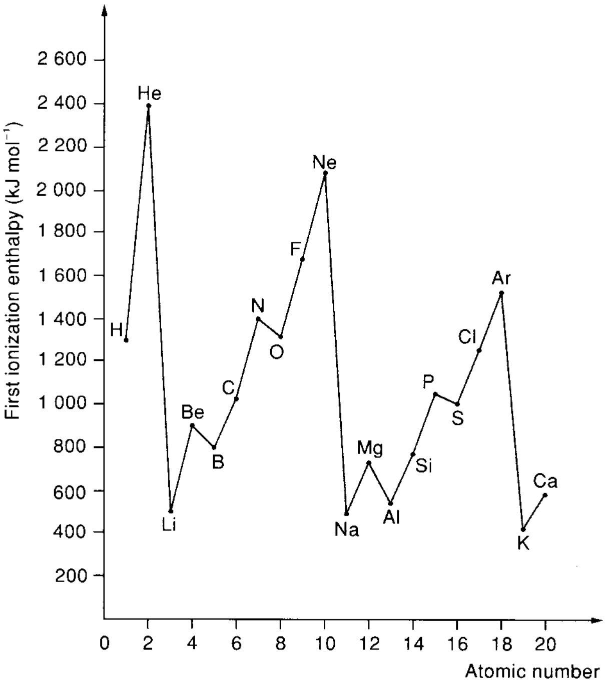
8.1 Periodic Variation in physical properties of the elements H to Ar.

(a) **Variation in first ionization enthalpies**



(i) Explain the variation of first I.E. for the noble gases

(ii) Explain the variation of 1st I.E. for the elements Li to Ne

(iii) The variation of 1st I.E. demonstrates substantial periodicity. Explain the reason for the existence of periodicity for the variation of 1st I.E.

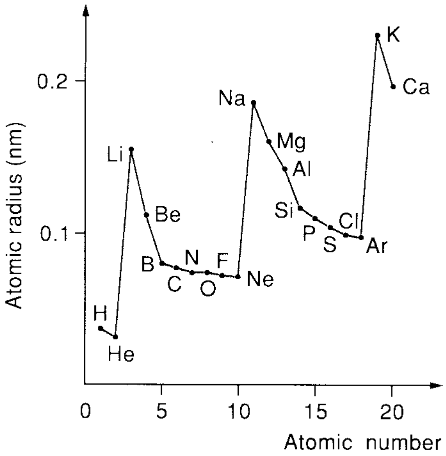
(b) Atomic Radius

There are two factors affecting atomic size.

(1) Attraction of the positively charged nucleus for the electrons

The higher the nuclear charge, the stronger the attraction for the electrons.

(2) Screening of the outer electrons from the nucleus by the inner electrons



(i) Explain why the atomic radii decrease across a period.

(ii) Briefly explain the trend of atomic radii for the group I metals (Li, Na and K)

(c) Electronegativity

The ability of an atom to attract the bonding electrons is called electronegativity.

Some values of electronegativity are shown below

Electronegativity increases →

Electronegativity decreases ↓

		H 2.1						He --
Li 1.0	Be 1.5		B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	Ne --
Na 0.9	Mg 1.2		Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	Ar --
K 0.8	Ca 1.0							

(*b*)

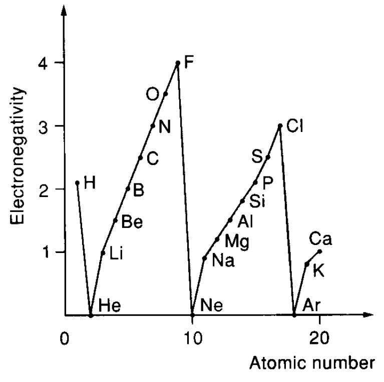


Fig.38-9 (a) Periodic trend of electronegativities (Pauling) (b) Variation of electronegativities with atomic numbers

(i) Across a period, electronegativity ____________ (increase/decrease) as nuclear charges __________ .

(ii) Electronegativity __________ down a group as the number of electron shells __________ .

(d) Melting Point

The melting point is a measure of the ease of breaking the solid lattice.

Some of the melting points of the elements are shown below.

