

## 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

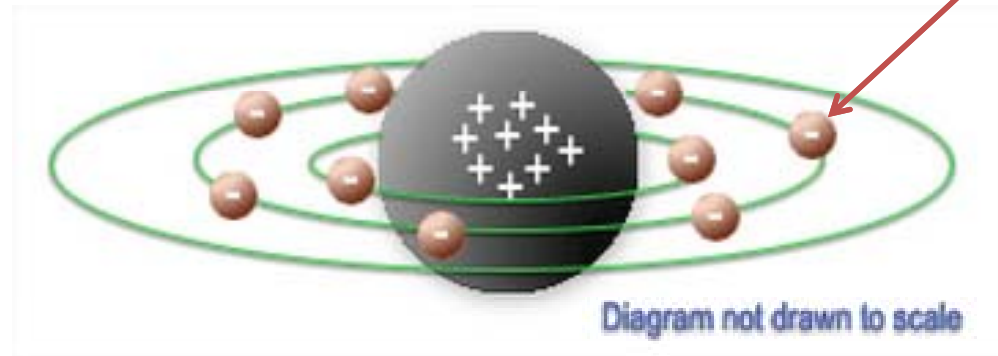
Today's focus.



# 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.

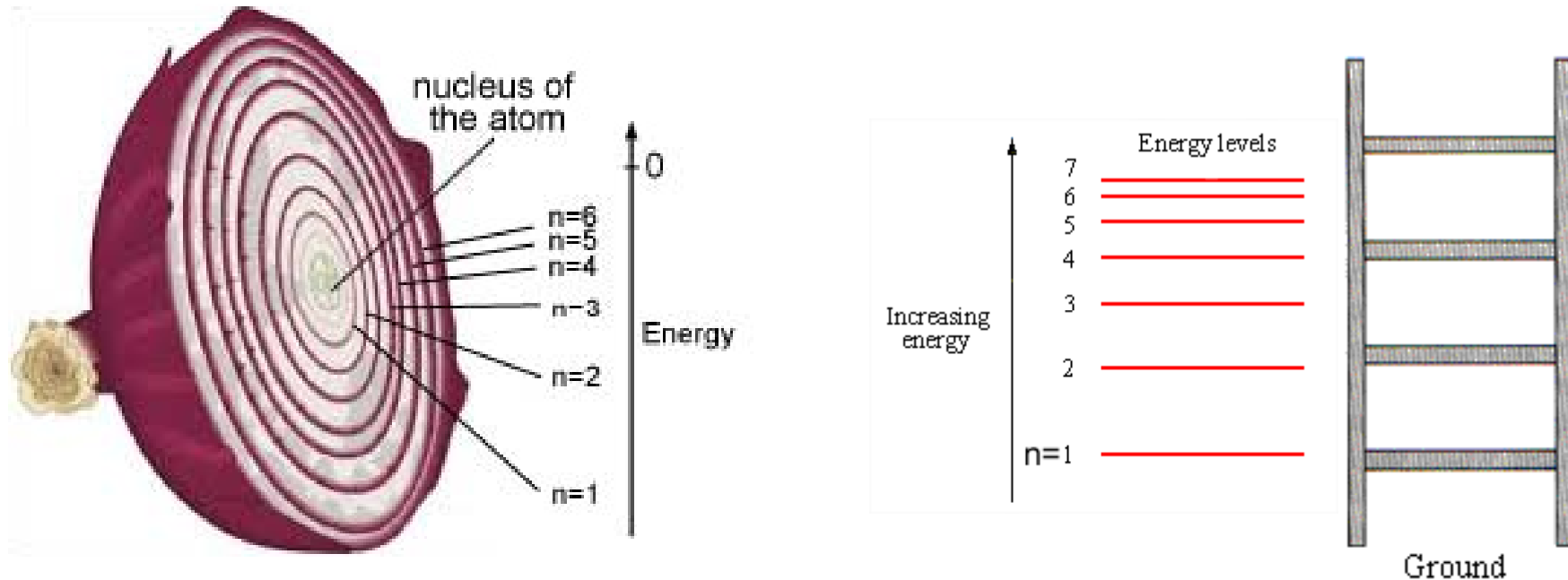
## Planetary model



Electrons inside an atom possess different energies.

