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# PERIODIC TABLE

## 4.2 Periodicity

### Lecture 6





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# LEARNING OUTCOMES

- Describe the periodicity of elements across period 3 and down groups 1 and 17 for the following physical properties:
  - i. metallic character
  - ii. melting point
  - iii. boiling point
- Describe and explain the acid-base character of oxides of elements in period 3.




## 4.2.8 Physical Properties down the Groups 1 and 17

- i) **Metallic character (group 1 & 17)**
- Metallic character is closely related to **atomic radius** and **ionization energy**.
  - The **easier** it is to **remove** electrons from an atom, the **more metallic** the element.
  - **Easy removal** of electrons corresponds to **large atomic radius** and **low ionization energy**.
  - Metallic character **increases down a group** and **decreases across a period** of the periodic table.


## 4.2.8 General properties of group 1 elements

- All elements in group 1 are **reactive metals**
- Melting and boiling points of group 1:



1
H 1
Li 3
Na 11
K 19
Rb 37
Cs 55
Fr 87

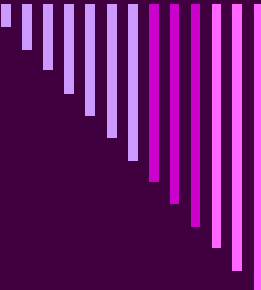
DECREASE ↓	1	Melting point [°C]	Boiling point [°C]
	Li 3	180	1340
	Na 11	98	881
	K 19	64	765
	Rb 37	39	688
	Cs 55	28	705



1
H 1
Li 3
Na 11
K 19
Rb 37
Cs 55
Fr 87

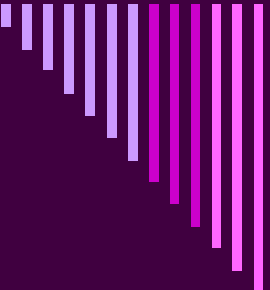
- Going down the group, the melting and boiling points of the elements **decrease**.
  - As we go down the group, the **size of atoms increases**; which caused the electron to be **less attracted** to the nucleus. Therefore the metallic bond is **weaker** as we go down the group.

## 4.2.8 Properties of Halogens



17
F 9
Cl 17
Br 35
I 53

- All the halogens exist as **diatom**,  $X_2$ .
- They have valence electrons with the configuration of  $ns^2np^5$ .
- This allows them to form **covalent bond** between atoms in order to achieve **noble gas configuration**.



17	Melting point [°C]	Boiling point [°C]
F 9	-217	-88
Cl 17	-101	-34
Br 35	-76	0
I 53	114	185

INCREASE  
↓

- Their physical properties change gradually as we go down the group.
- **Descending a group**, the melting and boiling points increase.
- This is related to the **increasing strength of van der Waals forces** with increasing size or **relative molecular mass**.
- Thus, **F and Cl are gases, Br is a liquid and I is a solid**



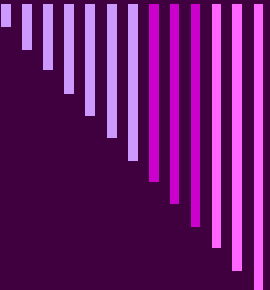
## 4.2.8 Physical Properties Across Period 3

### i) The melting / boiling point

- The melting / boiling point of a substance depends greatly on the type of **intermolecular forces** or bondings involved.

Element	Na	Mg	Al	Si	P	S	Cl	Ar
Melting point (°C)	97.8	651	660	1410	44	119	-101	-189
Boiling point (°C)	892	1107	2467	2680	280	445	-34.5	-186

Table 3.1: Melting and boiling point of elements in period 3



Variation of melting and boiling point of elements in period 3 can be discussed in 3 parts:

a) **Metallic structure (Na to Al)**

Metallic crystals have **positive metal ions attracted by electrons** in a **cloud** - metallic bonding.

**Strength of metallic bonding is proportional to the number of valence electrons.**

- Na-1 valence electron
- Mg- 2 valence electrons
- Al- 3 valence electrons

The more valence electrons,  
the stronger the metallic  
bonding and the higher  
melting / boiling point



## b) **Gigantic molecular structure (Si)**

- Silicon is made up of atoms that are tetrahedrally **covalent bonded** to other Si atoms at neighboring lattice sites.
- The result is a **crystal** that is essentially one **gigantic molecule**.
- Melting and boiling point of Si is **very high** because of the **strong attractions** between covalently bonded atoms.
- **High energy is needed to break the strong covalent bonding** in melting or boiling.



