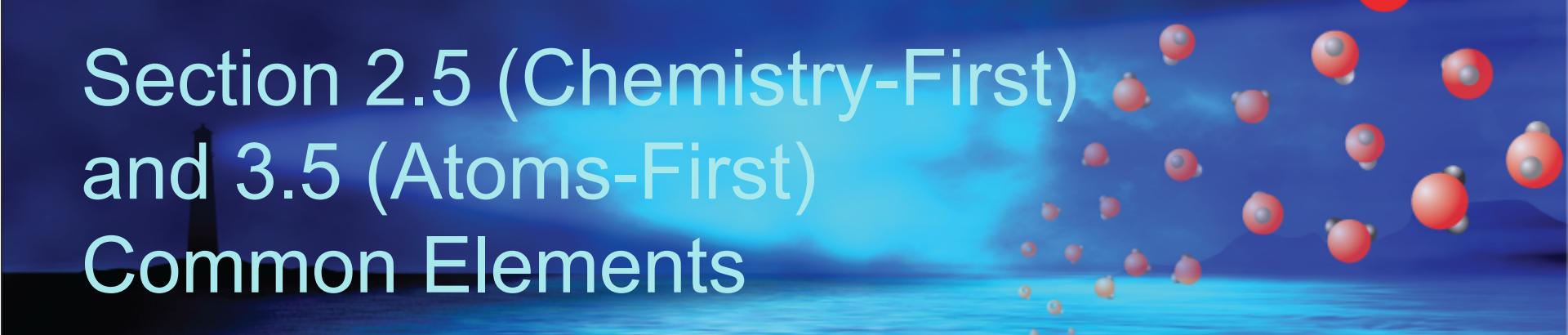


# Section 2.5 (Chemistry-First) and 3.5 (Atoms-First) Common Elements



## **An Introduction to Chemistry**

By Mark Bishop

# To Describe Structure of Elements

- What particles?
  - Noble gases – atoms
  - Other nonmetals - molecules
    - Diatomic elements –  $\text{H}_2$ ,  $\text{N}_2$ ,  $\text{O}_2$ ,  $\text{F}_2$ ,  $\text{Cl}_2$ ,  $\text{Br}_2$ ,  $\text{I}_2$
    - $\text{S}_8$ ,  $\text{Se}_8$ ,  $\text{P}_4$
  - Metallic elements – cations in a sea of electrons

# To Describe Structure of Elements (2)

- Solid, liquid, or gas?
  - Gases -  $\text{H}_2$ ,  $\text{N}_2$ ,  $\text{O}_2$ ,  $\text{F}_2$ ,  $\text{Cl}_2$ , He, Ne, Ar, Kr, and Xe
  - Liquids –  $\text{Br}_2$  and Hg
  - Solids – the rest
- Standard description of (1) solid, (2) liquid, (3) gas, or (4) metal.

# Helium Gas, He

																18 8A																												
1 1A		2 2A												1 3A	13 3A	14 4A	15 5A	16 6A	17 7A	2 He																								
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne																										
3	11 Na	12 Mg	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar																										
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr																										
5	37 Rb	38 Sr	39 Y	40 Zr	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																										
6	55 Cs	56 Ba	71 Lu	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																										
7	87 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	113 Uut	114 Uuq	115 Uup	116 Uuh																												
6	<table border="1"> <tr> <td>57 La</td> <td>58 Ce</td> <td>59 Pr</td> <td>60 Nd</td> <td>61 Pm</td> <td>62 Sm</td> <td>63 Eu</td> <td>64 Gd</td> <td>65 Tb</td> <td>66 Dy</td> <td>67 Ho</td> <td>68 Er</td> <td>69 Tm</td> <td>70 Yb</td> </tr> <tr> <td>89 Ac</td> <td>90 Th</td> <td>91 Pa</td> <td>92 U</td> <td>93 Np</td> <td>94 Pu</td> <td>95 Am</td> <td>96 Cm</td> <td>97 Bk</td> <td>98 Cf</td> <td>99 Es</td> <td>100 Fm</td> <td>101 Md</td> <td>102 No</td> </tr> </table>														57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	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		
57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb																															
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																															
7																																												

