AN INTRODUCTION TO
PERIODICITY

A guide for A level students

KNOCKHARDY PUBLISHING

2008
SPECIFICATIONS

PERIODICITY

INTRODUCTION

This *Powerpoint* show is one of several produced to help students understand selected topics at AS and A2 level Chemistry. It is based on the requirements of the AQA and OCR specifications but is suitable for other examination boards.

Individual students may use the material at home for revision purposes or it may be used for classroom teaching if an interactive white board is available.

Accompanying notes on this, and the full range of AS and A2 topics, are available from the KNOCKHARDY SCIENCE WEBSITE at...

www.knockhardy.org.uk/sci.htm

Navigation is achieved by...

either clicking on the grey arrows at the foot of each page

or using the left and right arrow keys on the keyboard

PERIODICITY

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INTRODUCTION

The Periodic Table is made up by placing the elements in ATOMIC NUMBER ORDER and arranging them in...

ROWS (PERIODS) and

COLUMNS (GROUPS)

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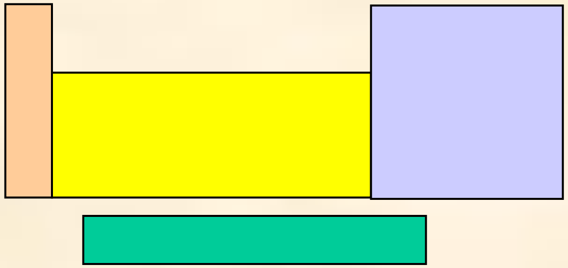
It is split into blocks; in each block the elements are filling, or have just filled, particular types of orbital



INTRODUCTION

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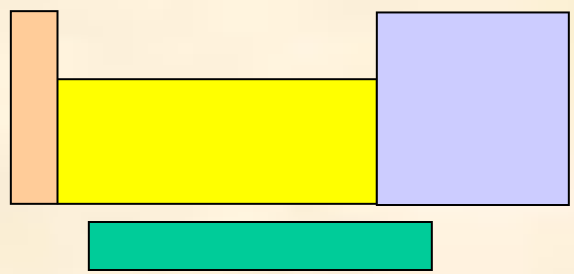

	Group(s)		
s block	I and II	end in s^1 or s^2
p block	III, IV, V, VI, VII and 0	end in p^1 to p^6
d block	Transition elements	end in d^1 to d^{10}
f block	Actinides and Lanthanides	end in f

INTRODUCTION

The outer electron configuration is a periodic function... it repeats every so often

Because many physical and chemical properties are influenced by the outer shell configuration of an atom, it isn't surprising that such properties also exhibit periodicity...

- **atomic radius**
- **ionic radius**
- **ionisation energy**
- **electron affinity**
- **electronegativity**
- **electrical conductivity**
- **melting point and boiling point**

It is much more important to know and understand each trend and how it arises than remember individual values.

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The first two periods in the periodic table are not typical...

Period 1	**(H, He)**	**contains only two elements**
Period 2	**(Li - Ne)**	**elements at the top of each group have small sizes and high I.E.values**
Period 3	**(Na-Ar)**	**is the most suitable period for studying trends**

ELECTRONIC CONFIGURATION

ELECTRONIC CONFIGURATION

The Aufbau principle states that… "ELECTRONS ENTER THE LOWEST AVAILABLE ENERGY LEVEL" . In period 3 the electrons fill the 3s orbital first, followed by the 3p orbitals. Notice how the electrons in the 3p orbitals remain unpaired, if possible, according to Hund's Rule.

	1s	2s	2p	3s	3p	
Na	↑↓	↑↓	↑↓ ↑↓ ↑↓	↑		$1s^2\ 2s^2\ 2p^6\ 3s^1$
Mg	↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓		$1s^2\ 2s^2\ 2p^6\ 3s^2$
Al	↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$
Si	↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑ ↑	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$
P	↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑ ↑ ↑	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$
S	↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑↓ ↑ ↑	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$
Cl	↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑↓ ↑↓ ↑	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$
Ar	↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑↓ ↑↓ ↑↓	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

BONDING & STRUCTURE

ELEMENTS

Moving from left to right the elements go from highly electropositive metals through metalloids with giant structures to the simple molecular structure of non-metals.

Na Mg Al Si P_4 S_8 Cl_2 Ar

< - - - metals - - - > metalloid < non metals (simple molecules) >

Typical properties	Metals	Non-metals
Appearance	solids - shiny when cut	gases, liquids, dull solids
Hardness	malleable and ductile	brittle
Electrical conductivity	excellent	poor
Melting point	high	low

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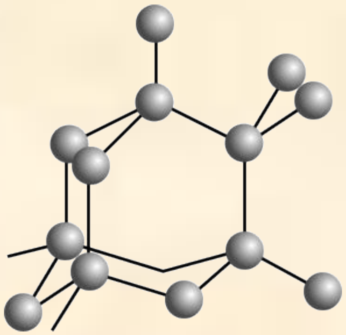
Not every element satisfies all the criteria. For example...

- carbon (graphite) is a non-metal which conducts electricity
- carbon and silicon have high melting points
- mercury is a liquid at room temperature and pressure

