Unit 8

On completion of the unit you should be able to:

1. state the mass, charge and location of protons, electrons and neutrons.
2. given the atomic number of an element, draw diagrams showing the protons in the nucleus and the electrons in shells (or energy levels) around the nucleus.
3. write the electron dot formulae for the elements in groups 1 to 8 in the periodic table.
4. define isotopes, mass number and atomic mass.
5. given the relative abundance and isotopic masses for an element, calculate the atomic mass of that element.
6. given the atomic number and mass number of an element, calculate the number of electrons.

ATOMS AND THE PERIODIC TABLE

8.1 **Atom**

- **Subatomic particles**

8.2 **Isotope**

Reading: Hebden – page 144-146

Today's focus.

8.3 **Arrangement of electrons**

- **Bohr model of the atom**
  Reading: Hebden – page 142
- **Lewis electron-dot formulas of elements**
  Reading: Hebden – page 167
- **Quantum mechanical model of the atom**

8.4 **Electron configurations of atoms**

8.5 **Atomic mass**

- **Tabulated atomic mass**

Reading: Hebden – page 150

8.6 **Periodic table of the elements**

- **Metals Nonmetals and Semimetals**
  - **Properties of metals**
  - **Properties of nonmetals**
  - **Properties of semimetals**

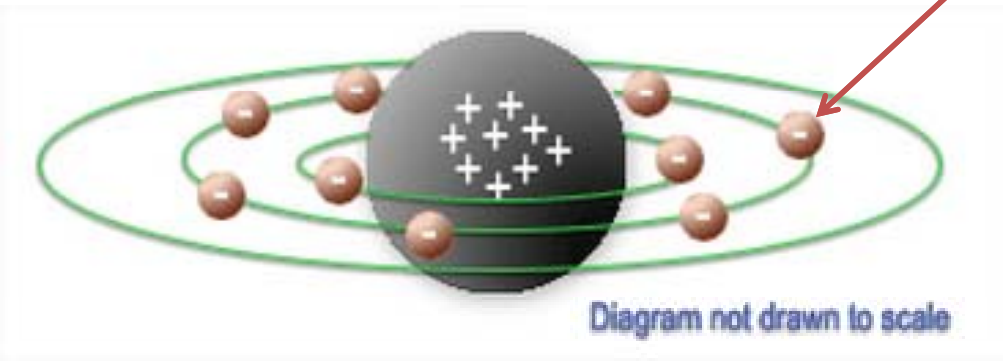
Bohr model of the atom

- Niels Bohr proposed the Bohr Model of the Atom in 1915.

- The Bohr Model has limitations, but it is important because it describes most of the accepted features of atomic theory without all of the high-level math.

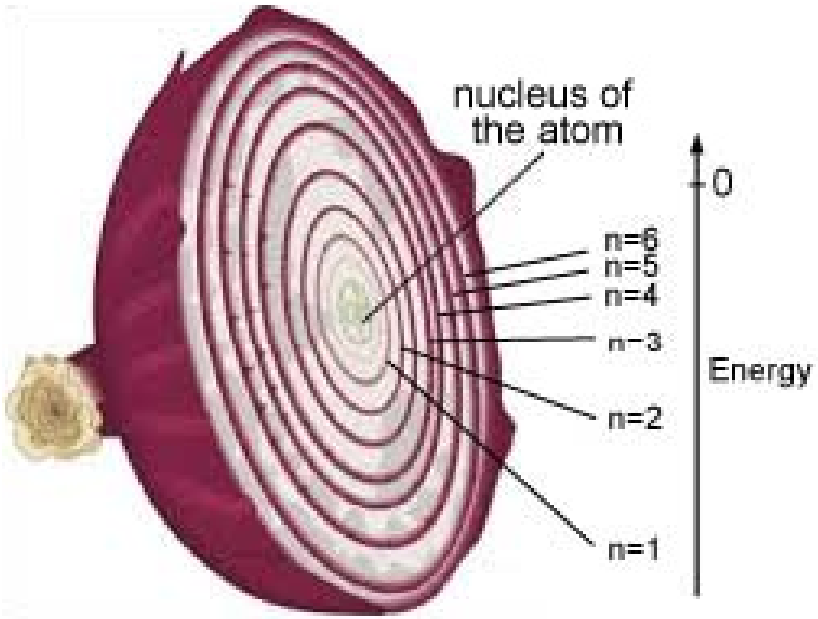
Planetary model

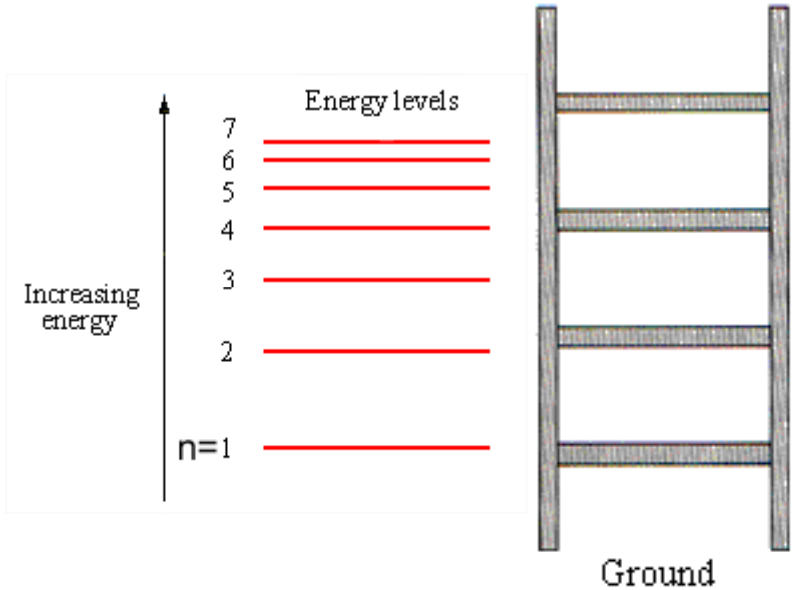
Electrons inside an atom possess different energies.



Bohr model of the atom

- Electrons occupy the shell structure of the atom.





