Development of the periodic table

4.1.2.2 · Atomic structure and the periodic table · revision notes

How the periodic table developed: early tables ordered by atomic weight, the changes Mendeleev made (gaps and swapped elements), and how later discoveries showed he was right. It is usually a 2 to 6 mark 'describe' or 'explain' question about how scientific ideas change with new evidence.

Key facts

- Early tables: ordered by atomic weight; incomplete; some elements in the wrong groups
- Mendeleev changed the order of some elements to fit similar properties
- Isotopes explain why atomic weight order is not always right
- Mendeleev left gaps for elements not yet discovered
- Elements discovered later (e.g. gallium, germanium) matched his predictions
- Modern table: ordered by atomic (proton) number

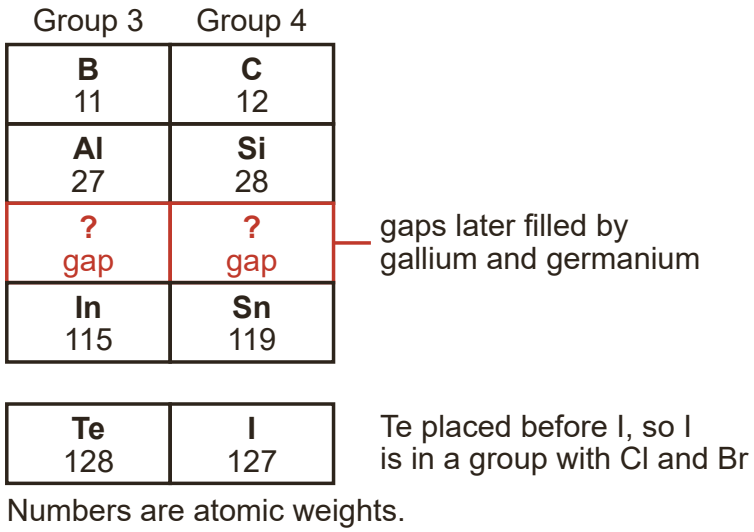
Notes

Early periodic tables

- Before protons, neutrons and electrons were discovered, scientists tried to classify the elements by arranging them in order of their **atomic weights** (what we now call relative atomic masses).
- The early tables were **incomplete**, because many elements had not yet been discovered.
- If the strict order of atomic weights was followed, some elements were placed in **inappropriate groups**, with elements whose properties were different from theirs.

What Mendeleev did

- **Dmitri Mendeleev** overcame some of these problems in two ways.
- He **left gaps** for elements that he thought had not been discovered yet, and used the patterns in his table to predict their properties.
- In some places he **changed the order** based on atomic weights, so that elements were in groups with similar properties. For example, he put tellurium (atomic weight about 128) before iodine (about 127), so that iodine was in the same group as chlorine and bromine.



Mendeleev left gaps and swapped the order of some elements.

Evidence that he was right

- Elements with properties that matched Mendeleev's predictions were later discovered and filled the gaps, e.g. gallium and germanium.
- His predictions had been tested and found to be correct, so other scientists accepted his table.
- After protons were discovered, scientists realised that the table is really in order of **atomic (proton) number**.
- Knowledge of **isotopes** explained why atomic weight order was not always correct.
- An element's atomic weight depends on the masses and abundances of its isotopes, so an element with fewer protons can still have a higher atomic weight if it has more of its heavier isotopes.

Mendeleev's table compared with the modern table

- Mendeleev: ordered mainly by atomic weight, with some swaps; had gaps; had no group of noble gases (they had not been discovered).
- Modern: ordered by atomic number; no gaps; includes Group 0 (the noble gases).

How to answer each type of question

Describe how Mendeleev's table differed from earlier tables 2 marks **Grade 5**

1. Gaps for undiscovered elements.
2. Some elements swapped out of atomic weight order so that they fitted groups with similar properties.

Example. Describe **two** ways in which Mendeleev's periodic table was different from earlier periodic tables.