Melting point increases →← Melting point decreases

↓ Melting Point decreases

↑ Melting Point decreases

		H -259						He -270
Li 180	Be 1280		B 2300	C 3730	N -210	O -218	F -220	Ne -249
Na 97.8	Mg 650		Al 660	Si 1410	P 44.2	S 119	Cl -101	Ar -189
K 63.7	Ca 850							

Unit : °C

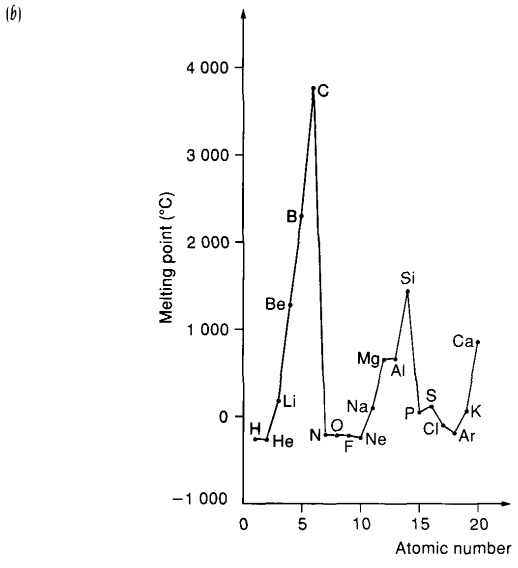


Fig.38-10 (a) Periodic trend of melting points (b) Variation of melting points with atomic numbers

The Periodicity of the melting points are in fact dependent very much on the type of bonding. The pattern shown in the above diagram can be explained on the basis of elements having three different types of structures

Structure	Type of bonding to be broken during melting	Group
Metallic	Metallic Bond	I, II & III
Giant Molecular	Covalent Bond	IV
Simple Molecular	Weak van der Waal’s forces	V, VI, VII & 0

(i) There is a gradual increase in melting points going from Group I to Group III. This is due to the increase in the number of valence electrons which in turn increases the strength of metallic bonding.

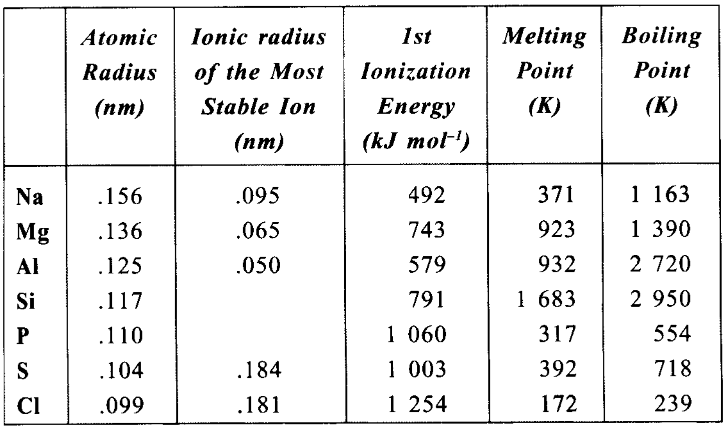
(ii) Group IV elements show a maximum in melting point on account of a strong giant molecular lattice. Strong covalent bonds have to be broken to melt the elements.

(iii) Group V to 0 elements show considerably lower melting points. These elements are bonded with weak van der Waal's forces only.

A summary on the physical properties of elements

Property	Across a Period	Down a Group
1st Ionization Energy		
Atomic Radius		
Electronegativity		
Melting Points	(Groups I to IV) (Groups V to 0)	(Groups I to IV) (Groups V to 0)

Classwork



	Atomic Radius (nm)	*Ionic radius of the Most Stable Ion (nm)*	*1st Ionization Energy (kJ mol^{-1})*	*Melting Point (K)*	*Boiling Point (K)*
Na	.156	.095	492	371	1 163
Mg	.136	.065	743	923	1 390
Al	.125	.050	579	932	2 720
Si	.117		791	1 683	2 950
P	.110		1 060	317	554
S	.104	.184	1 003	392	718
Cl	.099	.181	1 254	172	239

(a) Give the reason for the decrease in atomic radii across the Periodic Table.

(b) Compare the corresponding values of ionic and atomic radii and comment on the differences.

(c) Explain why there is a general trend in 1st ionization energies and suggest explanations for each of the discrepancies.

(d) What are the factors that influence the melting points shown in the table?

(e) The boiling points of sodium, magnesium and aluminium are much higher than their melting points. This is not the case for phosphorus, sulphur and chlorine. Why is this?