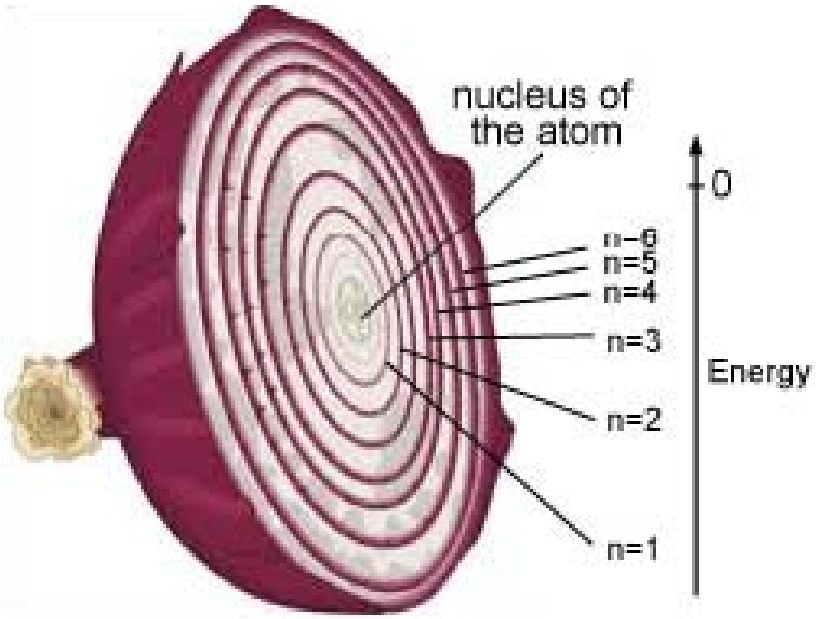
- The lowest energy is found in the innermost shell.

- When electrons start to occupy the shell structure of the atom, they will start to populate the innermost energy level first (n=1), then n=2, n=3, etc.

- Each energy level could only accommodate a certain number of electrons.

Bohr model of the atom

The maximum number of electrons that can populate a certain energy level is given by the following formula.



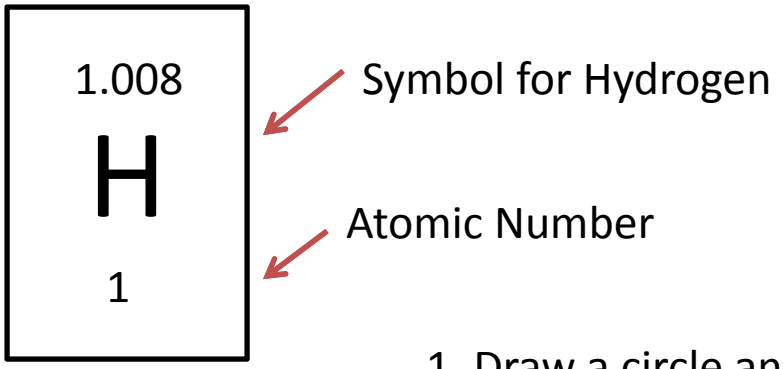
Maximum number of electrons in an energy level $= 2n^2$

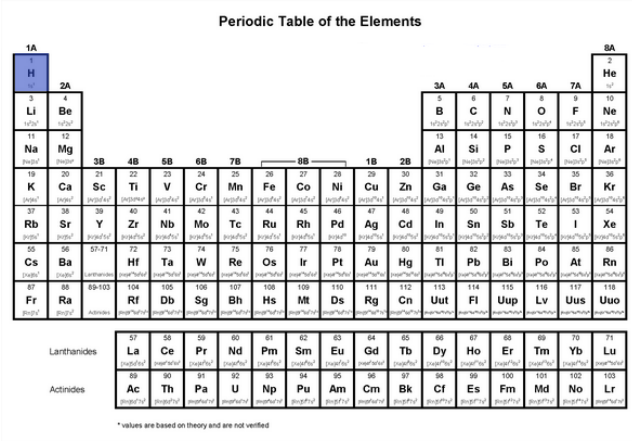
Energy Level	$2\ n^2$	Max # of electrons
n=1	$2\ (1)^2 =$	2 electrons
n=2	$2\ (2)^2 =$	8 electrons
n=3	$2\ (3)^2 =$	18 electrons
n=4	$2\ (4)^2 =$	32 electrons
n=5	$2\ (5)^2 =$	50 electrons
n=6	$2\ (6)^2 =$	72 electrons
n=7	$2\ (7)^2 =$	98 electrons

Let's draw Bohr diagrams!

Bohr Diagram for Hydrogen

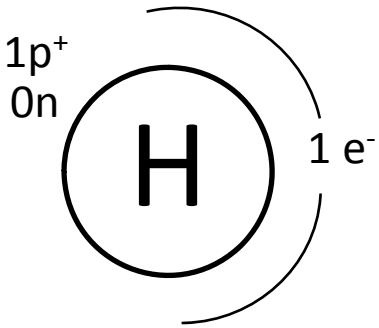
The Hydrogen atom





Hydrogen	
# of protons	1
# of neutrons	0
# of electrons	1
Mass number (#p + #n)	1

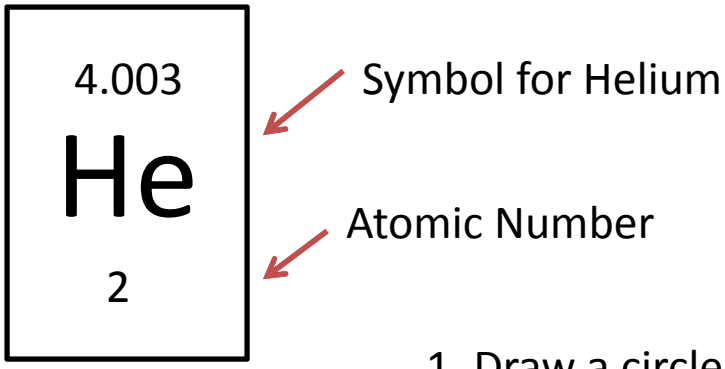
1. Draw a circle and label it with the symbol of the nucleus, H.
2. Write the number of protons for the nucleus, $1p^+$.
3. Write the number of neutrons for the nucleus, 0n.
4. Draw an arc to represent the 1st energy level. Label the arc $1e^-$ to represent that there is one electron in this 1st energy level.

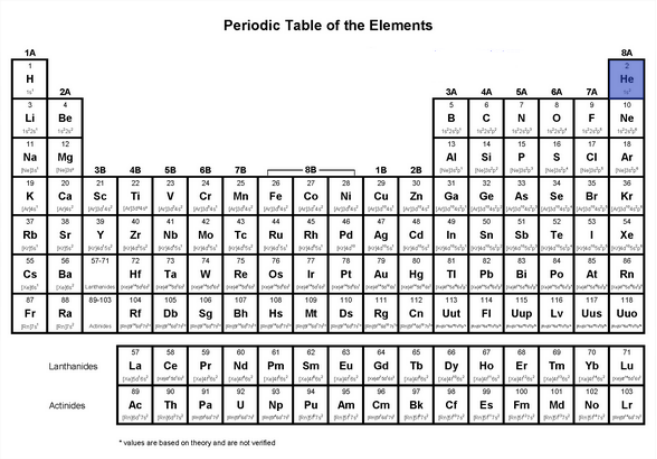


1 valence electron

Bohr Diagram for Helium

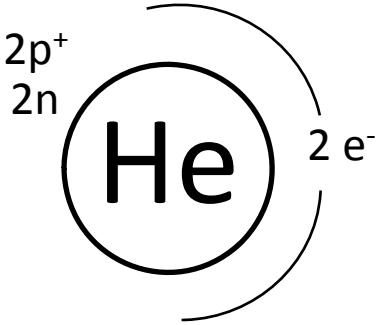
The Helium atom





Helium	
# of protons	2
# of neutrons	2
# of electrons	2
Mass number (#p + #n)	4

1. Draw a circle and label it with the symbol of the nucleus, He.
2. Write the number of protons for the nucleus, $2p^+$.
3. Write the number of neutrons for the nucleus, 2n.
4. Draw an arc to represent the 1st energy level. Label the arc $2e^-$ to represent that there are two electrons in this 1st energy level.