# Bohr model of the atom

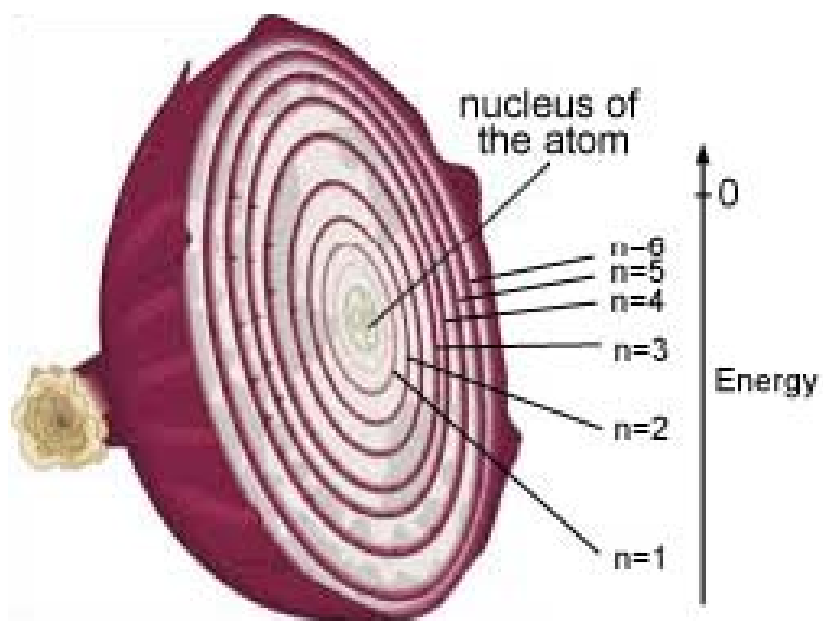
- Electrons occupy the shell structure of the atom.



- 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.

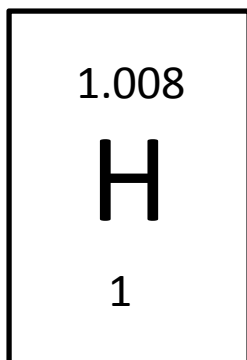


Maximum number  
of electrons in  
an energy level  $= 2n^2$

Energy Level	$2n^2$	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!

## The Hydrogen atom

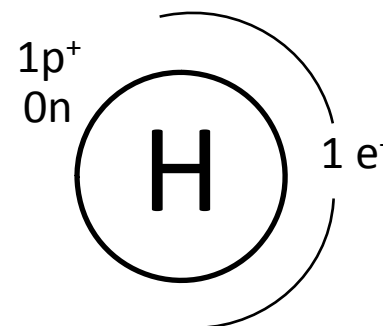


# Symbol for Hydrogen

## Atomic Number

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<sup>+</sup>**.
3. Write the number of neutrons for the nucleus, **0n**.
4. Draw an arc to represent the 1<sup>st</sup> energy level. Label the arc **1e<sup>-</sup>** to represent that there is **one** electron in this 1<sup>st</sup> energy level.

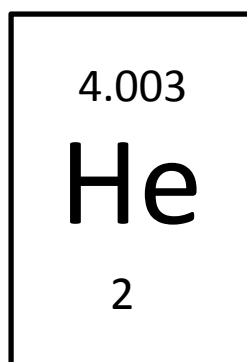


1 valence electron

[illegible]

## Bohr Diagram for Helium

## The Helium atom

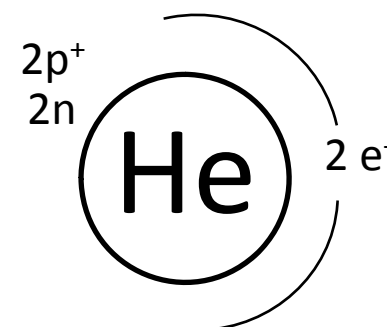


## Symbol for Helium

## Atomic Number

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<sup>+</sup>**.
3. Write the number of neutrons for the nucleus, **2n**.
4. Draw an arc to represent the 1<sup>st</sup> energy level. Label the arc **2e<sup>-</sup>** to represent that there are **two** electrons in this 1<sup>st</sup> energy level.