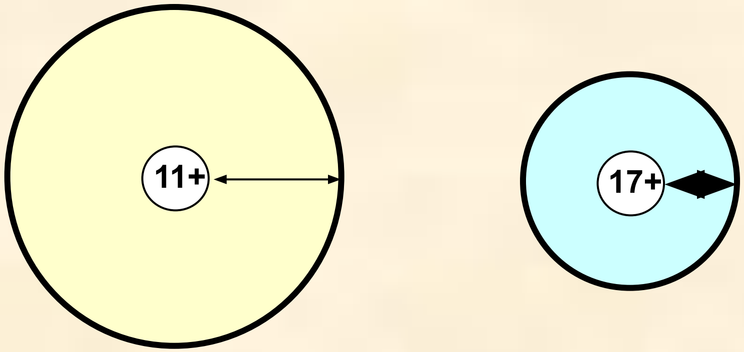


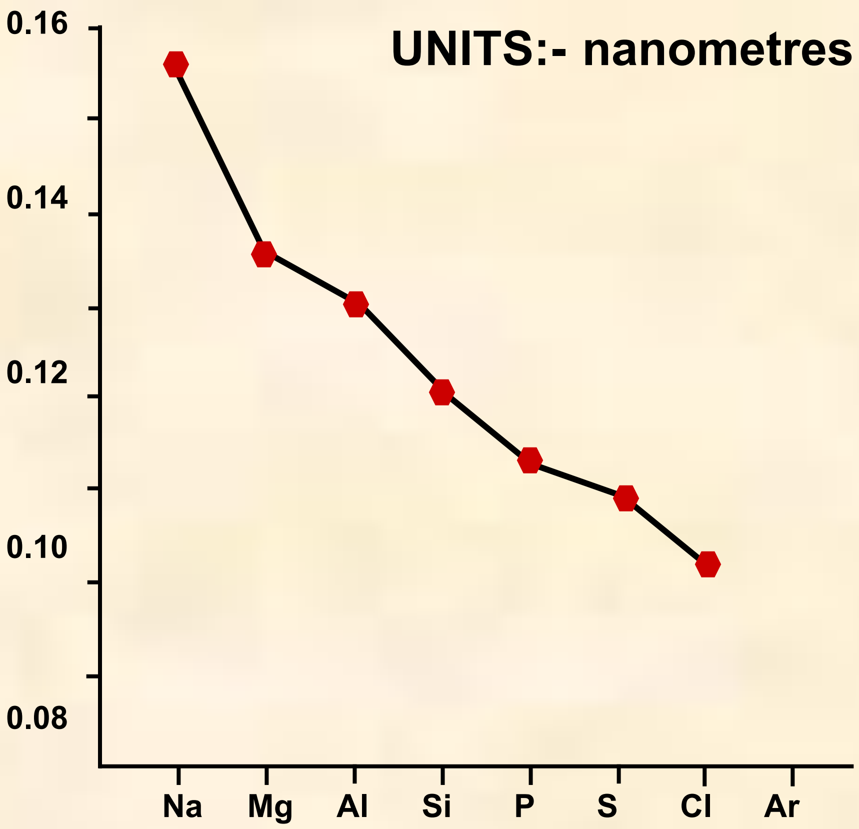
ATOMIC RADIUS

ATOMIC RADIUS

Decreases across a given period

The nuclear charge increases by +1 each time. As the nuclear charge increases it has a greater attraction for the electrons (which, importantly, are going into the same shell) and pulls them in slightly.





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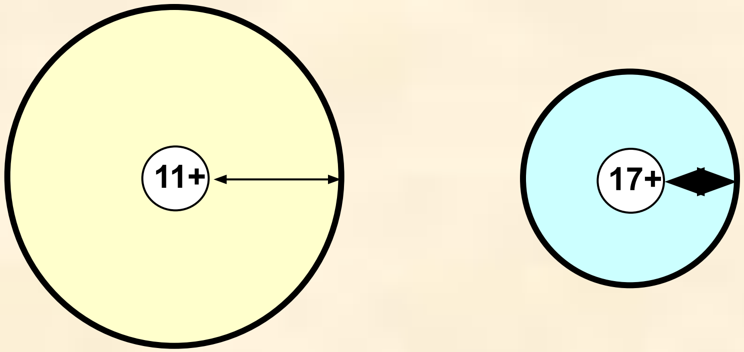

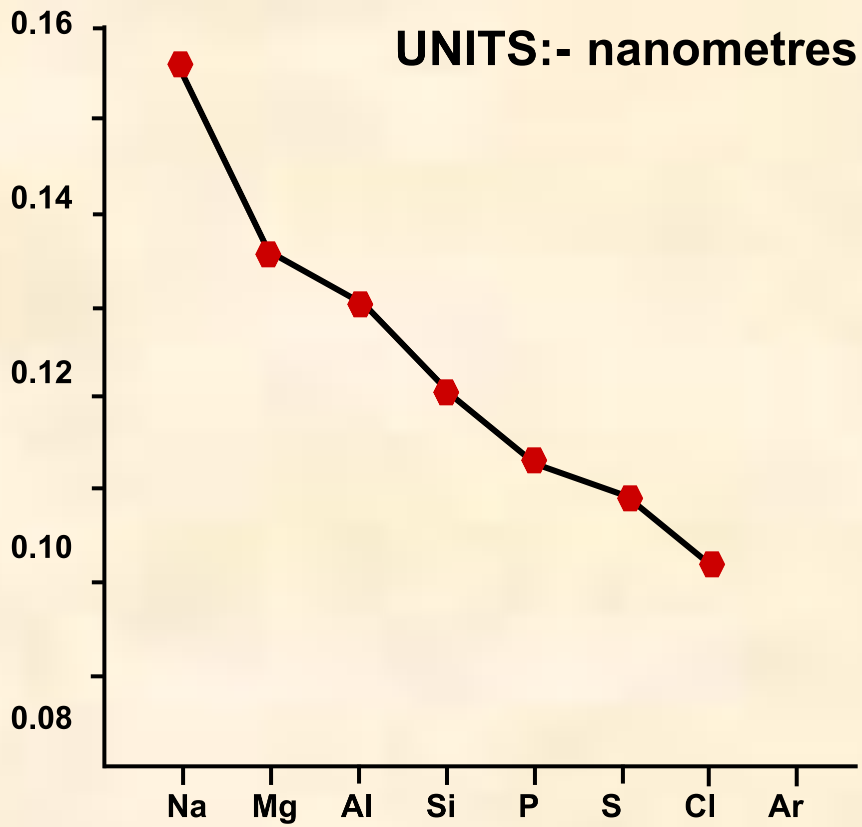

One is not actually measuring the true radius of an atom. In metals you measure metallic radius (half the distance between the inter-nuclear distance of what are effectively ions). Covalent radius is half the distance between the nuclei of atoms joined by a covalent bond. The values are measured by X-ray or electron diffraction. Argon's value cannot be measured as it only exists as single atoms.

1st IONISATION ENERGY

FIRST IONISATION ENERGY

Definition

The energy required to remove ONE MOLE of electrons (to infinity) from ONE MOLE of gaseous atoms to form ONE MOLE of gaseous positive ions.

e.g. $Na(g) \longrightarrow Na^{+}(g) + e^{-}$

$Al(g) \longrightarrow Al^{+}(g) + e^{-}$

Make sure you write in the (g)

It is a measure of the energy required to remove an outer shell electron from a gaseous atom. Electrons are negatively charged and are attracted to the positively charged nucleus. Electrons that are held more strongly will require more energy to overcome the attraction.