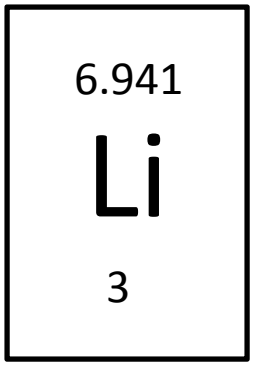


2 valence electrons

The 1st energy level is fully occupied.

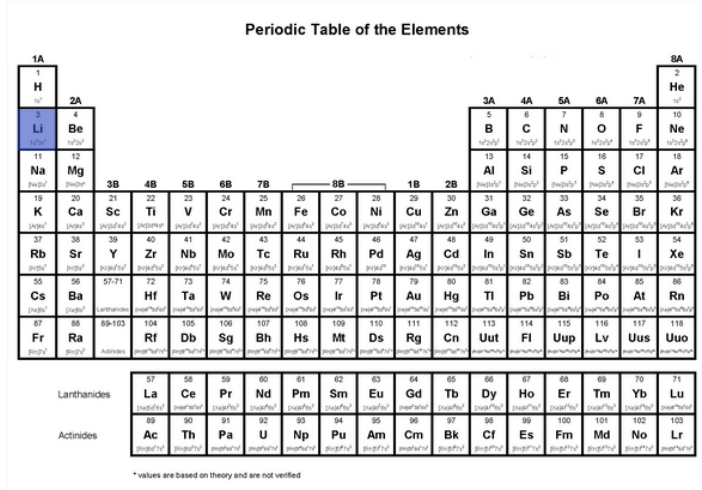
Bohr Diagram for Lithium

The Lithium atom



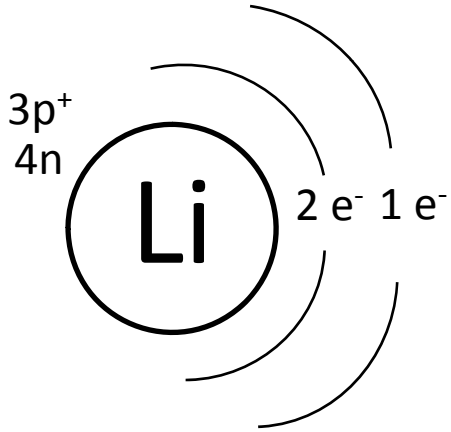
Symbol for Lithium

Atomic Number



Lithium	
# of protons	3
# of neutrons	4
# of electrons	3
Mass number (#p + #n)	7

1. Draw a circle and label it with the symbol of the nucleus, Li.
2. Write the number of protons for the nucleus, $3p^+$.
3. Write the number of neutrons for the nucleus, 4n.
4. Draw an arc to represent the first energy level. Label the arc $2e^-$ to represent that there are two electrons in the 1st energy level. Draw a 2nd arc and place the remaining one electron in the 2nd energy level.

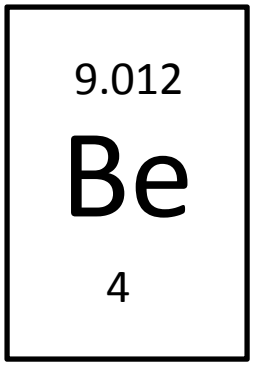


1 valence electron

2 core electrons

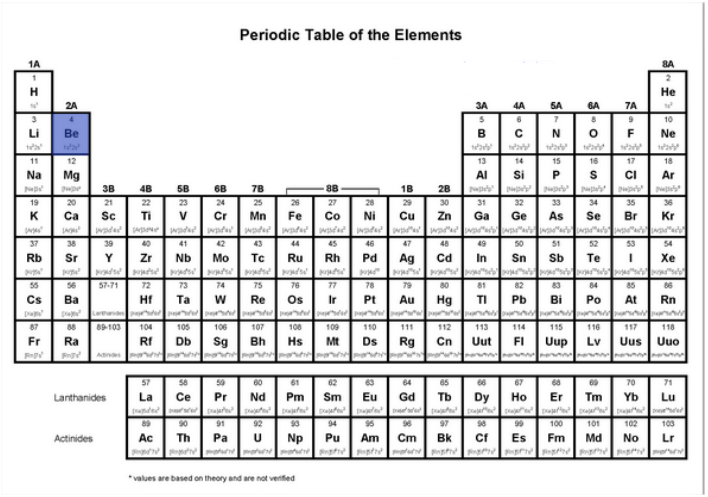
Bohr Diagram for Beryllium

The Beryllium atom



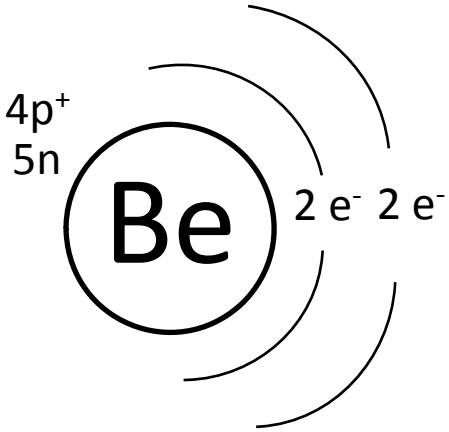
Symbol for Beryllium

Atomic Number



Beryllium	
# of protons	4
# of neutrons	5
# of electrons	4
Mass number (#p + #n)	9

1. Draw a circle and label it with the symbol of the nucleus, Be.
2. Write the number of protons for the nucleus, $4p^+$.
3. Write the number of neutrons for the nucleus, 5n.
4. Draw an arc to represent the first energy level. Label the arc $2e^-$ to represent that there are two electrons in the 1st energy level. Draw a 2nd arc and place the remaining two electrons in the 2nd energy level.