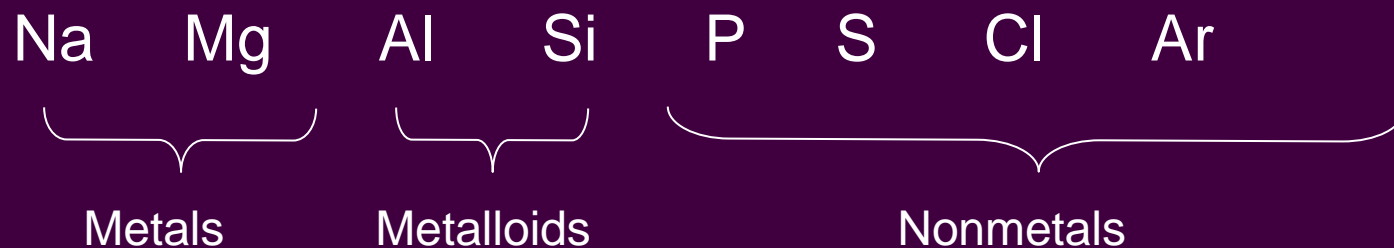
### c) Simple molecular structure ( P to Ar)

- These are mainly the **nonmetal** that exist as **molecules** of  $P_4$ ,  $S_8$ ,  $Cl_2$  and Ar (monoatom).
- The covalent bond between the atoms is very strong but the **intermolecular force**, that is, Van der Waals, is **very weak**.
- Van der Waals force is **proportional to molecular size (relative molecular mass)**.
- Molecular size:  $Ar < Cl_2 < P_4 < S_8$   
therefore melting / boiling point :  
 $Ar < Cl < P < S$



## 4.2.9 Acid-base character of oxides of Period 3

□ For Period 3:



□ Generally, when react with oxygen, **metal** will form **basic oxide** and **nonmetal** will form **acidic oxide**.; **metalloid** will form **amphoteric (both acidic and basic) oxide**.

## Acid-base behavior of oxides of Period 3

	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	P <sub>4</sub> O <sub>10</sub> (or P <sub>4</sub> O <sub>6</sub> )	SO <sub>3</sub> (or SO <sub>2</sub> )	Cl <sub>2</sub> O <sub>7</sub>
Adding H <sub>2</sub> O	Na <sub>2</sub> O + H <sub>2</sub> O → 2NaOH	MgO + H <sub>2</sub> O → Mg(OH) <sub>2</sub>	Insoluble	Insoluble	P <sub>4</sub> O <sub>10</sub> + 6H <sub>2</sub> O → 4H <sub>3</sub> PO <sub>4</sub>	SO <sub>3</sub> + H <sub>2</sub> O → H <sub>2</sub> SO <sub>4</sub>	Cl <sub>2</sub> O <sub>7</sub> + H <sub>2</sub> O → HClO <sub>4</sub>
Adding HCl	Na <sub>2</sub> O + H <sup>+</sup> → 2Na <sup>+</sup> + H <sub>2</sub> O	MgO + 2H <sup>+</sup> → Mg <sup>2+</sup> + H <sub>2</sub> O	Al <sub>2</sub> O <sub>3</sub> + 6H <sup>+</sup> → 2Al <sup>3+</sup> + 3H <sub>2</sub> O	No reaction	No reaction	No reaction	No reaction
Adding NaOH	No reaction	No reaction	Al <sub>2</sub> O <sub>3</sub> + 2OH <sup>-</sup> + 3H <sub>2</sub> O → 2Al(OH) <sub>4</sub> <sup>-</sup>	SiO <sub>2</sub> + 2OH <sup>-</sup> → SiO <sub>3</sub> <sup>2-</sup> + H <sub>2</sub> O	P <sub>4</sub> O <sub>10</sub> + 12OH <sup>-</sup> → 4PO <sub>4</sub> <sup>3-</sup> + 6H <sub>2</sub> O	SO <sub>3</sub> + OH <sup>-</sup> → SO <sub>4</sub> <sup>2-</sup> + H <sub>2</sub> O	Cl <sub>2</sub> O <sub>7</sub> + OH <sup>-</sup> → 2ClO <sub>4</sub> <sup>-</sup> + H <sub>2</sub> O
Nature	Basic Oxide	Basic Oxide	Amphote ric Oxide	Acidic Oxide	Acidic Oxide	Acidic Oxide	Acidic Oxide

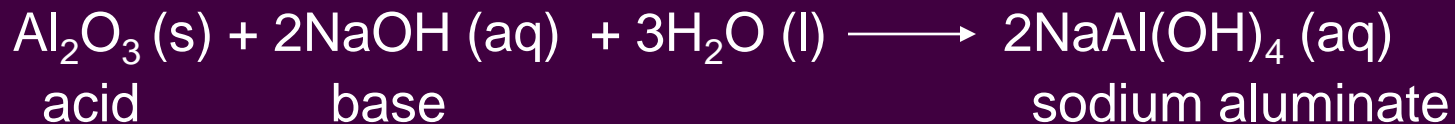
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- **Na** reacts with oxygen to form **basic oxide**. The oxide will produce base when react with water.



- **Mg** burns in oxygen to form **basic oxide**, MgO.



- **Al** forms **amphoteric oxide**, oxide that can react with either an acid or a base.

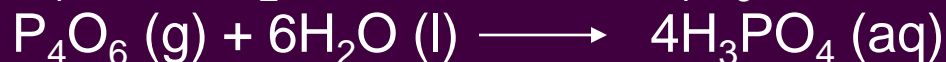


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- **Silicon** burns in oxygen to form **acidic oxide**.



acidic

- **Phosphorus** burns in oxygen to form **acidic oxide**.



phosphorus acid



phosphoric acid

- **Sulphur** burns in oxygen to form **acidic oxide**.



acid

base

- $\text{Cl}_2\text{O}_7 \text{ (g)} + \text{H}_2\text{O (l)} \longrightarrow 2\text{HClO}_4 \text{ (aq)}$

perchloric acid