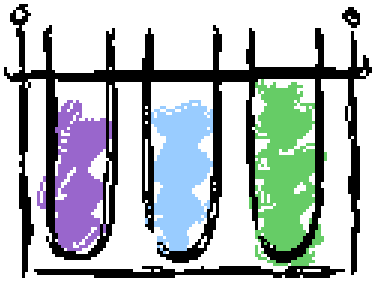


PERIODIC TABLE
4.2 Periodicity

(Lecture 2)

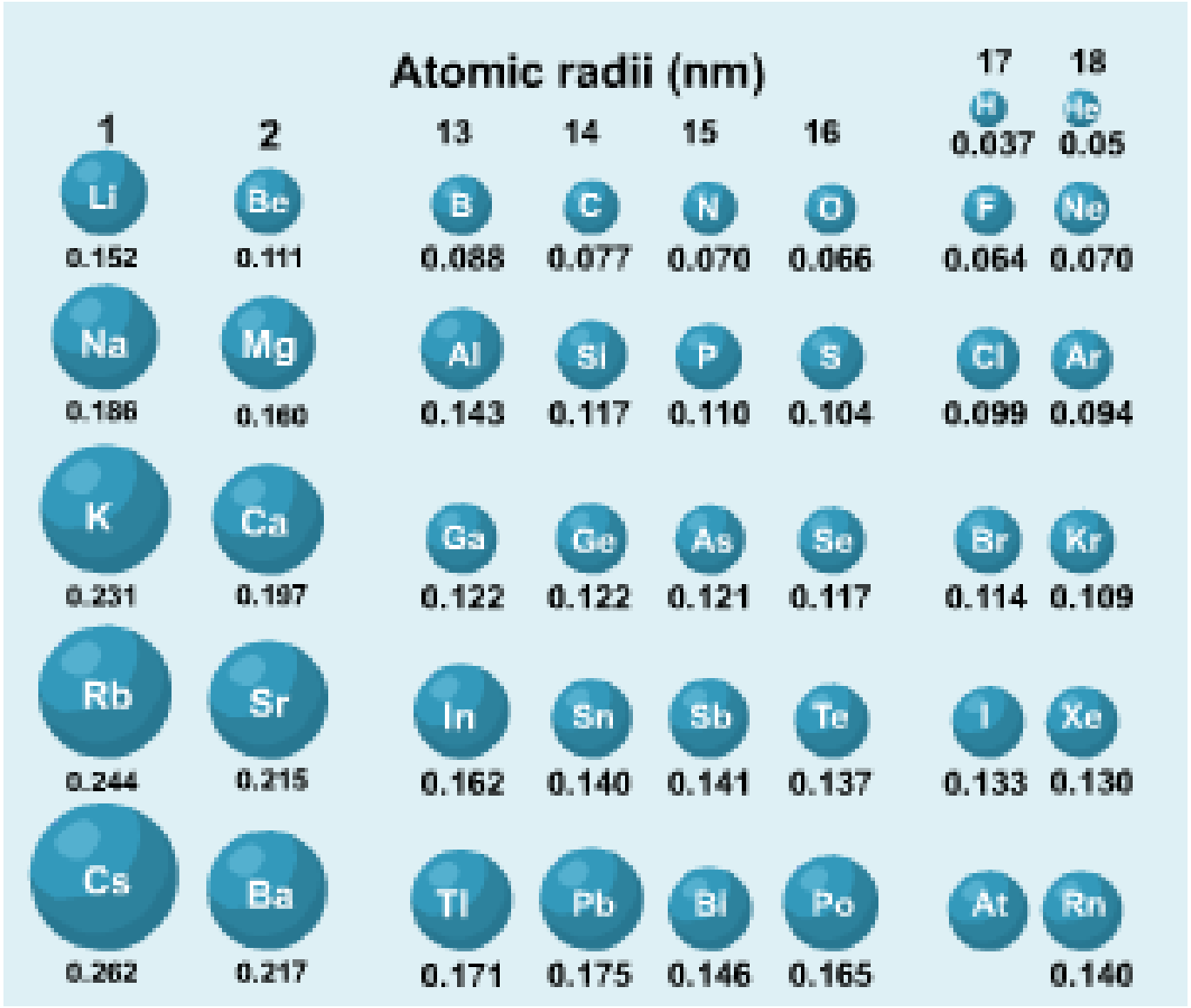
LEARNING OUTCOMES

- At the end of the lesson the students should be able to :

