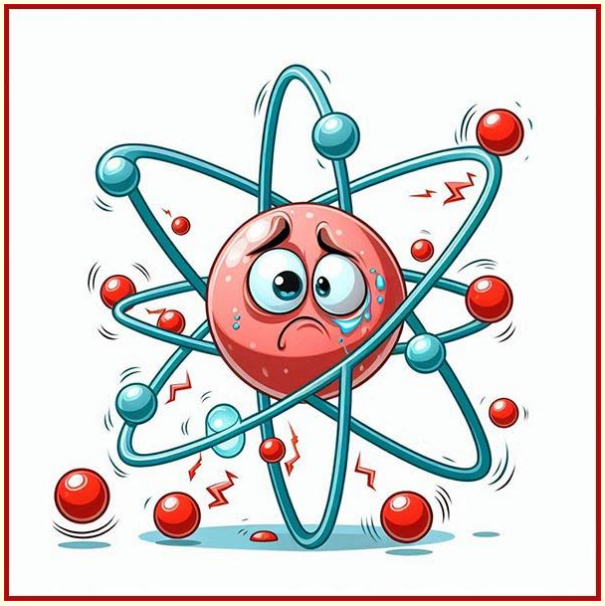
Trends in the ionisation energy across a period

Answer all the questions below as fully as you can then check your answers

1. Explain the meaning of the term first ionisation energy.



2. Why are ionisation energies always endothermic?

b. Write an equation to show the first ionisation energy of oxygen and chlorine.

c. What is the trend in atomic radius as we cross a period in the periodic table? Explain your answer.

3. What is the general trend in the values for the first ionisation energies of the period 3 elements?

a. Why is the first ionisation energy of magnesium higher than that of aluminium?

b. Why is the first ionisation energy of phosphorus higher than that of sulfur?

c. Will boron or beryllium have the highest first ionisation energy? Explain your answer.

Answers

1. Explain the meaning of the term first ionisation energy.

   The first ionisation energy of an element is the energy required to remove 1 mole of electrons from one mole of atoms in the gas phase.

2. Why are ionisation energies always endothermic?

   There is electrostatic attraction between the negatively charged electrons and the positively charged protons in the nucleus which must be overcome in order to separate them.

b. Write an equation to show the first ionisation energy of oxygen and chlorine.

$O_{(g)} \longrightarrow O^+_{(g)} + e$

$Cl_{(g)} \longrightarrow Cl^+_{(g)} + e$

c. What is the trend in atomic radius as we cross a period in the periodic table? Explain your answer.

The atoms get smaller as we cross a period due to increasing nuclear charge and the fact that the additional electrons are being added to the same principal energy level.

3. What is the general trend in the values for the first ionisation energies of the period 3 elements?

   The general trend is that the first ionisation energy increases across period 3.

a. Why is the first ionisation energy of magnesium higher than that of aluminium?

Aluminium is a p-block element with its outer valence electron in a 3p sub-level whereas the magnesium outer electrons are in a 3s sub-level. The 3p sub-level is higher in energy and so further from the nucleus so the electron will be easier to remove.

b. Why is the first ionisation energy of phosphorus higher than that of sulfur?

Phosphorus's outer valence electrons are in a $3p^3$ sub level with all electrons unpaired. However, in sulfur the valence electrons are in a $3p^4$ electronic configuration, there will be repulsion between the paired electrons in one of the p-orbitals. This repulsion will raise the energy of the orbitals and so increase the distance they are from the nucleus so less energy will be needed to remove the electron.

c. Will boron or beryllium have the highest first ionisation energy? Explain your answer.

The same argument applies here as to Mg-Al question earlier. Boron's outer electron is in a 2p sub-level whereas beryllium's valence electrons are in a s-sub level. The valence electron in boron is further from the nucleus and is more shielded so it will be require less energy to remove it.