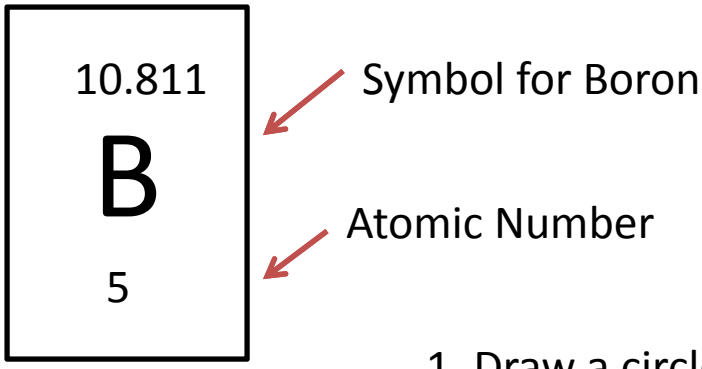


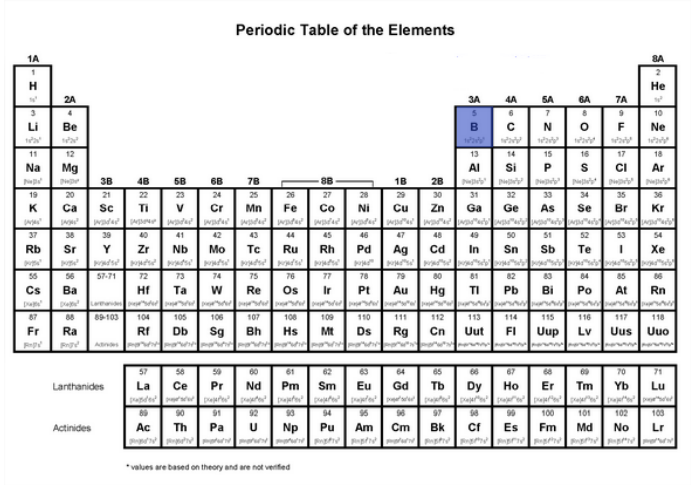
2 valence electrons

2 core electrons

Bohr Diagram for Boron

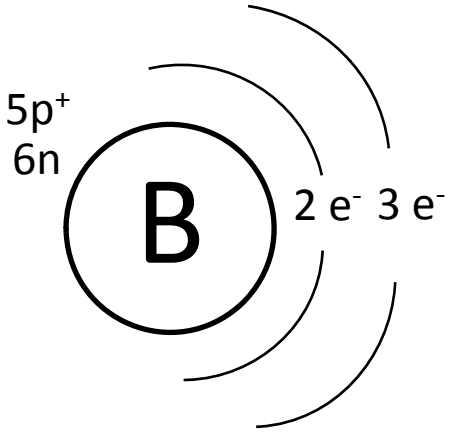
The Boron atom





Boron	
# of protons	5
# of neutrons	6
# of electrons	5
Mass number (#p + #n)	11

1. Draw a circle and label it with the symbol of the nucleus, B.
2. Write the number of protons for the nucleus, $5p^+$.
3. Write the number of neutrons for the nucleus, 6n.
4. Draw an arc to represent the first energy level. Label the arc $2e^-$ to represent that there are two electrons in the 1st energy level. Draw a 2nd arc and place the remaining three electrons in the 2nd energy level.

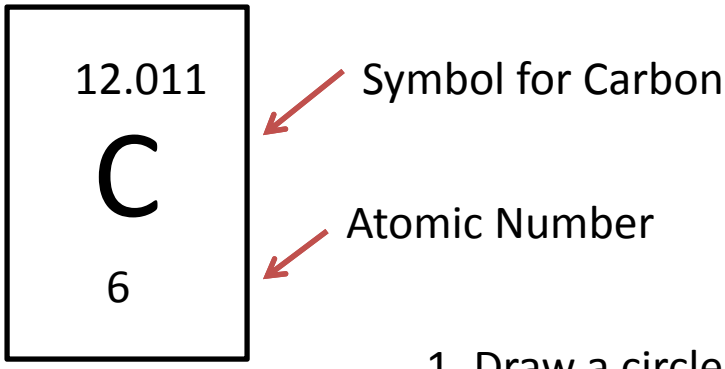


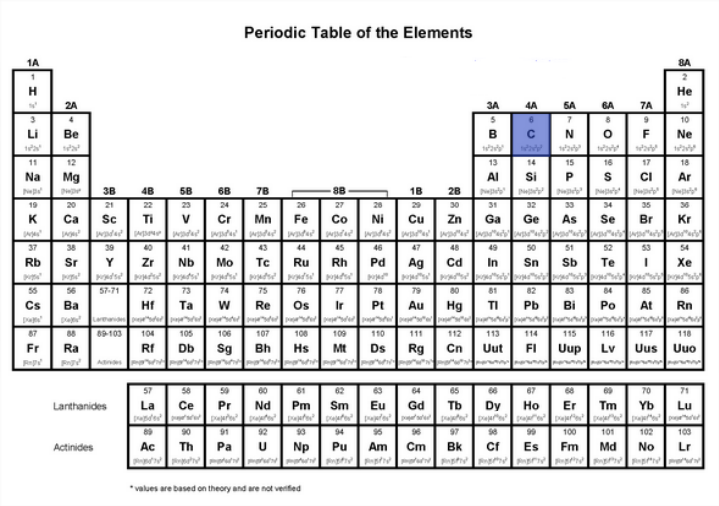
3 valence electrons

2 core electrons

Bohr Diagram for Carbon

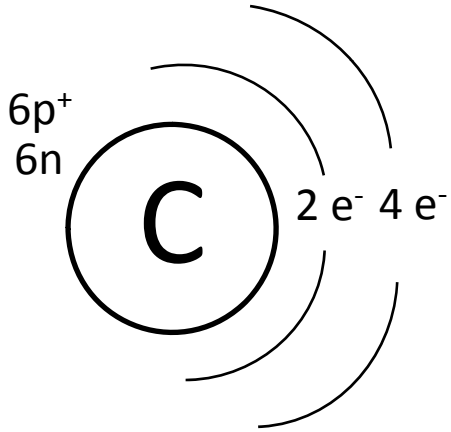
The Carbon atom





Carbon	
# of protons	6
# of neutrons	6
# of electrons	6
Mass number (#p + #n)	12

1. Draw a circle and label it with the symbol of the nucleus, C.
2. Write the number of protons for the nucleus, $6p^+$.
3. Write the number of neutrons for the nucleus, 6n.
4. Draw an arc to represent the first energy level. Label the arc $2e^-$ to represent that there are two electrons in the 1st energy level. Draw a 2nd arc and place the remaining four electrons in the 2nd energy level.