2 valence electrons

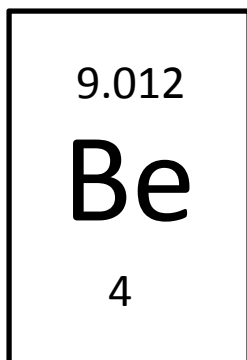
The 1<sup>st</sup> energy level is fully occupied.

[illegible]



# Bohr Diagram for Beryllium

## The Beryllium atom



Symbol for Beryllium

Atomic Number

Periodic Table of the Elements

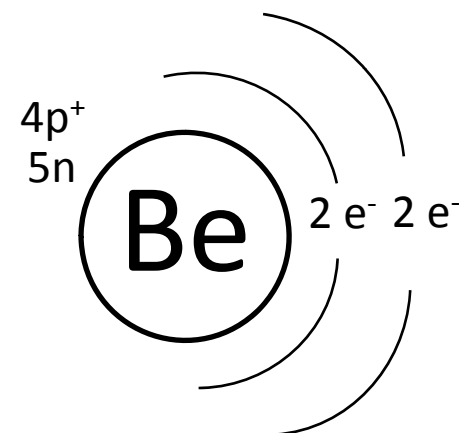
1A	1	H	2	He	8A
	3	Li	4	Be	
	5	B	6	C	7
	9	F	10	Ne	
11	12	Na	13	Al	14
15	16	S	17	Cl	18
19	20	K	21	Ca	22
23	24	V	25	Cr	26
27	28	Co	29	Ni	30
31	32	Ga	33	Ge	34
35	36	Br	37	Kr	
37	38	Rb	39	Sr	40
41	42	Nb	43	Mo	44
45	46	Tc	47	Ru	48
49	50	In	51	Sn	52
53	54	I	55	Xe	
57	58	Ce	59	Pr	60
61	62	Sm	63	Eu	64
65	66	Gd	67	Tb	68
69	70	Yb	71	Lu	
87	88	Ra	89	Ac	90
91	92	Th	93	Pa	94
95	96	Am	97	Cm	98
99	100	Fm	101	Md	102
103	104	Lr	105	Uuo	

\* values are based on theory and are not verified

### 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<sup>+</sup>**.
3. Write the number of neutrons for the nucleus, **5n**.
4. Draw an arc to represent the first energy level. Label the arc **2e<sup>-</sup>** to represent that there are **two** electrons in the 1<sup>st</sup> energy level. Draw a 2<sup>nd</sup> arc and place the remaining **two** electrons in the 2<sup>nd</sup> energy level.