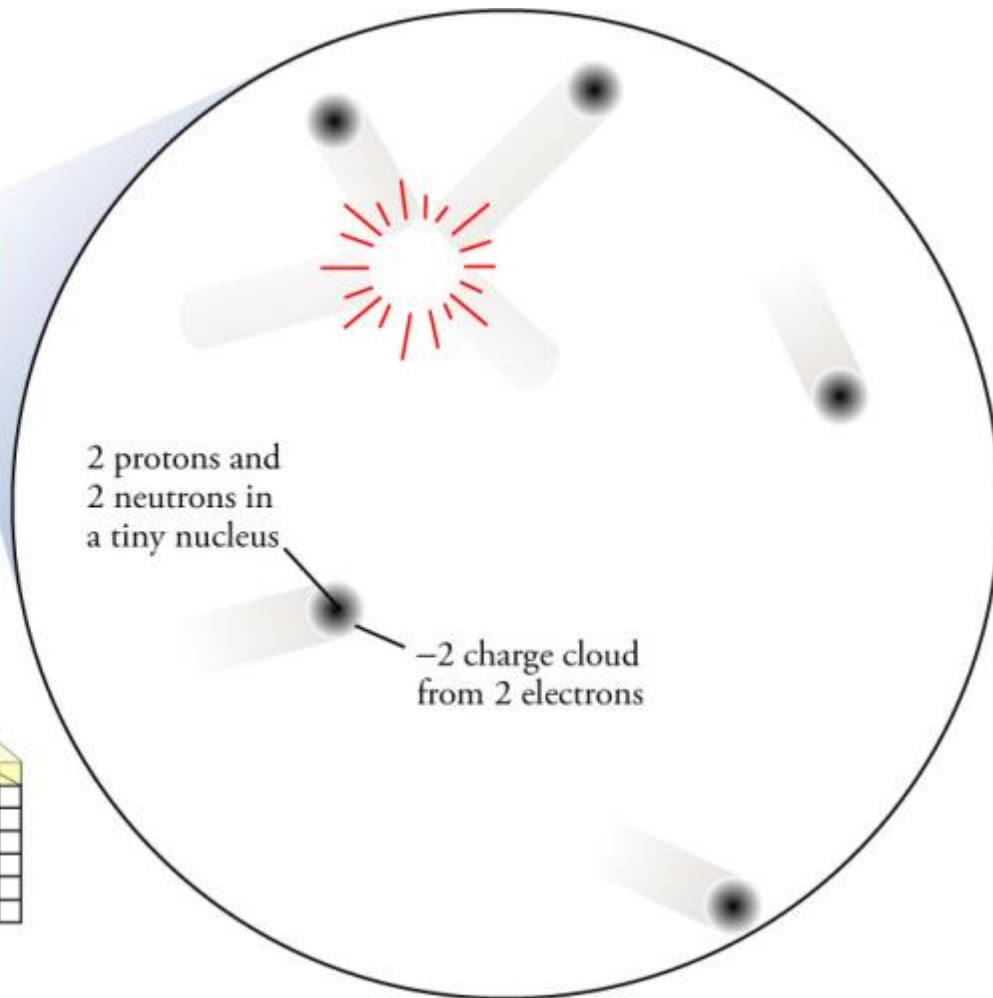
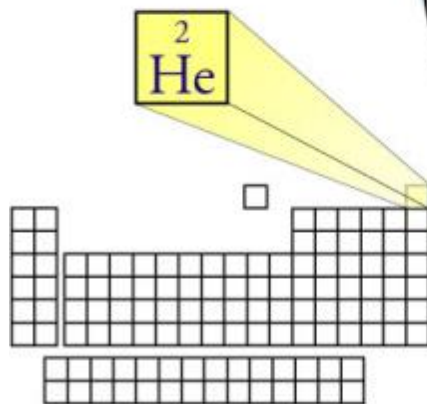
# To Describe Structure of Elements

- What particles?
  - Noble gases – atoms
  - Other nonmetals - molecules
    - Diatomic elements –  $\text{H}_2$ ,  $\text{N}_2$ ,  $\text{O}_2$ ,  $\text{F}_2$ ,  $\text{Cl}_2$ ,  $\text{Br}_2$ ,  $\text{I}_2$
    - $\text{S}_8$ ,  $\text{Se}_8$ ,  $\text{P}_4$
  - Metallic elements – cations in a sea of electrons

# Description of Gas

- Particles constantly moving in straight-line paths
- About 0.1% of volume occupied by particles...99.9% empty.
- Average distance between particles is about 10 times their diameter.
- No significant attractions or repulsions.
- Constant collisions that lead to changes in direction and velocity.
- Variable volume and shape, due to lack of attractions and a great freedom of motion.