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1st Ionisation Energy INCREASES across a period

Nuclear charge increases by one each time. Each extra electron, however, is going into the same main energy level so is subject to similar shielding and is a similar distance away from the nucleus. Electrons are held more strongly and are harder to remove. However the trend is not consistent.

FIRST IONISATION ENERGY

TREND

INCREASES across a period

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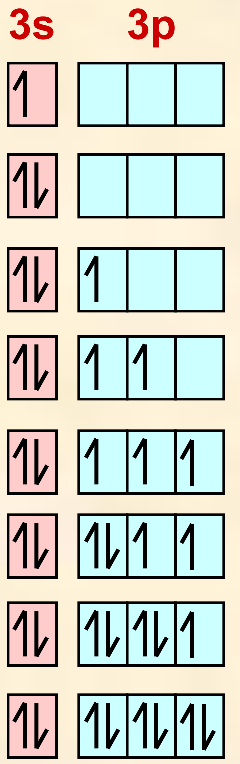
	NUCLEAR CHARGE
Na	11+
Mg	12+
Al	13+
Si	14+
P	15+
S	16+
Cl	17+
Ar	18+



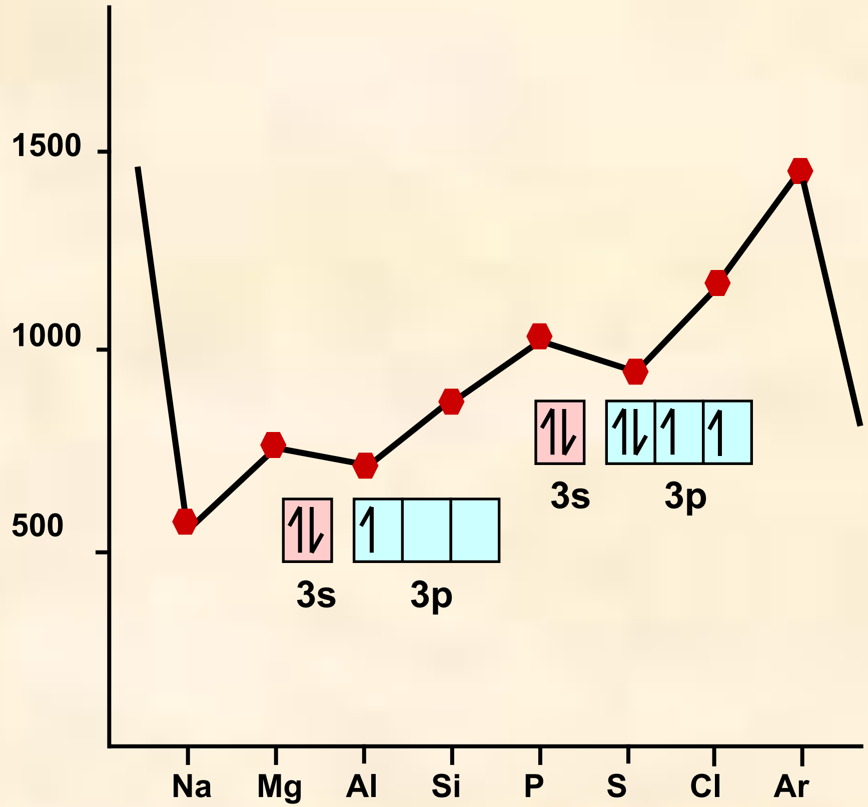
FIRST IONISATION ENERGY

TREND

Theoretically, the value should increase steadily across the period due to the increased nuclear charge. HOWEVER...

There is a DROP in the value for aluminium because the extra electron has gone into a 3p orbital. The increased shielding makes the electron easier to remove.

There is a DROP in the value for sulphur. The extra electron has paired up with one of the electrons already in one of the 3p orbitals. The repulsive force between the electrons means that less energy is required to remove one of them.



ELECTRICAL CONDUCTIVITY

ELECTRICAL CONDUCTIVITY

Substances conduct electricity when ions or electrons are free to move.

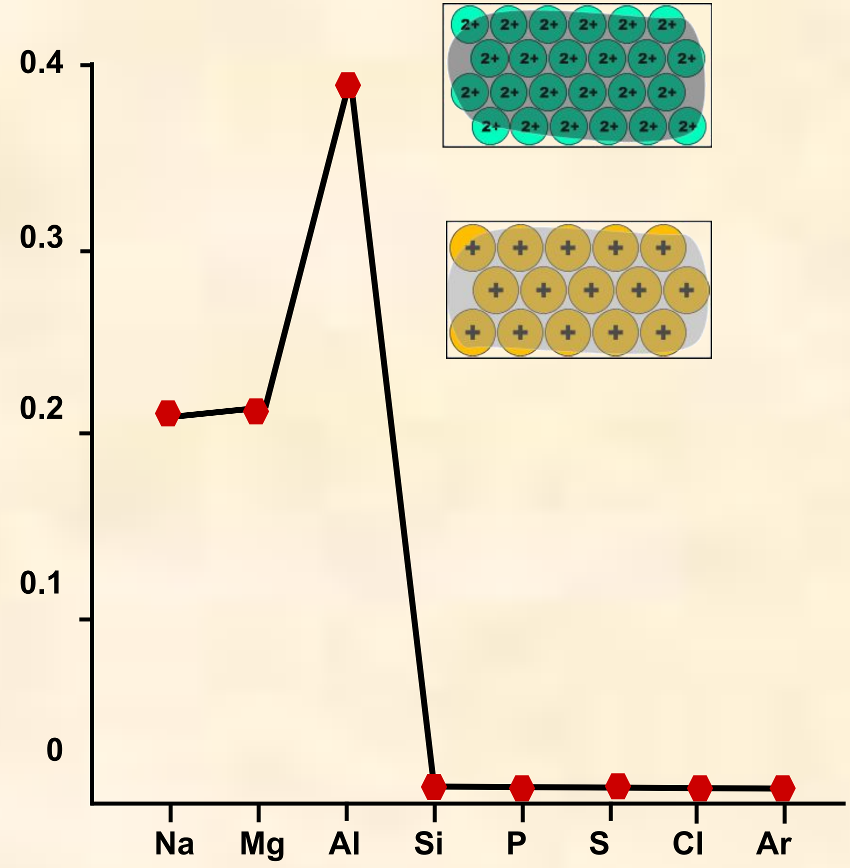
Periods Overall decrease across periods

Na, Mg, Al metallic bonding with delocalised electrons

Si, P, S, Cl covalently bonded - no electrons are free to move

Ar monatomic - electrons are held very tightly

Groups
Where there is any electrical conductivity, it decreases down a group.