2 valence electrons

2 core electrons

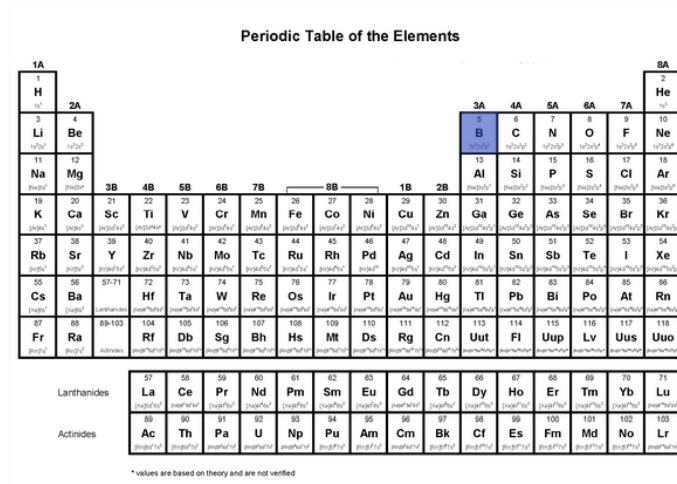


## The Boron atom

10.811  
**B**  
5

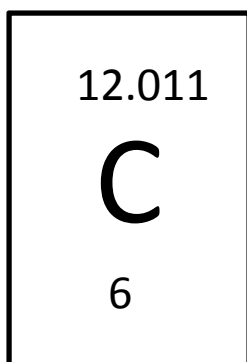
## Atomic Number

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



# Bohr Diagram for Carbon

## The Carbon atom



Symbol for Carbon

Atomic Number

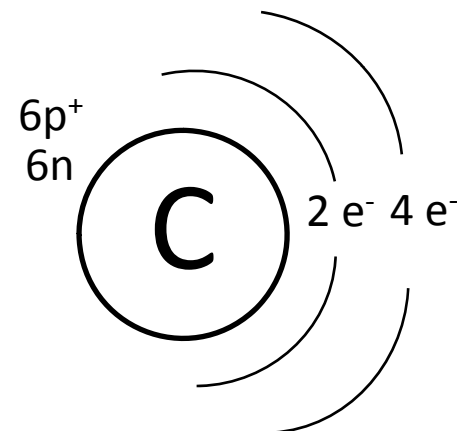
Periodic Table of the Elements

1A	1	H	2	He	8A
2A	3	Li	4	Be	
	5	B	6	C	7
	8	N	9	O	10
	11	Na	12	Mg	13
	14	Al	15	P	16
	17	S	18	Cl	19
	20	K	21	Ca	22
	23	Sc	24	Ti	25
	26	V	27	Cr	28
	29	Mn	30	Fe	31
	32	Co	33	Ni	34
	35	Cu	36	Zn	37
	38	Ga	39	Ge	40
	41	As	42	Se	43
	44	Br	45	Kr	46
	47	Rb	48	Sr	49
	50	Y	51	Zr	52
	53	Nb	54	Mo	55
	56	Tc	57	Ru	58
	59	Rh	60	Pd	61
	62	Ag	63	Cd	64
	65	In	66	Sn	67
	68	Sb	69	Te	70
	71	I	72	Xe	73
	74	Cs	75	Ba	76
	77	La	78	Hf	79
	80	Ta	81	W	82
	83	Re	84	Os	85
	86	Ir	87	Pt	88
	89	Au	90	Hg	91
	92	Tl	93	Pb	94
	95	Bi	96	Po	97
	98	At	99	Rn	100
	101	Fr	102	Ra	103
	104	Ac	105	Th	106
	107	Pa	108	U	109
	110	Np	111	Pu	112
	113	Am	114	Cm	115
	116	Bk	117	Cf	118
	119	Es	120	Fm	121
	122	Md	123	No	124
	125	Lr	126	Uuo	127

\* values are based on theory and are not verified

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<sup>+</sup>**.
3. Write the number of neutrons for the nucleus, **6n**.
4. Draw an arc to represent the first energy level. Label the arc **2e<sup>-</sup>** to represent that there are **two** electrons in the 1<sup>st</sup> energy level. Draw a 2<sup>nd</sup> arc and place the remaining **four** electrons in the 2<sup>nd</sup> energy level.

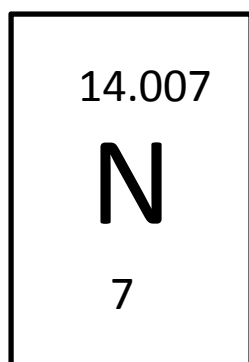


4 valence electrons

2 core electrons

# Bohr Diagram for Nitrogen

## The Nitrogen atom



Symbol for Nitrogen

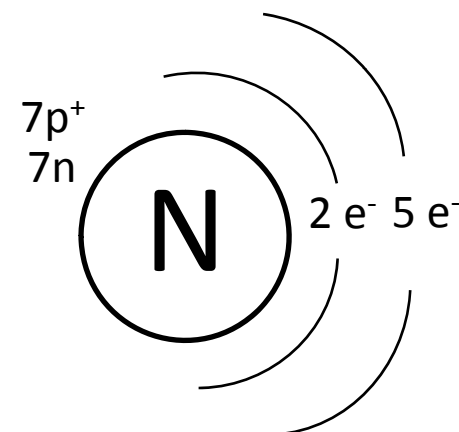
Atomic Number

## Periodic Table of the Elements

																		1A																		2A																		8A	
																		1																		2																		3	
																		H																		He																			
																		3																		4																		5	
																		Li																		Be																		B	
																		11																		12																		13	
																		Na																		Mg																		Al	
																		19																		20																		21	
																		K																		Ca																		Sc	
																		37																		38																		39	
																		Rb																		Sr																		Y	
																		55																		56																		57-71	
																		Cs																		Ba																		Hf	
																		87																		88																		89-103	
																		Fr																		Ra																		Rf	