Model answer. He left gaps for elements that had not been discovered yet (1). He changed the order of some elements (from atomic weight order) so that they were in groups with similar properties (1).

Explain why Mendeleev's table was accepted 2 marks **Grade 5**

1. Say that new elements were discovered that fitted the gaps.
2. Say that their properties matched his predictions.

Example. At first, some scientists did not accept Mendeleev's periodic table.
Explain why his table was later accepted.

Model answer. Elements were discovered that fitted the gaps he had left (1). Their properties matched the properties he had predicted (1).

Explain why atomic weight order did not always work 3 marks **Grade 7**

1. Say the modern table is in order of atomic (proton) number, and compare the numbers of protons.
2. Say relative atomic mass depends on the isotopes and their abundances.
3. Link this to the pair of elements in the question.

Example. Argon has a relative atomic mass of 39.9 and potassium has a relative atomic mass of 39.1. In the modern periodic table argon is placed before potassium.
Explain why.

Model answer. The modern table is in order of atomic (proton) number: argon has 18 protons and potassium has 19 (1). Relative atomic mass depends on the isotopes of an element and their abundances (1). Argon has a greater proportion of heavier isotopes, so its relative atomic mass is higher even though it has fewer protons (1).

6-mark: describe how the periodic table developed

6 marks | Grade 7

1. Go in time order: early tables, their problems, Mendeleev's changes, confirmation, then isotopes and atomic number.
2. Give a reason or result for each step, not just a list.
3. Use the key words: atomic weight, gaps, predicted, discovered, isotopes, atomic number.

Example. Describe how the periodic table developed from the early tables to the modern periodic table.

Model answer. Marked by levels; this answer would reach the top level (5 to 6 marks). Early scientists arranged the elements in order of atomic weight, because protons, neutrons and electrons were not known. These tables were incomplete, and following strict atomic weight order put some elements in groups with elements whose properties were different. Mendeleev left gaps for elements that had not yet been discovered, and predicted their properties. He also changed the order of some elements so that elements with similar properties were in the same group. Elements such as germanium were later discovered with properties that matched his predictions, so his table was accepted. After protons were discovered, the table was arranged in order of atomic number, and knowledge of isotopes explained why atomic weight order was not always correct.

Don't lose marks

- Saying Mendeleev ordered the elements by atomic number. Protons had not been discovered.
- Saying he guessed the gaps. He predicted properties from patterns, and the predictions were tested.
- Saying he swapped elements because of isotopes. Isotopes were discovered later; they explained why his swaps were right.
- Writing 'mass number' instead of atomic weight or relative atomic mass.

More tips

Memory tricks

- Weights then, numbers now: early tables used atomic weight; the modern table uses atomic number.
- Mendeleev's two changes: Gaps and Group swaps. The proof: gallium and germanium.
- Pairs that break atomic weight order: tellurium before iodine, argon before potassium.

Exam technique

- For 'why was it accepted', the key idea is that his predictions were tested and found to be correct.
- In the 6-mark question, write in time order and use linking words such as 'because', 'so' and 'later'.
- If the question gives data, quote the numbers in your answer.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

State how early tables were ordered

By atomic weight, because protons, neutrons and electrons had not been discovered.

Grade 4

Describe problems with early tables

They were incomplete, and strict atomic weight order put some elements in groups with the wrong properties.

Grade 5

Describe what Mendeleev did

He left gaps for undiscovered elements and changed the order of some elements to fit their properties.

Grade 5

Explain why Mendeleev's table was accepted

Elements were later discovered that filled the gaps and had the properties he predicted.

Grade 7

Explain why atomic weight order failed

Atomic weight depends on isotopes, so it does not always follow atomic number, e.g. argon and potassium.

Grade 7

Describe the whole development in order

Early tables, their problems, Mendeleev's changes, the discoveries that confirmed them, then isotopes and atomic number.

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