UNITS:- Siemens per metre

ELECTRONEGATIVITY

ELECTRONEGATIVITY

"The ability of an atom to attract the pair of electrons in a covalent bond to itself."

A measure of the attraction an atom has for the pair of electrons in a covalent bond.

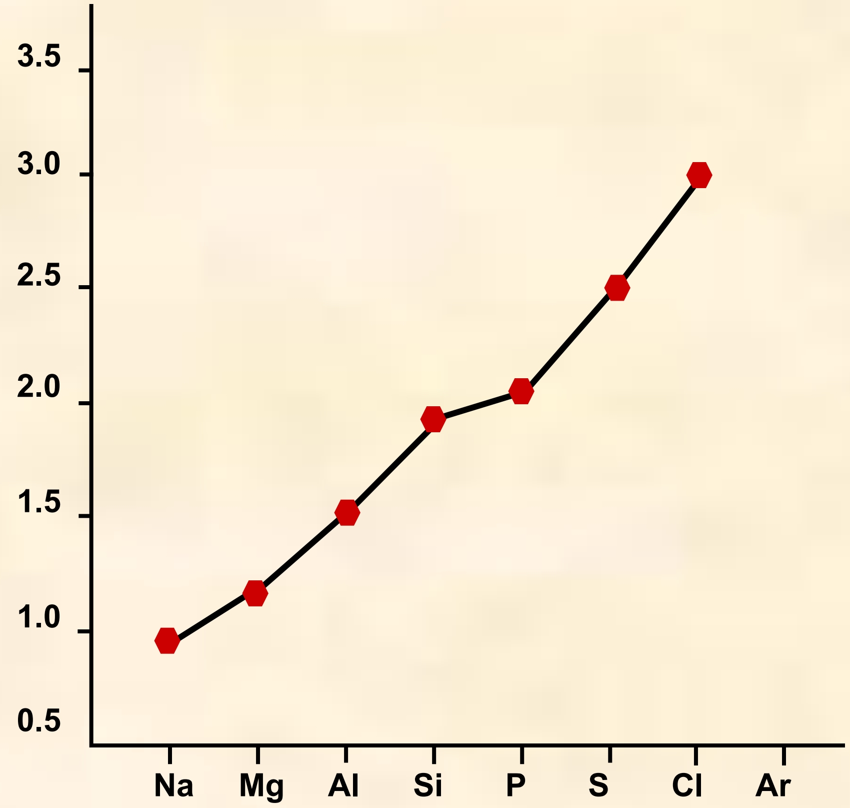
Do not confuse with electron affinity.

Increases across a period...

because the nuclear charge is increasing and therefore so does the attraction for the shared pair of electrons in a covalent bond.

Decreases down a group...

because although the nuclear charge is increasing, the effective nuclear charge is less due to shielding of filled inner shells and a greater distance from the nucleus.



UNITS:- Pauling Scale

MELTING POINT

MELTING POINT

Boiling and melting points are a measure of the energy required to separate the particles in a substance. Bond type is significant.

Periods

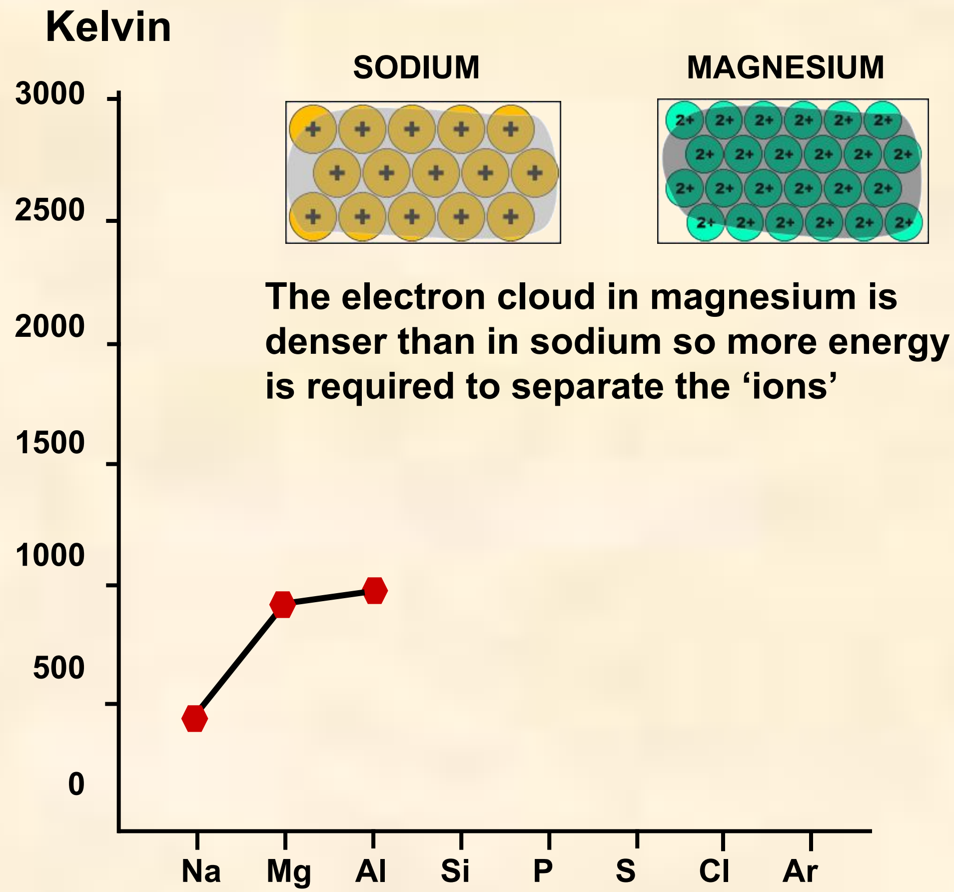
A general increase then a decrease

Metals Na-Al

Melting point increases due to the increasing strength of metallic bonding caused by ...

the larger number of electrons contributing to the "cloud"

larger charge and smaller size of ions gives rise to a larger charge density.