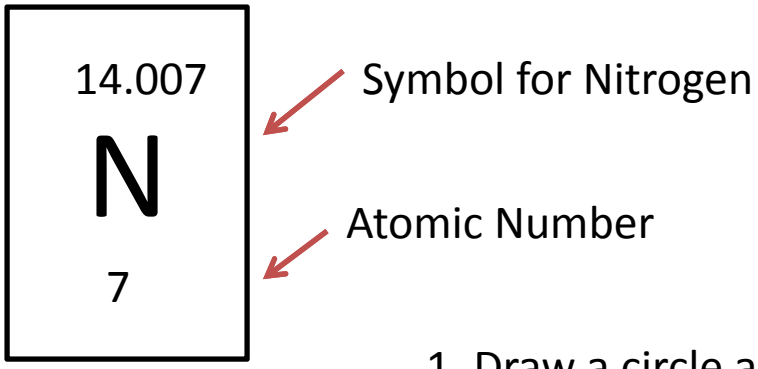


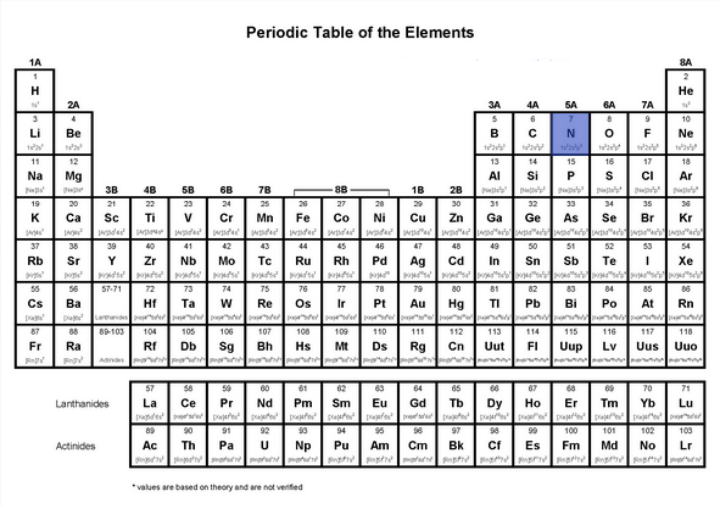
4 valence electrons

2 core electrons

Bohr Diagram for Nitrogen

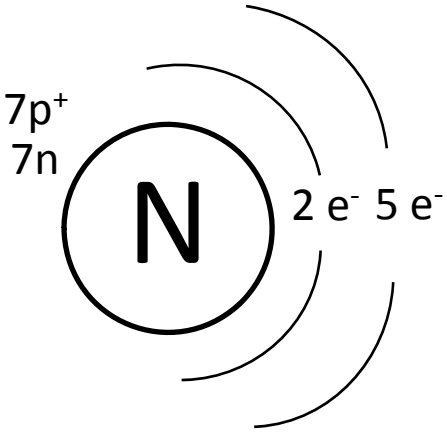
The Nitrogen atom





Nitrogen	
# of protons	7
# of neutrons	7
# of electrons	7
Mass number (#p + #n)	14

1. Draw a circle and label it with the symbol of the nucleus, N.
2. Write the number of protons for the nucleus, $7p^+$.
3. Write the number of neutrons for the nucleus, 7n.
4. Draw an arc to represent the first energy level. Label the arc $2e^-$ to represent that there are two electrons in the 1st energy level. Draw a 2nd arc and place the remaining five electrons in the 2nd energy level.

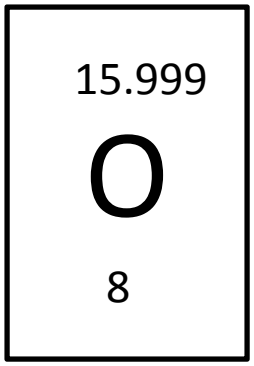


5 valence electrons

2 core electrons

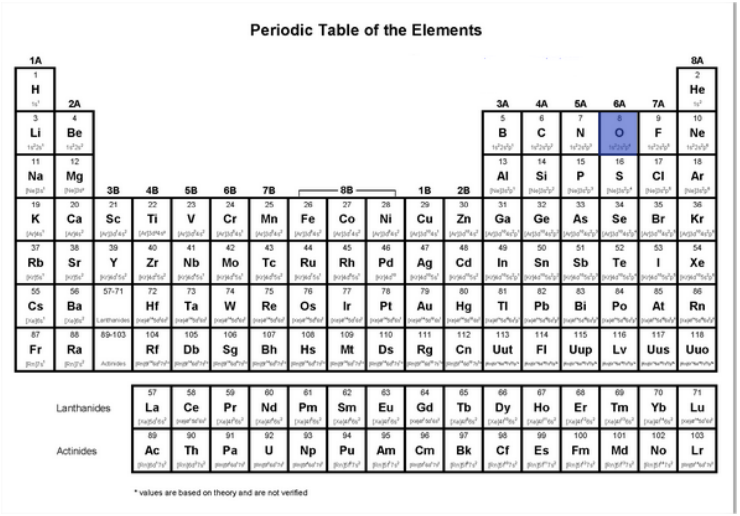
Bohr Diagram for Oxygen

The Oxygen atom



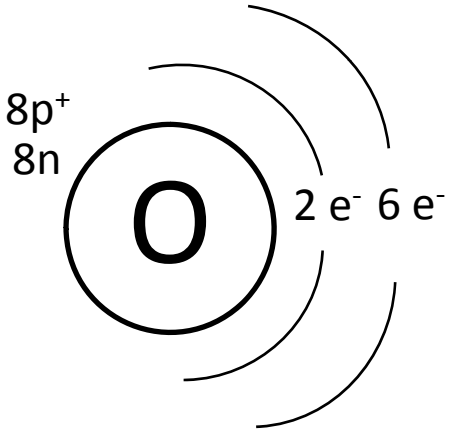
Symbol for Oxygen

Atomic Number



Oxygen	
# of protons	8
# of neutrons	8
# of electrons	8
Mass number (#p + #n)	16

1. Draw a circle and label it with the symbol of the nucleus, O.
2. Write the number of protons for the nucleus, $8p^+$.
3. Write the number of neutrons for the nucleus, 8n.
4. Draw an arc to represent the first energy level. Label the arc $2e^-$ to represent that there are two electrons in the 1st energy level. Draw a 2nd arc and place the remaining six electrons in the 2nd energy level.