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<sup>+</sup>**.
3. Write the number of neutrons for the nucleus, **7n**.
4. Draw an arc to represent the first energy level. Label the arc **2e<sup>-</sup>** to represent that there are **two** electrons in the 1<sup>st</sup> energy level. Draw a 2<sup>nd</sup> arc and place the remaining **five** electrons in the 2<sup>nd</sup> energy level.



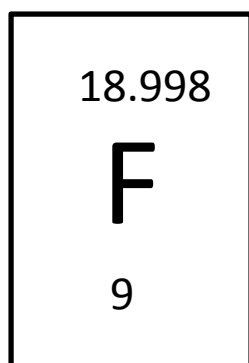
5 valence electrons

2 core electrons



# Bohr Diagram for Fluorine

## The Fluorine atom



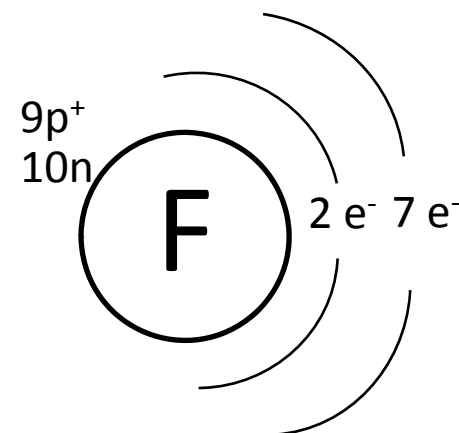
Symbol for Fluorine

Atomic Number

Periodic Table of the Elements																						
1A																	8A					
1	H																	2	He			
	3	4															5	6	7	8	9	10
	Li	Be															B	C	N	O	F	Ne
	11	12															13	14	15	16	17	18
	Na	Mg															Al	Si	P	S	Cl	Ar
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36				
	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr				
	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54				
	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe				
	55	56	57-71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86				
	Cs	Ba	Lanthanides	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn				
	87	88	89-103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118				
	Fr	Ra	Actinides	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Fl	Uup	Lv	Uus	Uuo				
	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136				
	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu							
	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr							
* values are based on theory and are not verified																						

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<sup>+</sup>**.
3. Write the number of neutrons for the nucleus, **10n**.
4. Draw an arc to represent the first energy level. Label the arc **2e<sup>-</sup>** to represent that there are **two** electrons in the 1<sup>st</sup> energy level. Draw a 2<sup>nd</sup> arc and place the remaining **seven** electrons in the 2<sup>nd</sup> energy level.