# Helium Gas, He



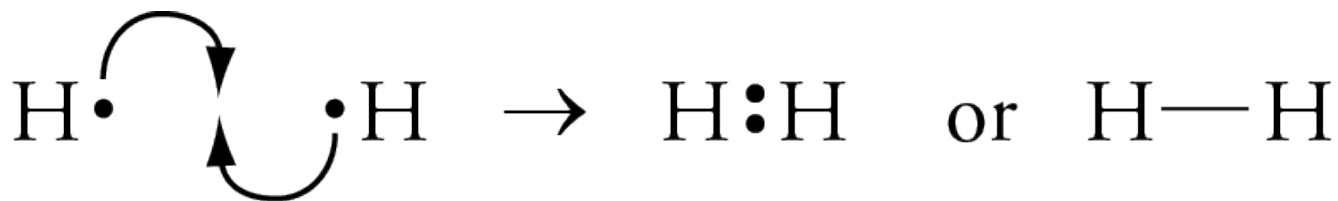
# To Describe Structure of Elements

- What particles?
  - Noble gases – atoms
  - Other nonmetals - molecules
    - Diatomic elements –  $\text{H}_2$ ,  $\text{N}_2$ ,  $\text{O}_2$ ,  $\text{F}_2$ ,  $\text{Cl}_2$ ,  $\text{Br}_2$ ,  $\text{I}_2$
    - $\text{S}_8$ ,  $\text{Se}_8$ ,  $\text{P}_4$
  - Metallic elements – cations in a sea of electrons



# Hydrogen Molecules

- Each hydrogen atom has one electron.
- Electrons are more stable when they are paired.
- To form a pair of electrons, two hydrogen atoms combine to form one a hydrogen molecule, H<sub>2</sub>.



# Covalent Bonds and Molecules

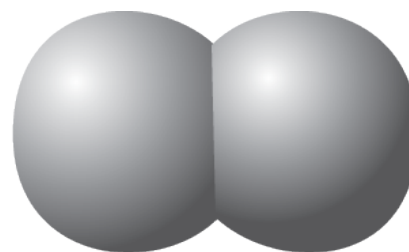


- **Covalent bond** = a link between atoms due to the sharing of two electrons
- **Molecule** = an uncharged collection of atoms held together by covalent bonds
- The link that holds two hydrogen atoms together is a covalent bond. We call the pair of hydrogen atoms a hydrogen molecule.
- Its chemical formula is  $H_2$ .

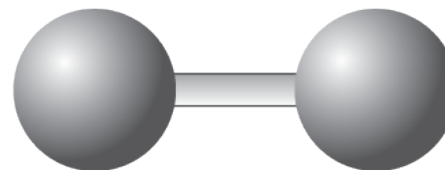
# Hydrogen, H<sub>2</sub>, Molecule

Hydrogen nuclei

The two electrons  
generate a charge  
cloud surrounding  
both nuclei.