The electron cloud in magnesium is denser than in sodium so more energy is required to separate the 'ions'

MELTING POINT

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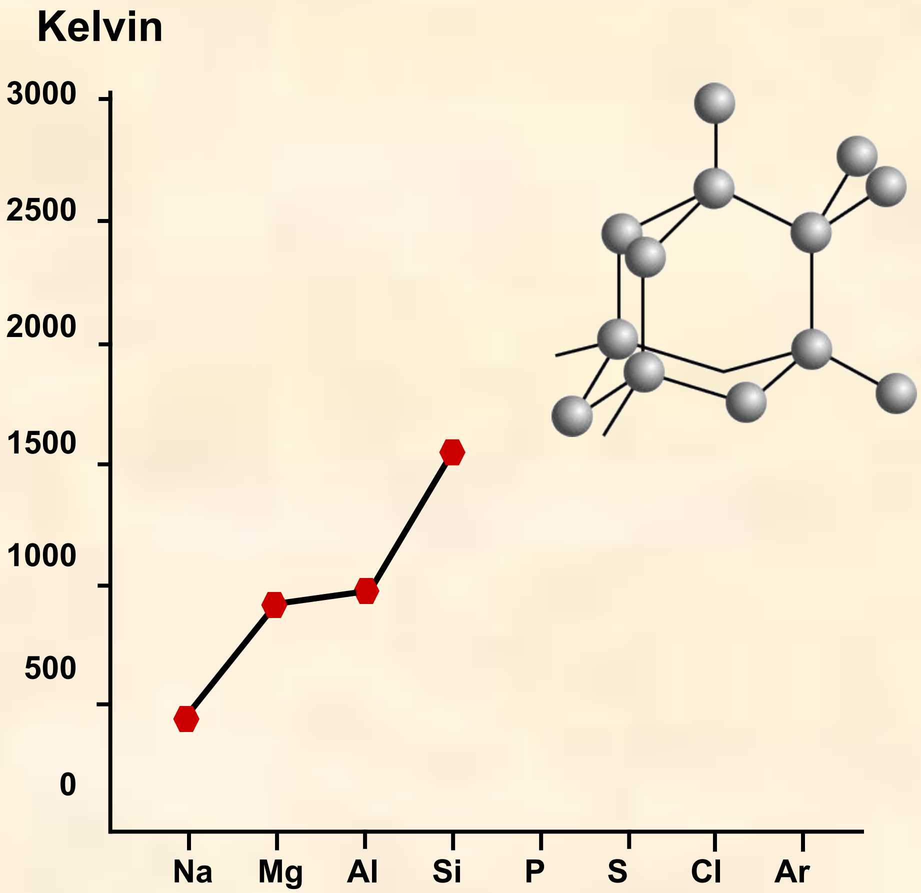
Non-metals Si-Ar

SILICON

Large increase in melting point as it has a giant molecular structure like diamond

A lot of energy is required to break the many covalent bonds holding the atoms together.



MELTING POINT

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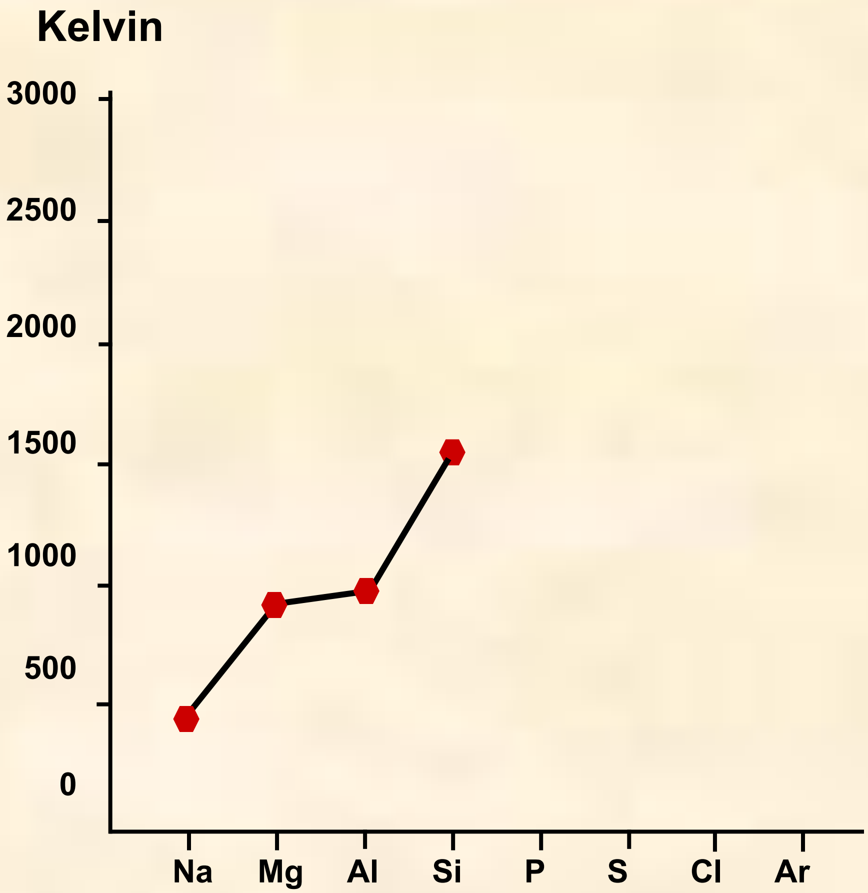
P, S, Cl, Ar

Very much lower melting points as they are simple covalent molecules

Melting point depends on the weak intermolecular van der Waals' forces.