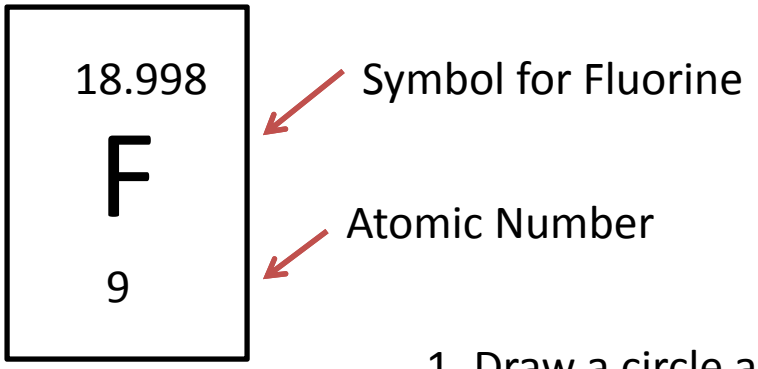


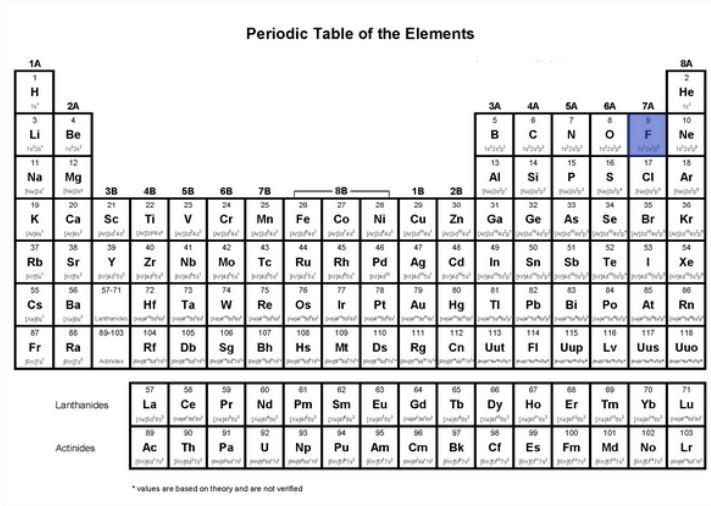
6 valence electrons

2 core electrons

Bohr Diagram for Fluorine

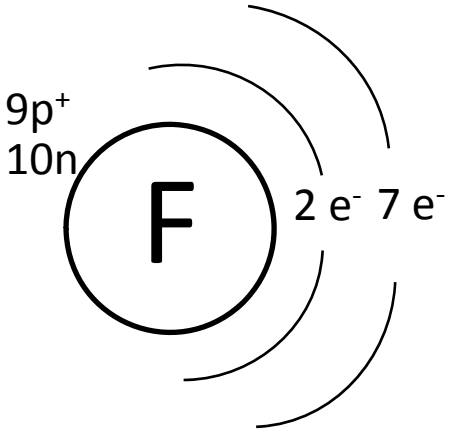
The Fluorine atom





Fluorine	
# of protons	9
# of neutrons	10
# of electrons	9
Mass number (#p + #n)	19

1. Draw a circle and label it with the symbol of the nucleus, F.
2. Write the number of protons for the nucleus, $9p^+$.
3. Write the number of neutrons for the nucleus, 10n.
4. Draw an arc to represent the first energy level. Label the arc $2e^-$ to represent that there are two electrons in the 1st energy level. Draw a 2nd arc and place the remaining seven electrons in the 2nd energy level.

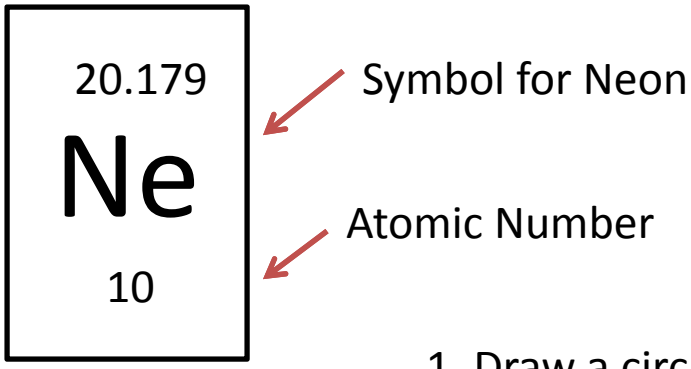


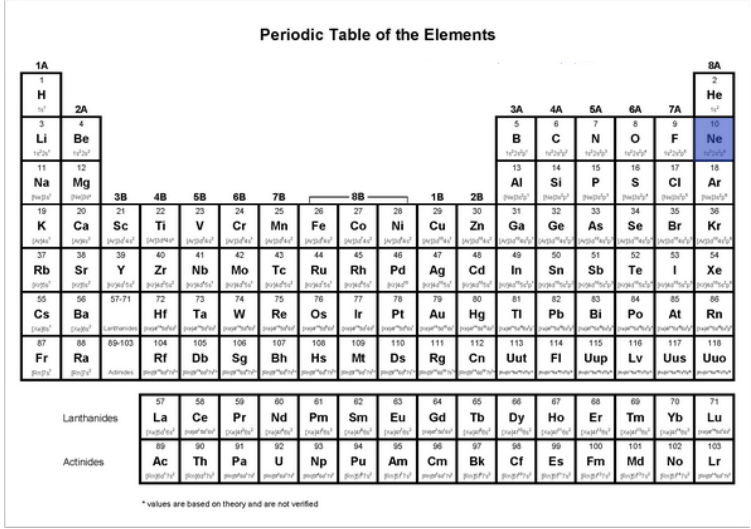
7 valence electrons

2 core electrons

Bohr Diagram for Neon

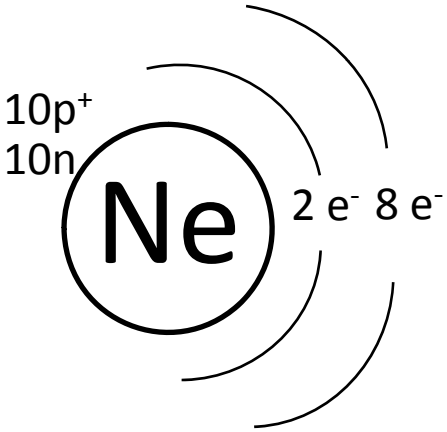
The Neon atom





Neon	
# of protons	10
# of neutrons	10
# of electrons	10
Mass number (#p + #n)	20

1. Draw a circle and label it with the symbol of the nucleus, Ne.
2. Write the number of protons for the nucleus, $10p^+$.
3. Write the number of neutrons for the nucleus, 10n.
4. Draw an arc to represent the first energy level. Label the arc $2e^-$ to represent that there are two electrons in the 1st energy level. Draw a 2nd arc and place the remaining eight electrons in the 2nd energy level.



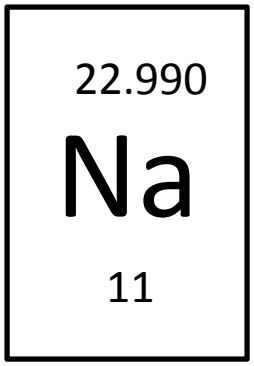
8 valence electrons

2 core electrons

The 2nd energy level is fully occupied.