7 valence electrons

2 core electrons

## Bohr Diagram for Neon

## The Neon atom

20.179
<b>Ne</b>
10

## Symbol for Neon

## Atomic Number

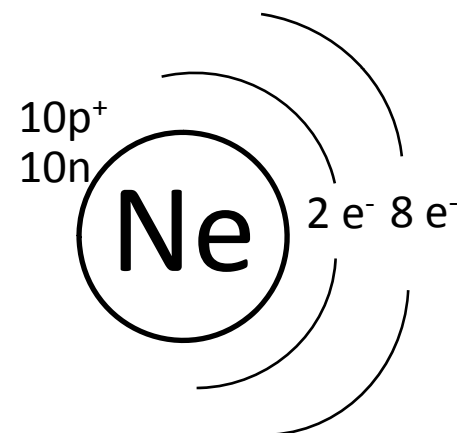
### Periodic Table of the Elements

1A																2A																3A										4A										5A										6A										7A										8A																																																																																																																																																													
1 H																2 He																																																																																																																																																																																																																															
3 Li																4 Be																																																																																																																																																																																																																															
11 Na																12 Mg																																																																																																																																																																																																																															
19 K																20 Ca																3B										4B										5B										6B										7B										8B										9B										10B										11B										12B																																																																																																																					
27 Co																28 Ni																13 Al										14 Si										15 P										16 S										17 Cl										18 Ar										19 K										20 Ca																																																																																																																																									
35 Br																36 Kr																41 Nb										42 Mo										43 Tc										44 Ru										45 Rh										46 Pd										47 Ag										48 Cd										49 In										50 Sn										51 Sb										52 Te										53 I										54 Xe																																																																													
55 Cs																56 Ba																57-71 Lanthanides										72 Hf										73 Ta										74 W										75 Re										76 Os										77 Ir										78 Pt										79 Au										80 Hg										81 Tl										82 Pb										83 Bi										84 Po										85 At										86 Rn																																																									
87 Fr																88 Ra																89-103 Actinides										104 Rf										105 Db										106 Sg										107 Bh										108 Hs										109 Mt										110 Ds										111 Rg										112 Cn										113 Uut										114 Uup										115 Fl										116 Lv										117 Uus										118 Uuo																																																									
89 La																90 Ce																91 Pr																92 Nd																93 Pm																94 Sm																95 Eu																96 Gd																97 Tb																98 Dy																99 Ho																100 Er																101 Tm																102 Yb																103 Lu															
89 Ac																90 Th																91 Pa																92 U																93 Np																94 Pu																95 Am																96 Cm																97 Bk																98 Cf																99 Es																100 Fm																101 Md																102 No																103 Lr															

\* values are based on theory and are not verified

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<sup>+</sup>**.
3. Write the number of neutrons for the nucleus, **10n**.
4. Draw an arc to represent the first energy level. Label the arc **2e<sup>-</sup>** to represent that there are **two** electrons in the 1<sup>st</sup> energy level. Draw a 2<sup>nd</sup> arc and place the remaining **eight** electrons in the 2<sup>nd</sup> energy level.



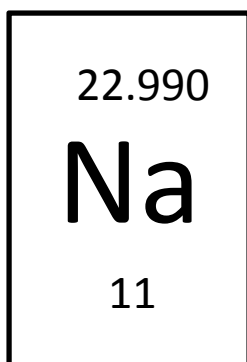
8 valence electrons

2 core electrons

The 2<sup>nd</sup> energy level is fully occupied.

# Bohr Diagram for Sodium

## The Sodium atom



Symbol for Sodium

Atomic Number

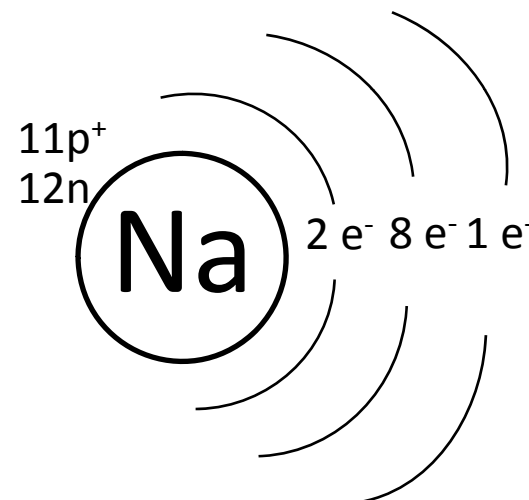
Periodic Table of the Elements

1A	1	H	2	He	8A
	3	Li	4	Be	
	5	B	6	C	7
	8	N	9	O	10
	11	Na	12	Mg	13
	14	Al	15	P	16
	17	S	18	Cl	19
	20	Ca	21	Sc	22
	23	Ti	24	V	25
	26	Cr	27	Mn	28
	29	Cu	30	Zn	31
	32	Ge	33	As	34
	35	Se	36	Br	37
	38	Kr	39	Rb	40
	41	Sr	42	Y	43
	44	Zr	45	Nb	46
	47	Mo	48	Tc	49
	50	Ru	51	Rh	52
	53	Pd	54	Ag	55
	56	Cd	57	In	58
	59	Sn	60	Sb	61
	62	Te	63	I	64
	65	Xe	66	Ba	67
	68	La	69	Ce	70
	71	Pr	72	Nd	73
	74	Pm	75	Sm	76
	77	Eu	78	Gd	79
	80	Tb	81	Dy	82
	83	Ho	84	Er	85
	86	Tm	87	Yb	88
	89	Lu	90	Hf	91
	92	Ta	93	W	94
	95	Re	96	Os	97
	98	Ir	99	Pt	100
	101	Au	102	Hg	103
	104	Tl	105	Pb	106
	107	Bi	108	Po	109
	110	At	111	Rn	112
	113	Fr	114	Ra	115
	116	Ac	117	Th	118
	119	Pa	120	U	121
	122	Np	123	Pu	124
	125	Am	126	Cm	127
	128	Bk	129	Cf	130
	131	Es	132	Fm	133
	134	Md	135	No	136
	137	Lr	138	Uuo	139