8.2 Periodic relationship among the oxides, chlorides and simple hydrides of the elements Li to Cl

Hydrides

Hydrides of Periods 2 and 3 are grouped according to their nature of bonding. They can be classified into four types :

1. ionic hydrides;
2. covalent hydrides with some ionic character;
3. typical covalent hydrides
4. polar covalent hydrides.

Period 2	LiH	BeH_2	B_2H_6	CH_4	NH_3	H_2O	HF
Period 3	NaH	NaH	AlH_3	SiH_4	PH_3	H_2S	HCl
	Ionic hydrides	Covalent hydrides with ionic character		Typical covalent hydrides		Polar covalent hydrides	

The structure of the hydrides varies from crystalline ionic lattices to gaseous covalent molecules. It is due to the increase in the electronegativity of the elements across the period.

Reaction of hydrides with water

Reaction of the hydrides with water (i.e. hydrolysis) depends on the type of bonding for the compounds. This is correlated with the position of the elements in the Periodic Table and the structure of the hydrides.

Ionic Hydrides

The hydrides formed by Group I metals are ionic hydrides. They react with water to give hydrogen gas and leave behind the hydroxide solution.

Covalent Hydrides with some ionic character

Group II and III hydrides are covalent hydrides with some ionic character.
They react with water to give hydrogen gas and hydroxide solution.

Typical Covalent hydrides

Group IV elements and phosphorus of Group V form covalent hydrides.
These hydrides do not dissolve nor react with polar water molecules. They are non-polar molecules.

Polar Covalent Hydrides

Hydrides of group V, group VI and group VII are polar covalent hydrides.

(a) Group V
NH_3 reacts with water to form an alkaline solution.
Eqn:

(b) Group VI
H_2S reacts with water to form an acidic solution.
Eqn.

(c) Group VII
HF and HCl dissolve in water to form strongly acidic solutions.
Eqns.

Oxides

Across Periods 2 and 3, the oxides change from strongly basic to amphoteric and then strongly acidic in step with the change in type of bonding from ionic to covalent.

Oxides of Periods 2 and 3 elements are grouped into three types according to the nature of their bonding.

(1) ionic oxides;

(2) ionic oxides with high covalent character;

(3) covalent oxides.

The acid strengths of oxides increase with increasing percentages of oxygen in the oxides as the partial positive charges on the central atom increase, thus increasing the electron accepting ability of the central atom.

Period 2	Li_2O	BeO	B_2O_3	CO_2	NO_2	O_2	F_2O
				CO	N_2O etc		
Period 3	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_3	Cl_2O_7
	Na_2O_2				P_4O_6	SO_2	Cl_2O etc
	Ionic oxides		Ionic oxides with high covalent character	Covalent oxides			

Reaction of oxides with water

Ionic oxides

Ionic oxides are basic, when dissolved, the oxide ion abstracts a proton from a water molecule to form 2 hydroxide ions.

Ionic oxides with high covalent character

These oxides are amphoteric. A good example is provided by aluminium oxide, which reacts with both acids and alkali. However, aluminium oxide is insoluble in water.

Covalent oxides

Group IV oxides are neutral or acidic, depending on the actual stoichiometry.

Group V, VI and VII oxides are mostly acidic.

Chlorides

Chlorides of Periods 2 and 3 elements can be grouped according to the nature of their bonding. There are three types of chlorides

(1) Ionic chlorides;
(2) intermediate chlorides with high covalent character;
(3) covalent chlorides.

Period 2	LiCl	$BeCl_2$	BCl_3	CCl_4	NCl_3	OCl_2	ClF
Period 3	NaCl	$MgCl_2$	$AlCl_3$	$SiCl_4$	PCl_5	S_2Cl_2	Cl_2
					PCl_3	SCl_2	
	Ionic chlorides		Intermediate chlorides with high covalent character	Covalent chlorides			

Reaction of chloride with water

Ionic Chlorides

Group I chlorides simply dissolve in water without any hydrolysis.

Intermediate chlorides with high covalent character

$BeCl_2$ and $AlCl_3$ are good examples of intermediate chlorides.

Both chlorides hydrolyse in water to form hydroxides and hydrogen chloride

Covalent chlorides

Covalent chlorides react to give a variety of products.

The extent to which chlorides are hydrolysed increases with the degrees of covalent character of the chlorides.