(a) Explain the variation in atomic and ionic radii

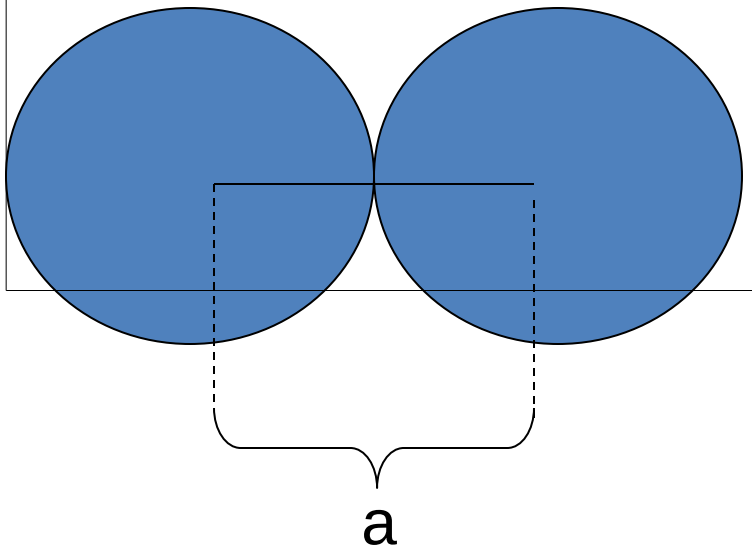
- i. across periods 2 and 3
- ii. across the first row of transition elements.
- iii. down a group.

(b) Explain the variation in the radius of isoelectronic species.


Atomic radii (nm)
1
2
13
14
15
16
17
18
H
0.037
He
0.05
Li
0.152
Be
0.111
B
0.088
C
0.077
N
0.070
O
0.066
F
0.064
Ne
0.070
Na
0.186
Mg
0.160
Al
0.143
Si
0.117
P
0.110
S
0.104
Cl
0.099
Ar
0.094
K
0.231
Ca
0.197
Ga
0.122
Ge
0.122
As
0.121
Se
0.117
Br
0.114
Kr
0.109
Rb
0.244
Sr
0.215
In
0.162
Sn
0.140
Sb
0.141
Te
0.137
I
0.133
Xe
0.130
Cs
0.262
Ba
0.217
Tl
0.171
Pb
0.175
Bi
0.146
Po
0.165
At
Rn
0.140

4.2.1 Variation in atomic and ionic radii

- The size/radius of atom is difficult to be defined exactly because the electron cloud has no clear boundary.
- To solve this, the atomic radius is taken as half of the distance between the nuclei of two adjacent identical atom.
- Example:



Radius, r = a/2 (Å)

Size $\propto$ volume

V = 4/3 πr3 , V $\propto$ r

There are two major factors affecting the size of atom in the Periodic Table:

1)Effective nuclear charge (Z_{eff})

Zeff = Z - S

Z= proton number

S = number of inner or core electrons

2) Value of the principal quantum number of the valence electrons (shielding effect)

4.2.1 Variation in atomic and ionic radii

i) Across the periods 2 & 3 and the first row of transition elements

- The atomic radius of elements is **decreased**.

- REASON:
  - The increase in effective nuclear charge,Z_{eff} due to the **increase in proton number across period. I**ncreasing the effective nuclear charge reduce the size of the orbital by pulling the electron inward. This results in contraction of atomic radius and therefore decrease in atomic size.

  - Outer electrons are being added to the partially occupied shells.

ii) Down within group

- As we go down within group, we observed the increase in size of atoms.
- REASON:
  - Down a group, the additional electrons of each of the element go to a bigger orbitals (larger value of n)
  - Though the valence configuration is the same, the additional inner orbitals leads to an increase in the shielding effect .
  - Hence the size of atom increases.

4.2.1 Variation in atomic and ionic radii

NOTE:

- Across the period, atomic radii decreases
- Down the group, atomic radii increases

4.2.3 Variation in the radius of isoelectronic species

a) Positive ions

- Formed when an atom loses electrons.
- When electrons are removed from the valence shell, the electron-electron repulsions decrease.
- Allows the remaining electrons to be pulled closer together around the nucleus, making the size smaller.
- Cations are smaller than the atoms from which they are formed.

b) Negative ions

- Always larger than the corresponding neutral atom
- Has more electrons than the neutral atom as it gains electron during its formation
- As for halides, the corresponding atom gained an electron and has the configuration of the representative noble gas of the same row.
- The electron-electron repulsions caused the electrons to spread out and experience less attraction for the nucleus.
- Hence the outer orbital expands.

C) Isoelectronic ions

- Atoms or ions with the same electronic configuration are said to be isoelectronic.
- Within isoelectronic series, the more positive the charge, the smaller the species and the more negative the charge, the larger the species.
- Example:

$$N^{3-} > O^{2-} > F^{-} > Na^{+} > Mg^{2+} > Al^{3+} > Si^{4+}$$

Electron configuration: $1s^2\ 2s^2\ 2p^6$

- Across the period, sizes of cations and anions decrease due to the increase of Z_{eff}.
- Ionic radii of $Na^{+} > Mg^{2+} > Al^{3+} > Si^{4+}$.
- They are isoelectronic (10 e) because their electron configurations are the same: $1s^2\ 2s^2\ 2p^6$.
- Ionic radii of $Cl^{-} < S^{2-} < P^{3-}$.
- They are isoelectronic (18 e) because their electronic configurations are the same: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$.
- Z_{eff} decrease, hence, ionic radii increase.