets do not share 'orbits' * ; electrons repel each other and planets attract each other; many atoms effectively identical – each solar system unique; solar systems evolve whereas atomic transitions are abrupt; electrons may effectively shield part of nuclear charge; all electrons are identical whereas planets are each different (in mass, size, composition); atoms seldom found in a free state, stable solar systems tend to be discrete; nucleus has 'grain' structure (discrete nucleons); solar system mostly in one plane (atoms approximate spherical symmetry); planets may have their own satellites.

* In post-16 courses the idea of electrons 'orbiting' may well have been replaced by more sophisticated ideas about orbitals, electron 'waves' and electron density.

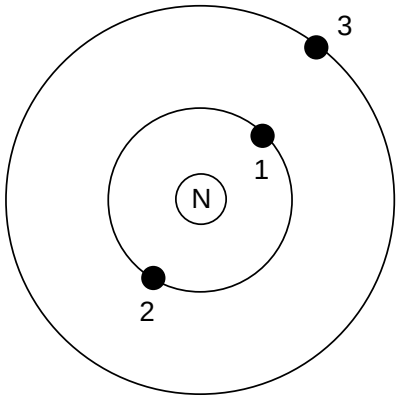
The atom and the solar system

The diagram on the right shows a simple model of an atom.

N is the nucleus, and there are three electrons, labelled 1, 2 and 3.

The electrons are attracted to the nucleus.

Below are some questions about the model of the atom shown in the diagram.



1. What type of force attracts the electrons towards the nucleus? _____

2. Is electron 3 attracted to the nucleus by a stronger force, a weaker force, or the same size force as electron 1?

_____

Why do you think this? _____

_____

_____

3. Which statement do you think is correct (✔) ?

- ❑ The force attracting the nucleus to electron 2 is larger than the force attracting electron 2 to the nucleus.
- ❑ The force attracting the nucleus to electron 2 is the same size as the force attracting electron 2 to the nucleus.
- ❑ The force attracting the nucleus to electron 2 is smaller than the force attracting electron 2 to the nucleus.
- ❑ There is no force acting on the nucleus attracting it to electron 2.

Why do you think this? _____

_____

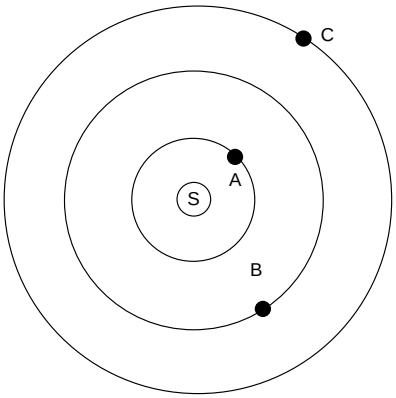
_____

4. Is there any force between electron 1 and electron 3? _____

Why do you think this? _____

_____

_____



The diagram on the left shows a simple model of a solar system.

S is the sun, and there are three planets, labelled A, B and C.

The planets are attracted to the sun.

Below are some questions about the solar system shown in the diagram.

5. What type of force attracts the planets towards the sun? _____

_____

6. Is planet C attracted to the sun by a stronger force, a weaker force, or the same size force as planet A?

_____

Why do you think this? _____

_____

_____

7. Which statement do you think is correct (✔) ?

- ❑ The force attracting the sun to planet B is larger than the force attracting planet B to the sun.
- ❑ The force attracting the sun to planet B is the same size as the force attracting planet B to the sun.
- ❑ The force attracting the sun to planet B is smaller than the force attracting planet B to the sun.
- ❑ There is no force acting on the sun attracting it to planet B.

Why do you think this? _____

_____

_____

8. Is there any force between planet A and planet C?

_____

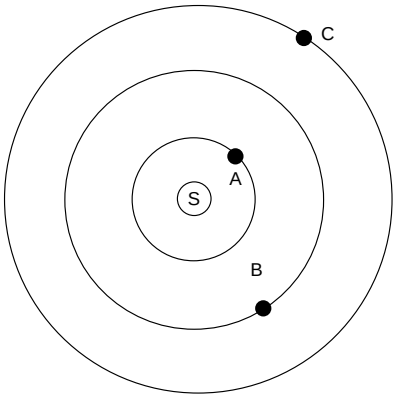
Why do you think this? _____

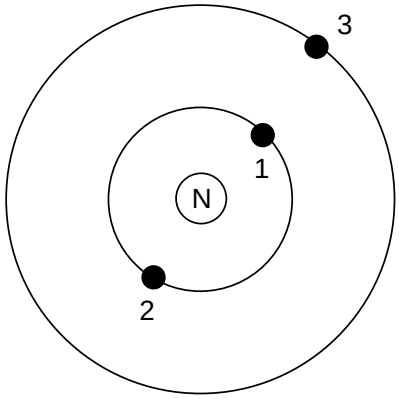
_____

_____

Comparing the atom with the solar system

Look at the models shown in the diagrams, and try to think of ways in which the atom and the solar system are similar, and ways in which they are different:





List the similarities and differences you can think of.

In which ways are they similar?

In which ways are they different?

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