The larger the molecule the greater the van der Waals' forces

	P_4	S_8	Cl_2
relative mass	124	256	71
melting point	44°C	119°C	-101°C



MELTING POINT

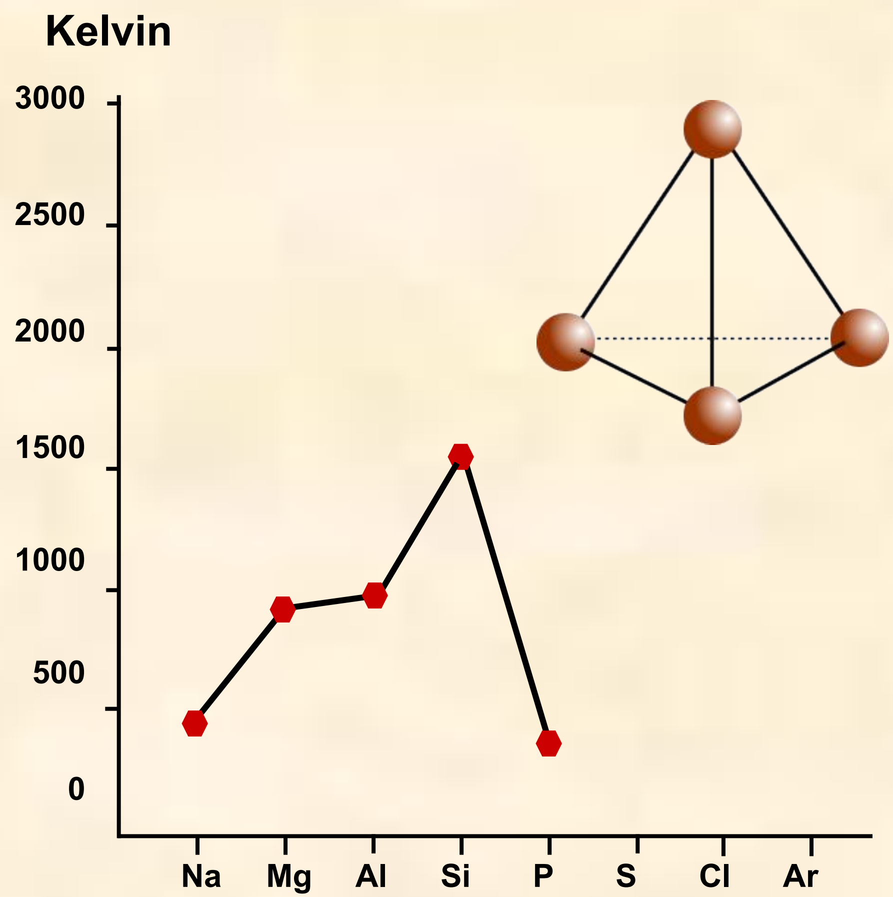
Boiling and melting points are a measure of the energy required to separate the particles in a substance. Bond type is significant.

PHOSPHORUS

can exist is several allotropic forms. In red phosphorus, each molecule exists in a tetrahedral structure. The atoms are joined by covalent bonds within the molecule

formula P_4
relative mass 124
melting point 44°C

Melting point drops dramatically as intermolecular attractions are now due to weak van der Waals' forces.



MELTING POINT

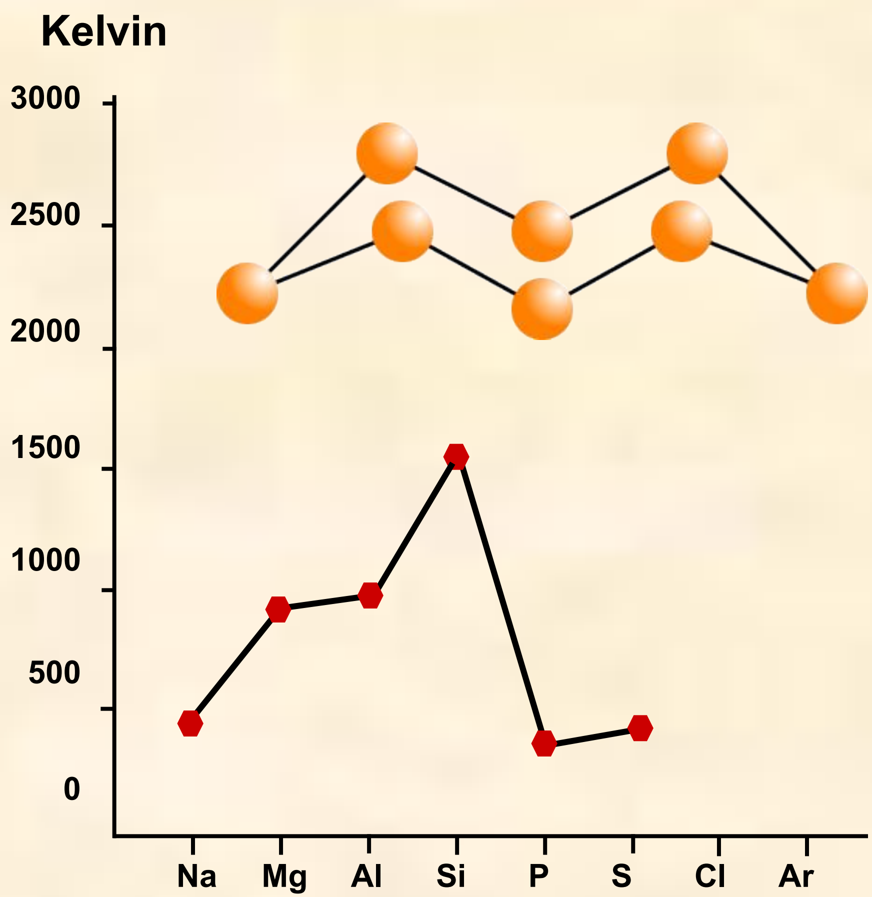
Boiling and melting points are a measure of the energy required to separate the particles in a substance. Bond type is significant.

SULPHUR

can exist is several allotropic forms. Molecule can exist in a **puckered eight membered ring** structure. The atoms are joined by covalent bonds within the molecule

formula S_8
relative mass 256
melting point 119°C

Melting point rises slightly as the molecule is bigger so has slightly stronger van der Waals' forces.



MELTING POINT

Boiling and melting points are a measure of the energy required to separate the particles in a substance. Bond type is significant.

