Trends in melting and boiling points of Period 3 elements

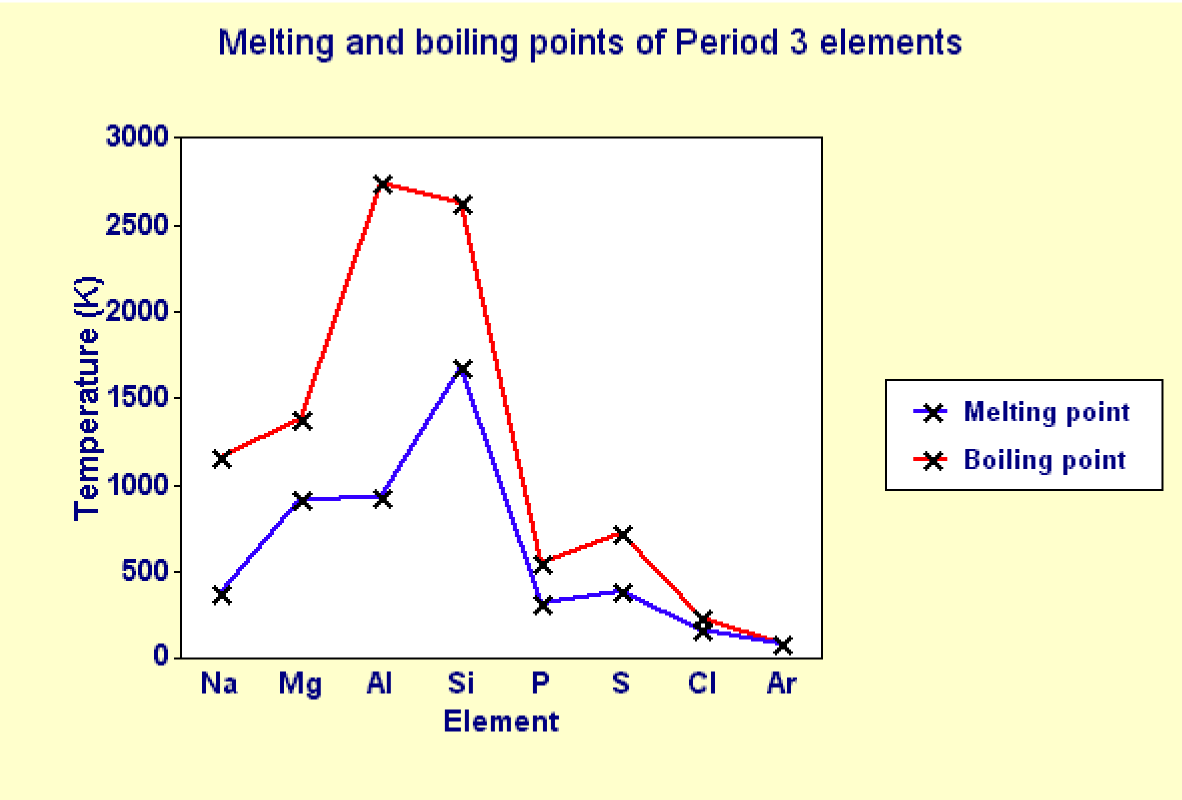
The trends in melting points and boiling points going across Period 3 are not straightforward, and need more detailed consideration than the trends in Group 2:

- Melting points generally increase going from sodium to silicon, then decrease going to argon (with a "bump" at sulphur).
- Boiling points generally increase going from sodium to aluminium, then decrease to argon (again with a "bump" at sulphur).

Table of physical data

Element	Proton number	Symbol	Melting point (K)	Boiling point (K)
sodium	11	Na	371	1156
magnesium	12	Mg	922	1380
aluminium	13	Al	933	2740
silicon	14	Si	1683	2628
phosphorus	15	P	317	553
sulphur	16	S	392	718
chlorine	17	Cl	172	238
argon	18	Ar	84	87

Graph of physical data



Explanation of these trends

Melting

When a substance melts, some of the attractive forces holding the particles together are broken or loosened so that the particles can move freely around each other but are still close together. The stronger these forces are, the more energy is needed to overcome them and the higher the melting temperature.

Boiling

When a substance boils, most of the remaining attractive forces are broken so the particles can move freely and far apart. The stronger the attractive forces are, the more energy is needed to overcome them and the higher the boiling temperature.

Sodium, magnesium and aluminium

Sodium, magnesium and aluminium are all metals. They have **metallic bonding**, in which positive metal ions are attracted to delocalised electrons. Going from sodium to aluminium:

- the charge on the metal ions increases from +1 to +3 (with magnesium at +2) ...
- the number of delocalised electrons increases ...
- so the strength of the metallic bonding increases and ...
- the melting points and boiling points increase.

Silicon

Silicon is a **metalloid** (an element with some of the properties of metals and some of the properties of non-metals). Silicon has **giant covalent bonding**. It has a giant lattice structure similar to that of diamond, in which each silicon atom is covalently-bonded to four other silicon atoms in a tetrahedral arrangement. This extends in three dimensions to form a giant molecule or macromolecule.

Silicon has a very melting point and boiling point because:

- all the silicon atoms are held together by strong covalent bonds ...
- which need a very large amount of energy to be broken.

Phosphorus, sulphur, chlorine and argon

These are all **non-metals**, and they exist as small, separate molecules. Phosphorus, sulphur and chlorine exist as simple molecules, with strong covalent bonds between their atoms. Argon exists as separate atoms (it is monatomic).

Their melting and boiling points are very low because:

- when these four substances melt or boil, it is the **van der Waal's forces** between the molecules which are broken ...
- which are very weak bonds ...
- so little energy is needed to overcome them.

Sulphur has a higher melting point and boiling point than the other three because:

- phosphorus exists as P_4 molecules ...
- sulphur exists as S_8 molecules ...
- chlorine exists as Cl_2 molecules ...
- argon exists individual Ar atoms ...
- the strength of the van der Waal's forces decreases as the size of the molecule decreases ...
- so the melting points and boiling points decrease in the order $S_8 > P_4 > Cl_2 > Ar$