\* values are based on theory and are not verified

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<sup>+</sup>**.
3. Write the number of neutrons for the nucleus, **12n**.
4. Draw an arc to represent the first energy level. Label the arc **2e<sup>-</sup>** to represent that there are **two** electrons in the 1<sup>st</sup> energy level. Draw a 2<sup>nd</sup> arc and place **eight** electrons in the 2<sup>nd</sup> energy level. Draw a 3<sup>rd</sup> arc and place **one** electron in the 3<sup>rd</sup> energy level.



1 valence electron

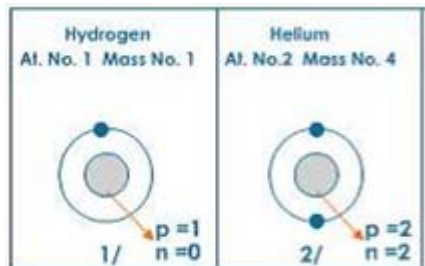
10 core electrons

Draw the Bohr Diagrams:

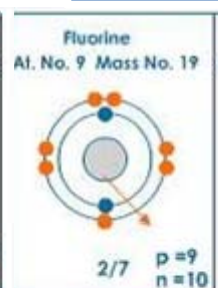
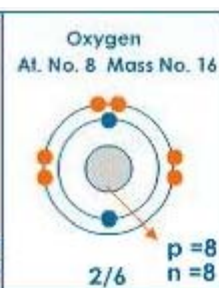
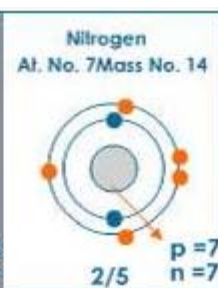
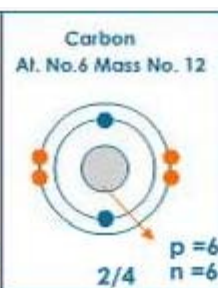
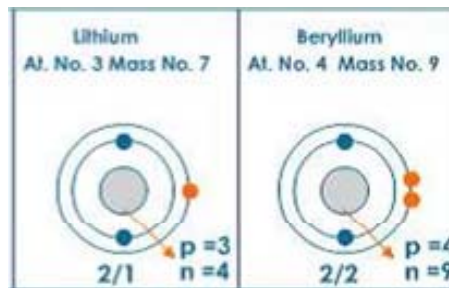
Draw Bohr diagrams for the first  
20 elements of the Periodic Table  
and compare to these.



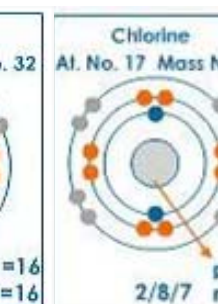
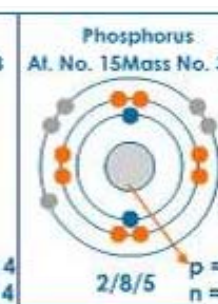
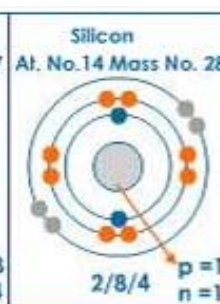
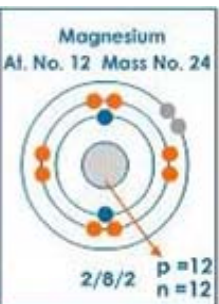
# Draw the Bohr Diagrams for Elements 1-20



