

# **PERIODIC TABLE**

## **4.2 Periodicity**

(Lecture 4)

- At the end of the lesson the students should be able to :
  - (a) Deduce the electronic configuration of an element and its position in the periodic table based on successive ionisation energy data.

## **LEARNING OUTCOMES**

## 4.2.5 Determination the electronic configuration of an atom using successive ionization energies

- In general, successive ionization energies always increase because each subsequent electron is being pulled away from an **increasingly more positive ion**, and that requires more work.
- A **large** increase in successive ionization energies occurs between the removal of the **last valence electron** and the removal of the **first core electron**.

# Ionization energies elements (kJ mo<sup>-1</sup>)

	first	second	third	fourth	fifth	sixth	seventh
Li	520	7297	11810	-	-	-	-
Be	900	1757	14840	21000	-	-	-
B	800	2430	3659	25020	32810	-	-
C	1086	2352	4619	6221	37800	47300	-
N	1402	2857	4577	7473	9443	53250	64340
O	1314	3391	5301	7468	10980	13320	71300

- Therefore, we can determine the electronic configuration of the valence electron for an element M using following methods:
- **Method 1:-**  
By determining the IE ratios
- **Method 2:-**  
By determining the differences in ionization energy:

### Example 3.2.3.

Be:  $1s^2 2s^2$

IE	1	2	3	4
(kJmol <sup>-1</sup> )	899	1757	14845	21000


- Method 1:-

By determining the IE ratios:

$$\frac{IE_2}{IE_1} = \frac{1757}{899} = 1.95$$

$$\frac{IE_3}{IE_2} = \frac{14845}{1757} = 8.45$$

$$\frac{IE_4}{IE_3} = \frac{21000}{14845} = 1.41$$

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- The first and second electron are removed from the same energy subshell (2s).
  - The third electron is removed from an inner subshell that is 1s, hence it requires a higher IE3 (8.45 times) than IE2.
  - Since  $IE3 / IE2$  have the highest ratio, 2 valence electrons are present.
  - Electron configuration:  $ns^2$
  - This element is Be: Group 2

- Method 2:-

By determining the differences in ionization energy:

$$IE_2 - IE_1 = 858 \text{ kJ mol}^{-1}$$

$$IE_3 - IE_2 = \mathbf{13088} \text{ kJ mol}^{-1}$$

$$IE_4 - IE_3 = 6155 \text{ kJ mol}^{-1}$$

- The first and second electron are removed from the same energy subshell (2s).
- The third electron is removed from an inner subshell that is 1s, hence it requires a higher IE<sub>3</sub> than IE<sub>2</sub> (a difference of 13088 kJmol<sup>-1</sup>).
- Since IE<sub>3</sub> - IE<sub>2</sub> have the highest difference, 2 valence electrons are present.
- Electron configuration: ns<sup>2</sup>
- This element is Be: Group 2

### Example 3.2.4:

Five successive ionization energies ( $\text{kJmol}^{-1}$ ) for atom M is shown below:

$\text{IE}_1$	$\text{IE}_2$	$\text{IE}_3$	$\text{IE}_4$	$\text{IE}_5$
800	1580	3230	4360	16000

Determine

- electron configuration of the valence electron for M
- group number of M in the periodic table

By determining the IE ratios:

$$\frac{IE_2}{IE_1} = \frac{1580}{800} = 1.98$$

$$\frac{IE_3}{IE_2} = \frac{3230}{1580} = 2.04$$

$$\frac{IE_4}{IE_3} = \frac{4360}{3230} = 1.35$$

$$\frac{IE_5}{IE_4} = \frac{16000}{4360} = 3.67$$

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- Since the ratio  $IE_5/IE_4$  is the highest, this shows that there are 4 valence electrons in the valence shell.
  - The fifth electron is removed from an inner shell with octet configuration.
  - Electron configuration of valence electron for M is  $ns^2np^2$
- M is in Group 14 at the periodic table