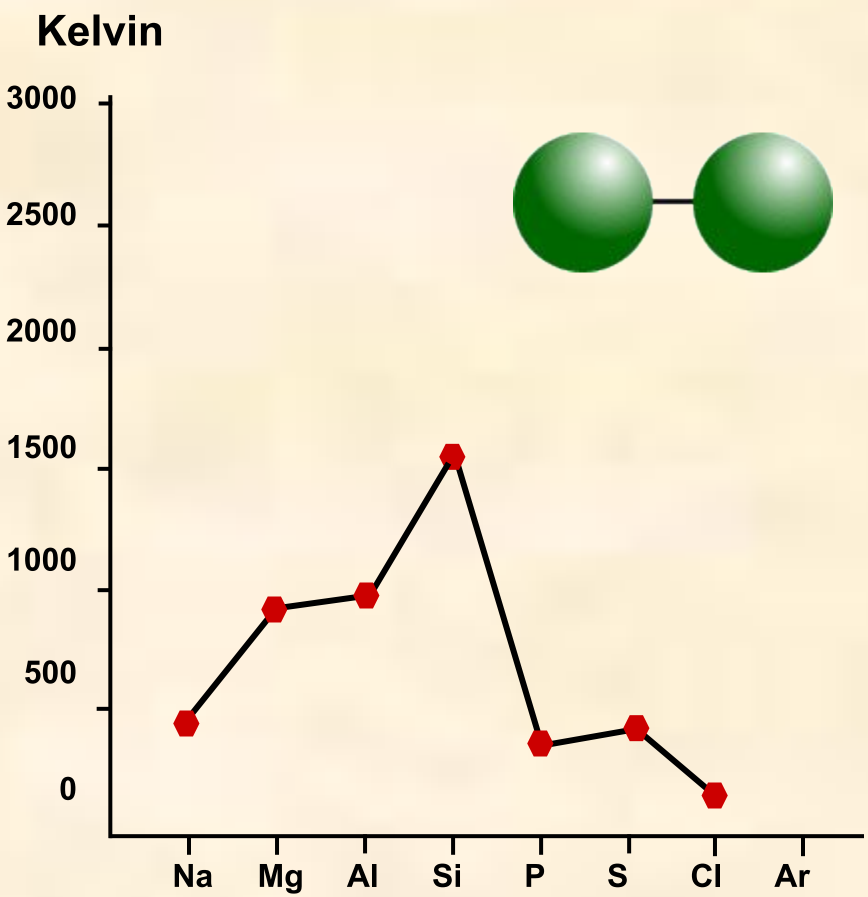
CHLORINE

Exists as a linear diatomic molecule.

The atoms are joined by covalent bonds within the molecule

formula Cl_2
relative mass 71
melting point -101°C

Melting point falls slightly as the molecule is smaller so has slightly lower van der Waals' forces.



MELTING POINT

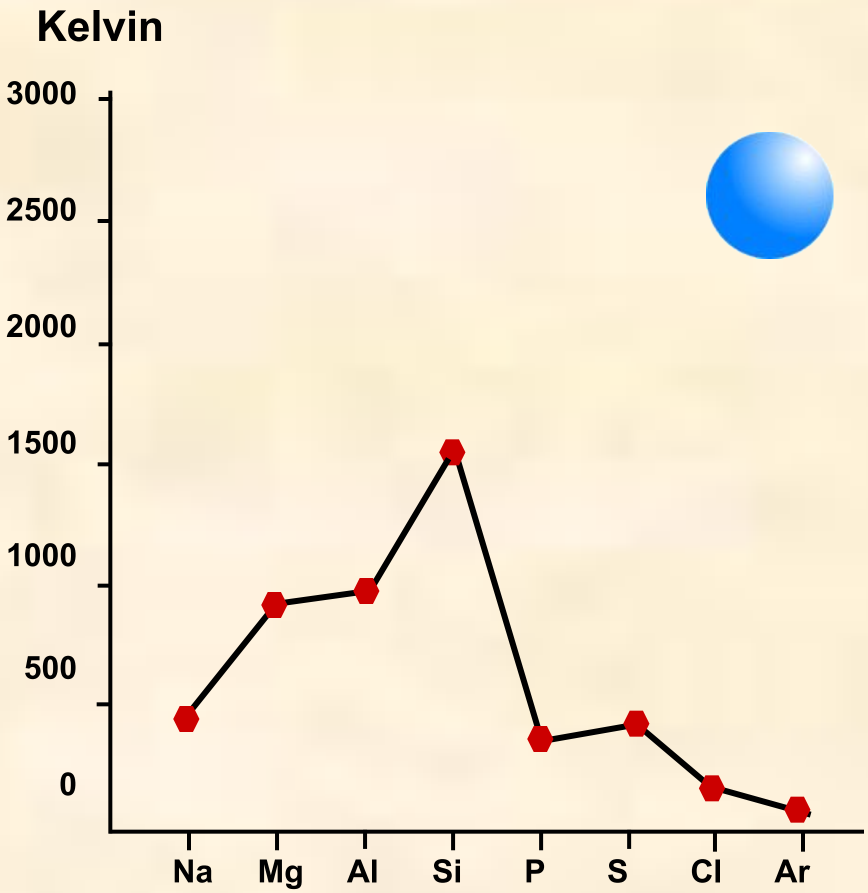
Boiling and melting points are a measure of the energy required to separate the particles in a substance. Bond type is significant.

ARGON

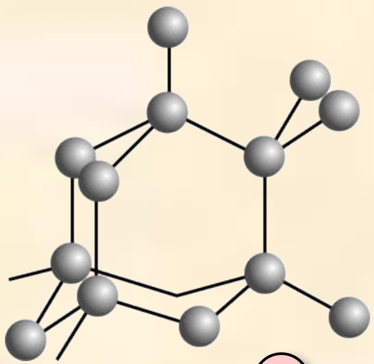
Exists as a monatomic species.

