Year 13 Science: Electron configuration and periodic trends

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

Practice

1. Write the electron configuration of titanium (Z = 22).

2. Write the electron configuration of Fe^{2+} (Z = 26).

3. Which is larger, a magnesium atom or a Mg^{2+} ion?

4. Which has the higher first ionisation energy, phosphorus or sulfur?

5. Put nitrogen, oxygen and fluorine in order of increasing electronegativity.

6. Write the electron configurations of vanadium, V (Z = 23), and Ni^{2+} (Z = 28), using s, p, d notation.

7. Explain why the first ionisation energy of aluminium (578 kJ mol^{-1}) is lower than that of magnesium (738 kJ mol^{-1}).

8. The K^+ ion has a radius of 138 pm and the Cl^- ion 181 pm. Explain why K^+ is smaller, even though both ions have the same number of electrons.

9. Justify the trend in electronegativity from chlorine (3.16) to bromine (2.96) to iodine (2.66).

Fix the mistake

10. Correct this statement: "Fe^{2+} is [Ar] $3d^4\ 4s^2$, because the last electrons in are the first out."

11. Correct this statement: "Atomic radius gets bigger across a period because there are more electrons."

12. Correct this statement: "Chromium is [Ar] $3d^4\ 4s^2$, following the filling order."

13. Correct this statement: "Ionisation energy decreases down a group because there are more protons."

Answer key (for parents and tutors)

1. Write the electron configuration of titanium (Z = 22).
   $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2\ 4s^2$, or [Ar] $3d^2\ 4s^2$.

2. Write the electron configuration of Fe^{2+} (Z = 26).
   Iron is [Ar] $3d^6\ 4s^2$; the two 4s electrons go first, so Fe^{2+} is [Ar] $3d^6$.

3. Which is larger, a magnesium atom or a Mg^{2+} ion?
   The Mg atom: Mg^{2+} has lost its whole third shell, and its 12 protons pull the remaining 10 electrons in closer.

4. Which has the higher first ionisation energy, phosphorus or sulfur?
   Phosphorus: its three 3p electrons are unpaired, while sulfur's fourth 3p electron is paired, and the repulsion makes it easier to remove.

5. Put nitrogen, oxygen and fluorine in order of increasing electronegativity.
   N < O < F: across Period 2 the nuclear charge increases while the shell stays the same.

6. Write the electron configurations of vanadium, V (Z = 23), and Ni^{2+} (Z = 28), using s, p, d notation.
   V: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$; Ni: [Ar] $3d^8\ 4s^2$, so Ni^{2+}: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8$ (Achieved for both correct).

7. Explain why the first ionisation energy of aluminium (578 kJ mol^{-1}) is lower than that of magnesium (738 kJ mol^{-1}).
   Magnesium's outer electron is in 3s and aluminium's is in 3p. The 3p electron is higher in energy and is partly shielded from the nucleus by the $3s^2$ electrons, so although aluminium has one more proton, its 3p electron is held less tightly and less energy is needed to remove it (Merit links the subshell to the shielding; Excellence also explains why the extra proton does not outweigh it).

8. The K^+ ion has a radius of 138 pm and the Cl^- ion 181 pm. Explain why K^+ is smaller, even though both ions have the same number of electrons.
   Both ions have 18 electrons as $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$, so the same number of shells and the same shielding. K^+ has 19 protons and Cl^- only 17, so the nucleus of K^+ attracts the same electron cloud more strongly and pulls it closer, making K^+ smaller (Excellence names what is the same as well as the difference in protons).

9. Justify the trend in electronegativity from chlorine (3.16) to bromine (2.96) to iodine (2.66).
   Down group 17 each atom has an extra shell (Cl three, Br four, I five), so the bonding pair is further from the nucleus and more shielded by inner electrons. Although the number of protons increases, the greater distance and shielding weaken the attraction for the bonding electrons, so electronegativity decreases from 3.16 to 2.96 to 2.66 (Excellence uses all of protons, shells, shielding and attraction).

10. Correct this statement: "Fe^{2+} is [Ar] $3d^4\ 4s^2$, because the last electrons in are the first out."
    Transition metals lose 4s electrons first: Fe^{2+} is [Ar] $3d^6$.

11. Correct this statement: "Atomic radius gets bigger across a period because there are more electrons."
    The extra electrons go into the same shell while protons increase, so the radius gets smaller.

12. Correct this statement: "Chromium is [Ar] $3d^4\ 4s^2$, following the filling order."
    Chromium is [Ar] $3d^5\ 4s^1$ and copper is [Ar] $3d^{10}\ 4s^1$: a half-full or full 3d is more stable.

13. Correct this statement: "Ionisation energy decreases down a group because there are more protons."
    There are more protons, but the outer electron is in a higher shell, further away and more shielded, which outweighs the extra protons.