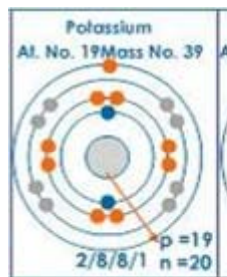
Row 1 Elements



Row 2 Elements



Row 3 Elements



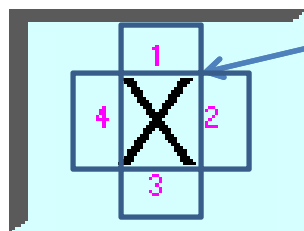
Row 4 Elements

## 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.




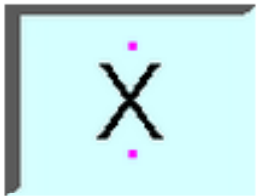
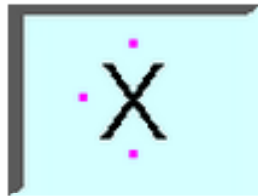
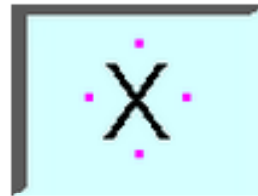
The symbol represents the nucleus and the inner or core electrons for the element.

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).

			
1 valence electron	2 valence electrons	3 valence electrons	4 valence electrons

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

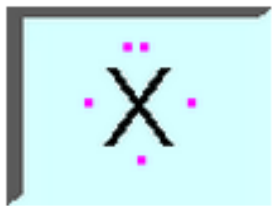
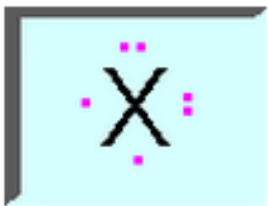
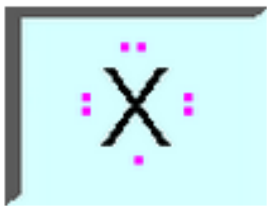
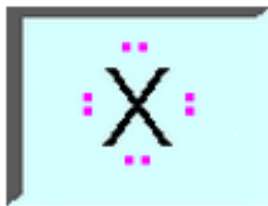
The exception is He.



## Lewis Electron Dot Symbols:

### Rules for writing Lewis electron-dot symbols of elements

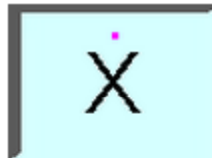
4. For assigning more than 4 valence electrons, start pairing up electrons on the four sides to a **maximum of eight electrons**.

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

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

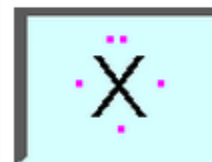
Representative Elements in:	Number of Valence Electrons
Group IA	1 valence electron
Group IIA	2 valence electrons
Group IIIA	3 valence electrons
Group IVA	4 valence electrons
Group VA	5 valence electrons
Group VIA	6 valence electrons
Group VIIA	7 valence electrons
Group VIIIA	8 valence electrons

**Group IA**



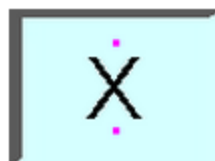
X = H, Li, Na, K, Rb, Cs, Fr

**Group VA**



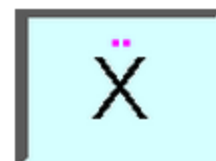
X = N, P, As, Sb, Bi

**Group IIA**



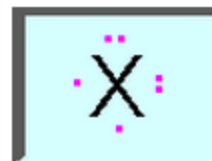
X = Be, Mg, Ca, Sr, Ba, Ra

The exception is He.



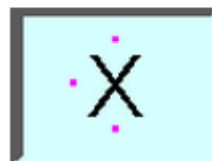
X = He

**Group VIA**



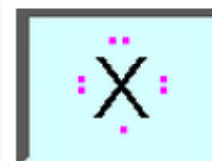
X = O, S, Se, Te, Po

**Group IIIA**



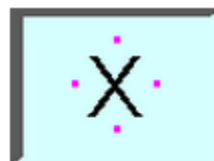
X = B, Al, Ga, In, Tl

**Group VIIA**



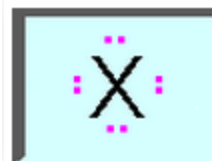
X = F, Cl, Br, I, At

**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.