formula	Ar
relative mass	40
melting point	-189 °C

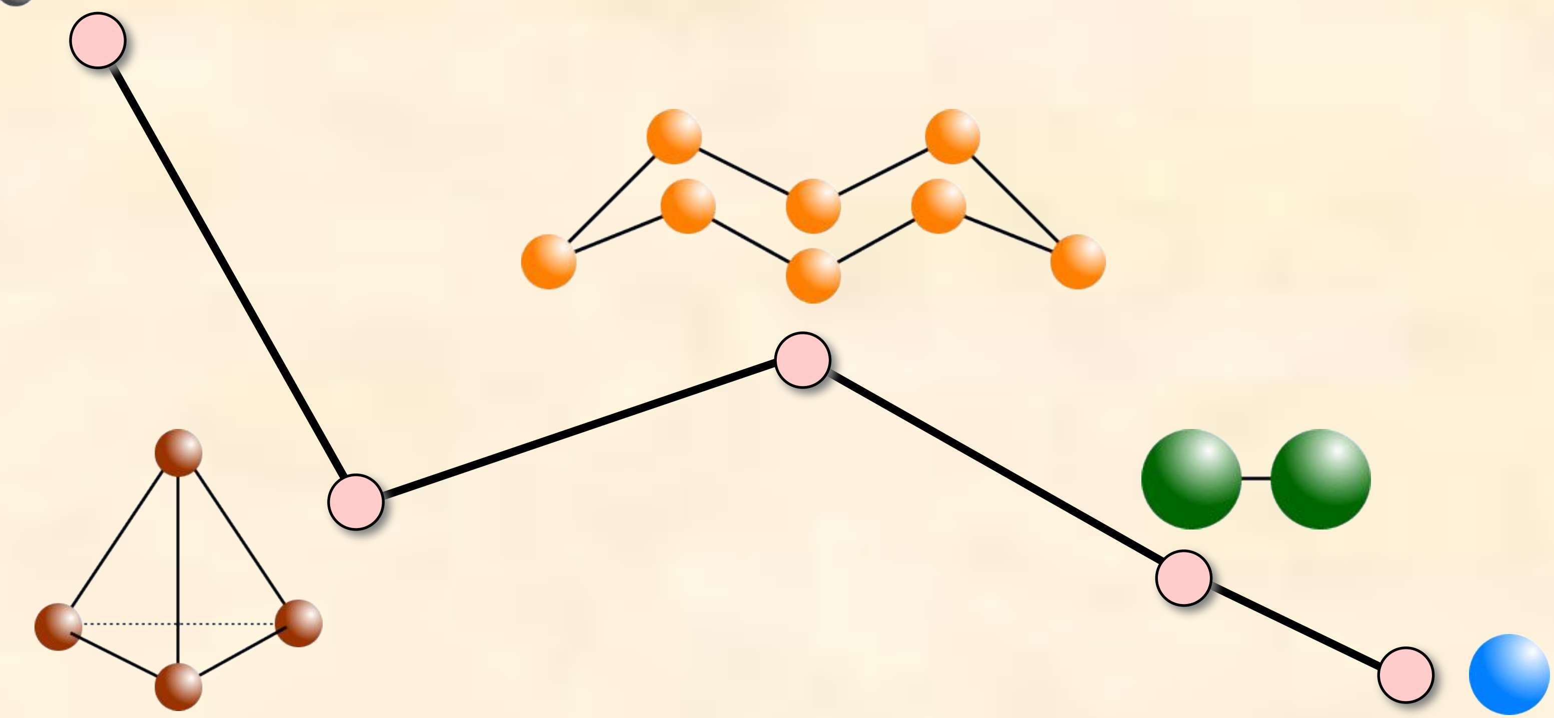
Melting point falls.



MELTING POINT TREND - NON METALS



	P_4	S_8	Cl_2	Ar	
relative mass		124	256	71	40
melting point / K		317	392	172	84

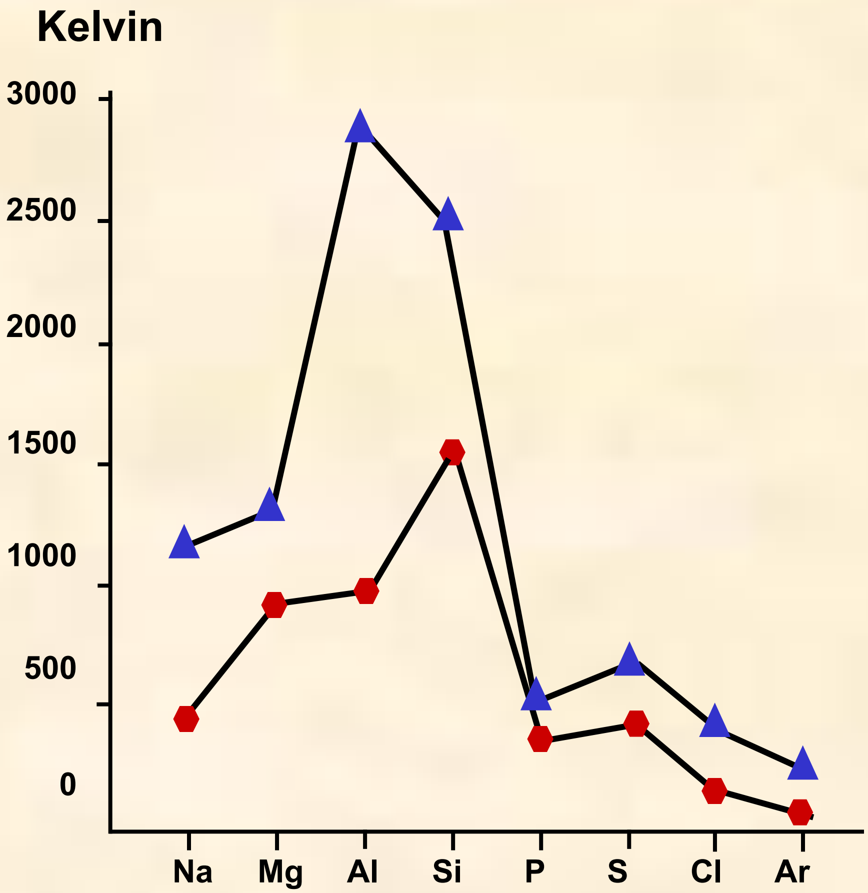


BOILING POINT

Boiling and melting points are a measure of the energy required to separate the particles in a substance. Bond type is significant.

Boiling points tend to be a better measure and show better trends because solids can be affected by the crystal structure as well as the type of bonding.

As is expected, the boiling points are higher than the melting points.



REVISION CHECK

What should you be able to do?

Recall and explain the trend in electronic configuration across Period 3

Recall and explain the trend in atomic radius across Period 3

Recall and explain the trend in 1st Ionisation Energy across Period 3

Recall and explain the trend in atomic radius across Period 3

Recall and explain the trend in electronegativity across Period 3

Recall and explain the trend in electrical conductivity of the elements in Period 3

Recall and explain the trend in melting and boiling points of the elements in Period 3

CAN YOU DO ALL OF THESE?

YES

NO

You need to go over the relevant topic(s) again

Click on the button to return to the menu

WELL DONE!

Try some past paper questions

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THE END