

Shells, groups and the periodic table

Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Worksheet answers

Each answer shows the electron count, the arrangement and the group or period. Check that your arrangement adds up to the atomic number and that every outer shell obeys the limits of 2, 8 and 8.

Level: Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** HS-PS1-1, HS-PS1-2

Problem 1 Write the arrangements

Fill 2, then 8, then 8.

1. Mg: 2,8,2.
2. F: 2,7.
3. K: 2,8,8,1.
4. B: 2,3.

Mg 2,8,2; F 2,7; K 2,8,8,1; B 2,3.

Problem 2 Group and period

Group = outer electrons (Group 0 for a full shell); period = number of shells.

1. 2,8,3: Group 3, period 3.
2. 2,6: Group 6, period 2.
3. 2,4: Group 4, period 2.
4. 2,8,8: Group 0, period 3.

3 and 3; 6 and 2; 4 and 2; 0 and 3.

Problem 3 Shell capacity

1. Shell 1: 2; shell 2: 8; shell 3: 8.
2. Helium has 2 electrons, which fills shell 1. Neon is 2,8, which fills shell 2.

2, 8, 8; both outer shells are full.

Problem 4 Reading a shell diagram

1. Counting the dots in each shell gives 2,8,6.
2. $2 + 8 + 6 = 16$ electrons, so 16 protons.
3. Atomic number 16 is sulfur.
4. 6 outer electrons gives Group 6; 3 shells gives period 3.

2,8,6; sulfur; Group 6, period 3.

Problem 5 Complete the table

Element	Atomic number	Arrangement	Group	Period
Beryllium	4	2,2	2	2
Nitrogen	7	2,5	5	2
Chlorine	17	2,8,7	7	3
Calcium	20	2,8,8,2	2	4

Be 2,2; N 2,5; Cl 2,8,7; Ca 2,8,8,2.

Problem 6 Same group, same behaviour

1. A (2,1) and C (2,8,1) are both Group 1. B (2,8,5) and D (2,5) are both Group 5.
2. E (2,8,8) has a full outer shell, so it is a noble gas.
3. B, C and E have three numbers, so three shells.

A and C; B and D; E; B, C and E.

Problem 7 Deduce the element

1. 2,8,5: 15 electrons, atomic number 15, phosphorus.
2. 2,8,8,2: 20 electrons, atomic number 20, calcium.
3. Two shells with 7 outer electrons: 2,7: atomic number 9, fluorine.

Phosphorus 2,8,5 (15); calcium 2,8,8,2 (20); fluorine 2,7 (9).

Problem 8 Mendeleev's prediction

1. $(5.5 - 5.32) \div 5.32 \times 100 = 0.18 \div 5.32 \times 100 = 3.4 \%$.
2. $(72.6 - 72) \div 72.6 \times 100 = 0.6 \div 72.6 \times 100 = 0.83 \%$.
3. A prediction made before the element was found came true, which showed the table captured a real pattern.

3.4 % and 0.83 %.

Problem 9 Tellurium and iodine

1. $127.6 - 126.9 = 0.7$.
2. Iodine behaves like chlorine and bromine, so it belongs in their group, even though it is lighter than tellurium.
3. Ordering by atomic number puts tellurium (52) before iodine (53), so Mendeleev's choice was right.

Difference = 0.7; order by atomic number, not mass.

Problem 10 Metal or non-metal?

1. P is a metal; Q is a non-metal.

2. P has 2 outer electrons, which it tends to lose. Q has 6 outer electrons and tends to gain 2.

3. Atomic number 12 is magnesium; atomic number 16 is sulfur.

P is magnesium, a metal; Q is sulfur, a non-metal.

Problem 11 Spot the errors

1. Chlorine has 17 electrons: 2,8,7.

2. Period equals the number of shells. Sodium (2,8,1) has 3 shells, so period 3.

3. Elements in the same period have the same number of shells. Elements in the same group share outer electrons.

Cl 2,8,7; Na is period 3; same period means same shells.

Problem 12 Unreactive noble gases

1. Each outer shell is full.

2. A full outer shell is stable, so the atoms do not need to lose, gain or share electrons.

3. The first shell is full with 2 electrons, so helium behaves like the others.

Full outer shells make noble gases stable and unreactive.

Problem 13 Locate the elements

1. A (period 2, Group 1) and B (period 3, Group 1).

2. D is in Group 0.

3. C: period 3, Group 7 gives 2,8,7. E: period 4, Group 2 gives 2,8,8,2. F: period 3, Group 3 gives 2,8,3.

A and B; D; C 2,8,7, E 2,8,8,2, F 2,8,3.

Problem 14 Atomic number from arrangement

1. $2 + 8 + 4 = 14$, silicon.

2. $2 + 8 + 8 + 1 = 19$, potassium.

3. $2 + 3 = 5$, boron.

4. $2 + 8 + 2 = 12$, magnesium.

14, 19, 5 and 12.

Problem 15 Same arrangement, different species

Na^+ : $11 - 1 = 10$ electrons, 2,8, like neon.

F^- : $9 + 1 = 10$ electrons, 2,8, like neon.

Mg^{2+} : $12 - 2 = 10$ electrons, 2,8, like neon.

Cl^- : $17 + 1 = 18$ electrons, 2,8,8, like argon.

Na^+ , F^- , Mg^{2+} match neon; Cl^- matches argon.

Problem 16 Unknown atom with 15 electrons

1. 2,8,5.
2. 5 outer electrons: Group 5. 3 shells: period 3.
3. It is on the right of the table, so a non-metal (phosphorus). It needs $8 - 5 = 3$ more electrons to reach 2,8,8.

2,8,5; Group 5, period 3; non-metal gaining 3 electrons.

Problem 17 Argon and potassium

1. By mass alone, potassium (39.1) comes before argon (39.9).
2. By atomic number, argon (18) comes before potassium (19).
3. Argon is an unreactive gas (2,8,8) and potassium is a reactive metal (2,8,8,1). Argon belongs at the end of period 3 and potassium at the start of period 4, matching atomic number.

Order by atomic number: argon then potassium.

Problem 18 Newlands' octaves

1. Counting lithium as 1, the eighth is sodium.
2. Lithium is 2,1 and sodium is 2,8,1, both with one outer electron.
3. The second shell holds 8, so after 8 more electrons a new shell begins and the outer-electron count restarts.
4. After calcium extra elements fill an inner shell (the transition metals), so periods become longer than 8 and a fixed octave breaks down.

Sodium; both have 1 outer electron; new shells cause the repeat.

Problem 19 Outer electrons graph

1. Atomic number 9: 7; atomic number 13: 3; atomic number 18: 8.
2. Outer electrons equal 1 at atomic numbers 11 and 19, the same group as atomic number 3.
3. Each of these atoms starts a new shell with one electron in it.
4. Helium fills the first shell, which holds only 2.

7, 3, 8; atomic numbers 11 and 19; new shell; first shell holds 2.

Problem 20 Evaluate the evidence

1. The predictions were made before germanium was known and agree within about 1 % on mass and 3.4 % on density, and the oxide formula was correct. A random guess would be unlikely to match so well, so the support is strong.
2. The order by mass sometimes gave the wrong column (tellurium and iodine), and Mendeleev had no reason to explain this until Moseley showed atomic number is the real ordering.

Strong support, but the ordering by mass remained unexplained.