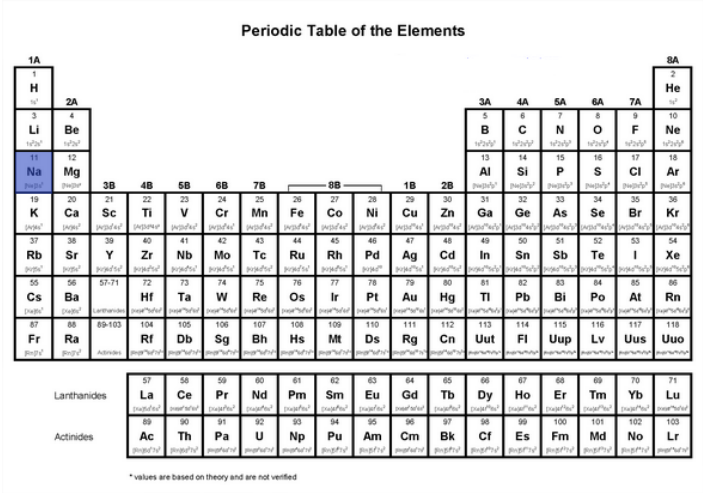
Bohr Diagram for Sodium

The Sodium atom



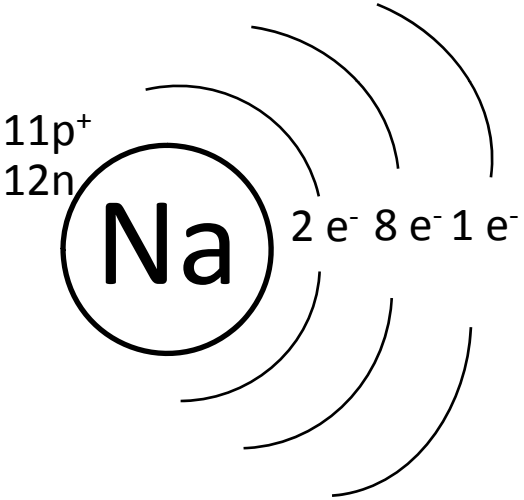
Symbol for Sodium

Atomic Number



Sodium	
# of protons	11
# of neutrons	12
# of electrons	11
Mass number (#p + #n)	23

1. Draw a circle and label it with the symbol of the nucleus, Na.
2. Write the number of protons for the nucleus, $11p^+$.
3. Write the number of neutrons for the nucleus, 12n.
4. Draw an arc to represent the first energy level. Label the arc $2e^-$ to represent that there are two electrons in the 1st energy level. Draw a 2nd arc and place eight electrons in the 2nd energy level. Draw a 3rd arc and place one electron in the 3rd energy level.



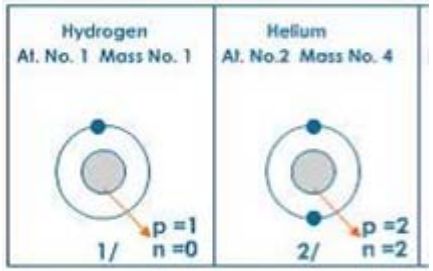
1 valence electron

10 core electrons

Draw the Bohr Diagrams:

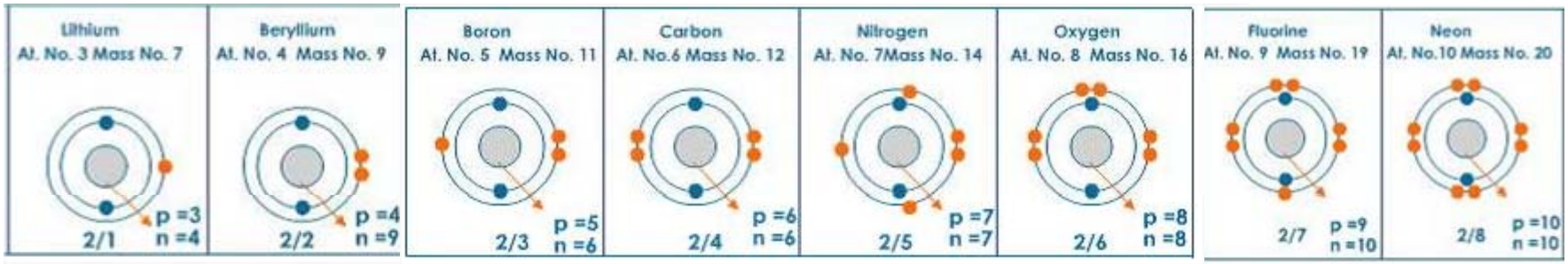
Draw Bohr diagrams for the first 20 elements of the Periodic Table and compare to these.

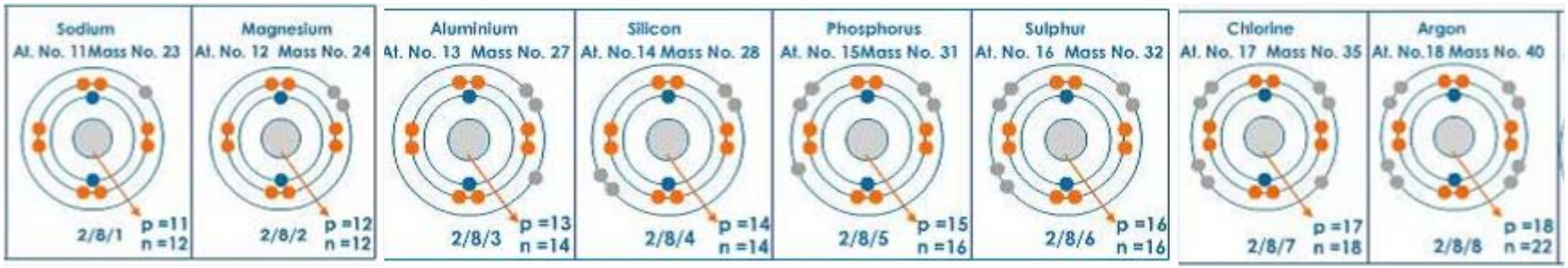
Draw the Bohr Diagrams for Elements 1-20



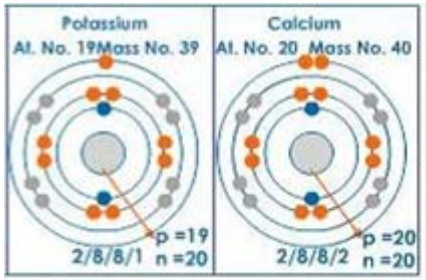
Row 1 Elements

Row 2 Elements





Row 3 Elements



Row 4 Elements

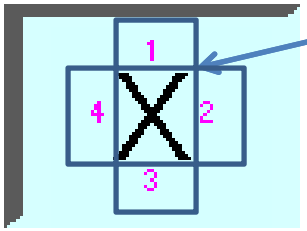
Image credit: http://www.tutorvista.com/content/science/science-i/structure-atom/arrangement-electrons-atom.php

Lewis Electron Dot Symbols:

The Lewis electron-dot symbols *focus on the valence electrons*. These are the electrons that participate in chemical reactions. Lewis electron-dot symbols work well for the representative elements (‘A‘ elements).

Rules for writing Lewis electron-dot symbols of elements

1. Write the symbol for the element. ‘X’ represents a generic element. There are four sides surrounding the symbol. Each side can accommodate two valence electrons.



The symbol represents the nucleus and the inner or core electrons for the element.

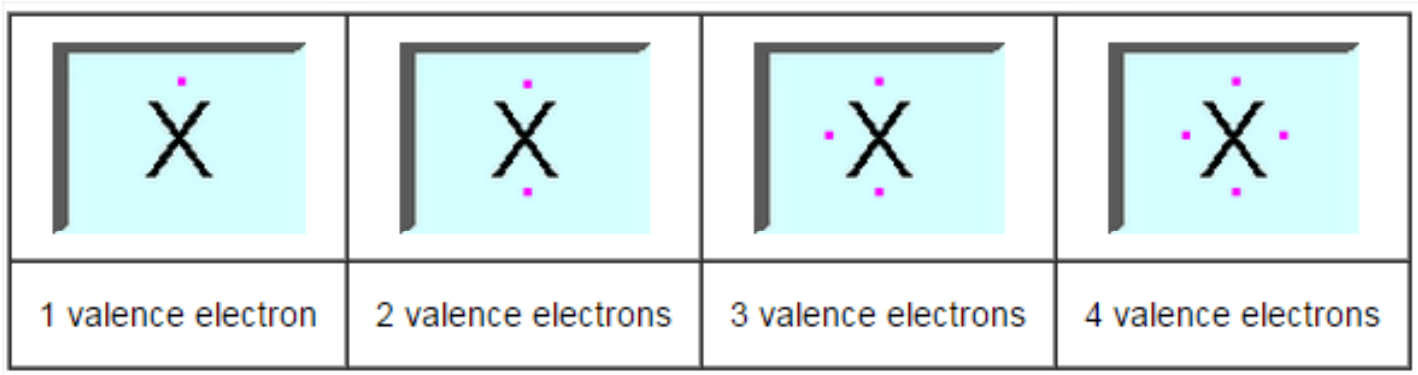
The number of dots you put around the symbol represents the actual number of valence electrons for the element.

Lewis Electron Dot Symbols:

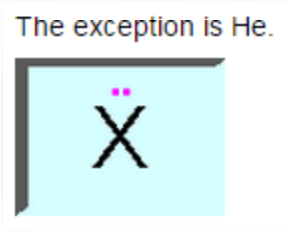
Rules for writing Lewis electron-dot symbols of elements

2. Determine the number of valence electrons for the element. Use a dot to represent an electron.

3. Assign a dot to each side of the symbol up to a **maximum of four valence electron**. Keep the electrons unpaired (i.e. one valence electron on each side of the symbol).



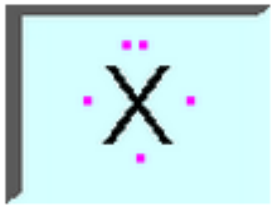
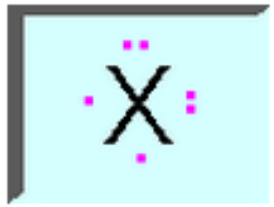
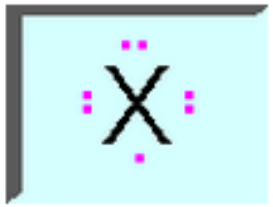
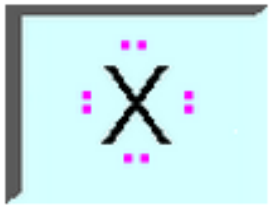
(NOTE: Helium is an exception, with both valence electrons paired up on the same side of the symbol.)



Lewis Electron Dot Symbols:

Rules for writing Lewis electron-dot symbols of elements

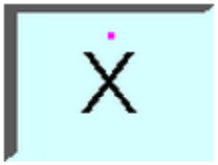
4. For assigning more than 4 valence electrons, start pairing up electrons on the four sides to a **maximum of eight electrons**.

			
5 valence electron	6 valence electrons	7 valence electrons	8 valence electrons

Lewis Electron Dot Symbols
For Elements in Group 1A to VIII A:

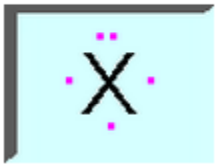
Representative Elements in:	Number of Valence Electrons
Group IA	1 valence electron
Group IIA	2 valence electrons
Group IIIA	3 valence electrons
Group IVA	4 valence electrons
Group VA	5 valence electrons
Group VIA	6 valence electrons
Group VIIA	7 valence electrons
Group VIIIA	8 valence electrons

Group IA



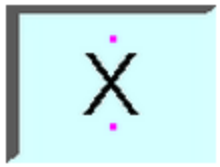
X = H, Li, Na, K, Rb, Cs, Fr

Group VA



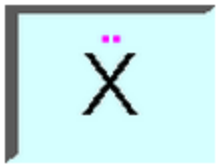
X = N, P, As, Sb, Bi

Group IIA



X = Be, Mg, Ca, Sr, Ba, Ra

The exception is He.



X = He

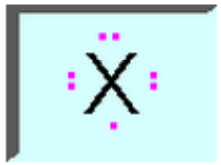
Group VIA

X = O, S, Se, Te, Po

Group IIIA

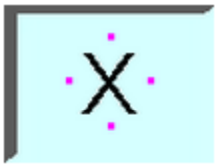
X = B, Al, Ga, In, Tl

Group VIIA



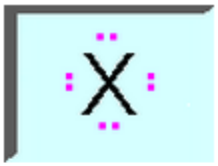
X = F, Cl, Br, I, At

Group IVA



X = C, Si, Ge, Sn, Pb

Group VIIIA



X = Ne, Ar, Kr, Xe, Rn

Unit 8

On completion of the unit you should be able to:

1. state the mass, charge and location of protons, electrons and neutrons.
2. given the atomic number of an element, draw diagrams showing the protons in the nucleus and the electrons in shells (or energy levels) around the nucleus.
3. write the electron dot formulae for the elements in groups 1 to 8 in the periodic table.
4. define isotopes, mass number and atomic mass.
5. given the relative abundance and isotopic masses for an element, calculate the atomic mass of that element.
6. given the atomic number and mass number of an element, calculate the number of electrons.

ATOMS AND THE PERIODIC TABLE

8.1 **Atom**

- **Subatomic particles**

8.2 **Isotope**

Reading: Hebden – page 144-146

8.3 **Arrangement of electrons**

- **Bohr model of the atom**
  Reading: Hebden – page 142
- **Lewis electron-dot formulas of elements**
  Reading: Hebden – page 167
- **Quantum mechanical model of the atom**

8.4 **Electron configurations of atoms**

8.5 **Atomic mass**

- **Tabulated atomic mass**

Reading: Hebden – page 150

8.6 **Periodic table of the elements**

- **Metals Nonmetals and Semimetals**
  - **Properties of metals**
  - **Properties of nonmetals**
  - **Properties of semimetals**

Next lecture we will focus on the Quantum Mechanical model and writing electron configuration of the atom.