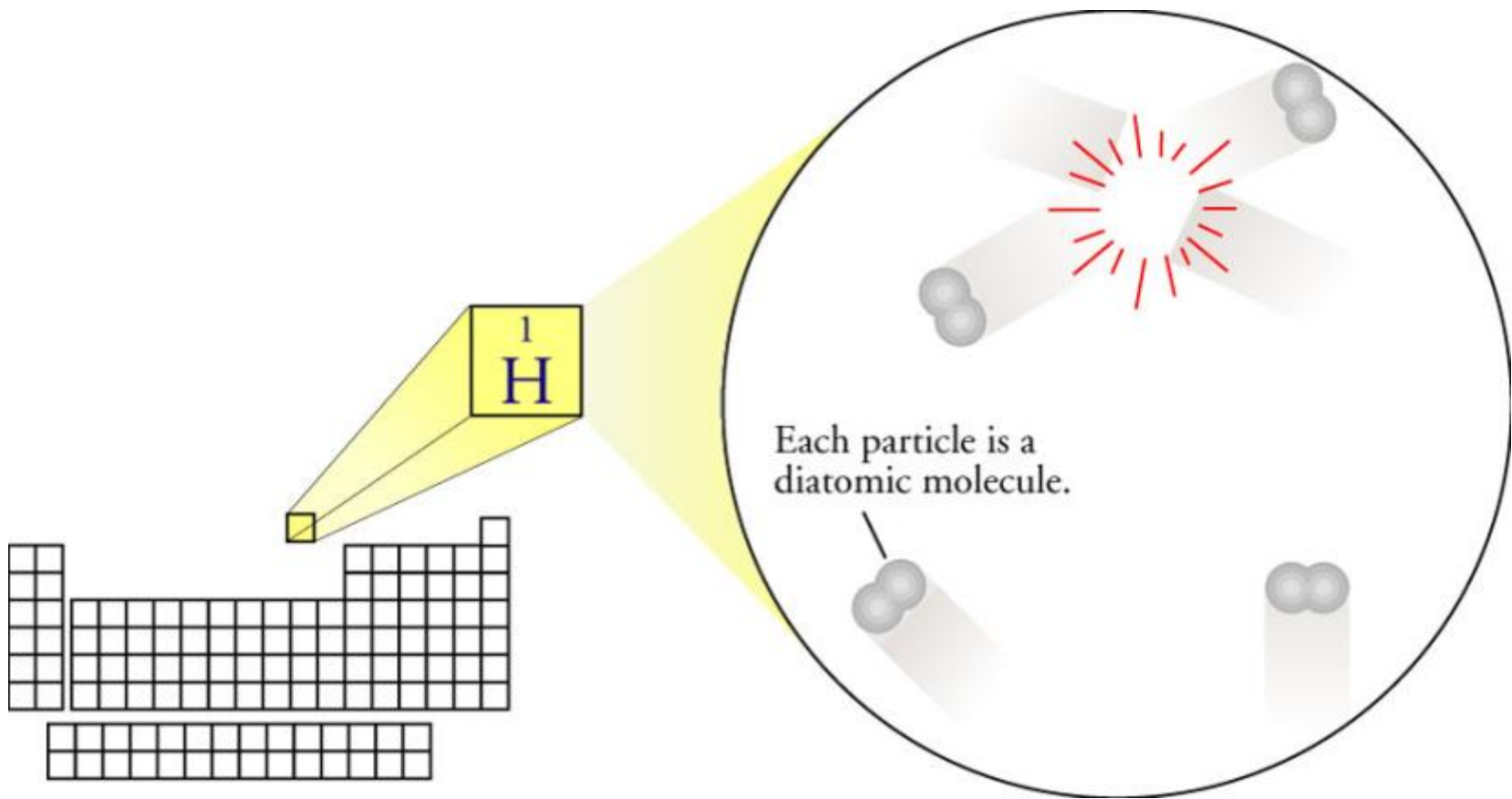


Space-filling model  
Emphasizes  
individual atoms



Ball-and-stick model  
Emphasizes bond

# Hydrogen Gas, H<sub>2</sub>



# Diatomic Molecules

- Molecules that have two atoms are called **diatomic**.
- Hydrogen ( $H_2$ ), nitrogen ( $N_2$ ), oxygen ( $O_2$ ), fluorine ( $F_2$ ), chlorine ( $Cl_2$ ), bromine ( $Br_2$ ), and iodine ( $I_2$ ) are diatomic.

# Diatomic Molecules

												1	13	14	15	16	17	18	
												1	3A	4A	5A	6A	7A	8A	
												1	H	3A	4A	5A	6A	7A	2
												1	H	3A	4A	5A	6A	7A	2
												1	H	3A	4A	5A	6A	7A	2
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	
3	11 Na	12 Mg	3B	4B	5B	6B	7B	8B	8B	8B	11 1B	12 2B	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
5	37 Rb	38 Sr	39 Y	40 Zr	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	
6	55 Cs	56 Ba	71 Lu	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	
7	87 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	113 Uut	114 Uuq	115 Uup	116 Uuh			
6			57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb			
7			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			

# Bromine



- The element bromine,  $\text{Br}_2$ , is composed of diatomic molecules.
- Bromine is one of the two elements that are liquids.

# To Describe Structure of Elements (2)

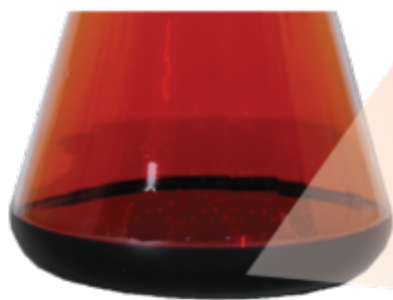
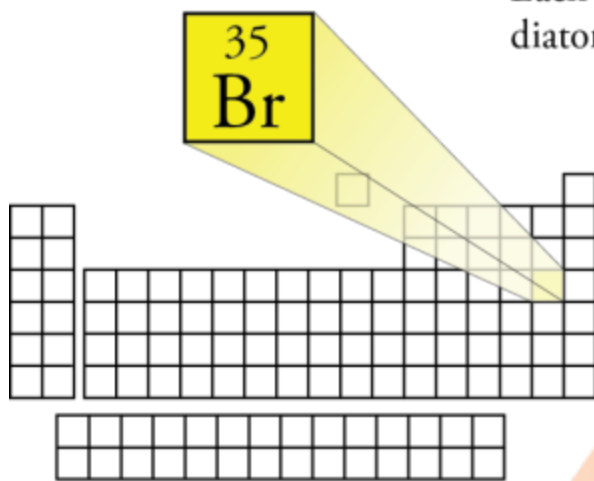
- Solid, liquid, or gas?
  - Gases -  $\text{H}_2$ ,  $\text{N}_2$ ,  $\text{O}_2$ ,  $\text{F}_2$ ,  $\text{Cl}_2$ , He, Ne, Ar, Kr, and Xe
  - Liquids –  $\text{Br}_2$  and Hg
  - Solids – the rest
- Standard description of (1) solid, (2) liquid, (3) gas, or (4) metal.



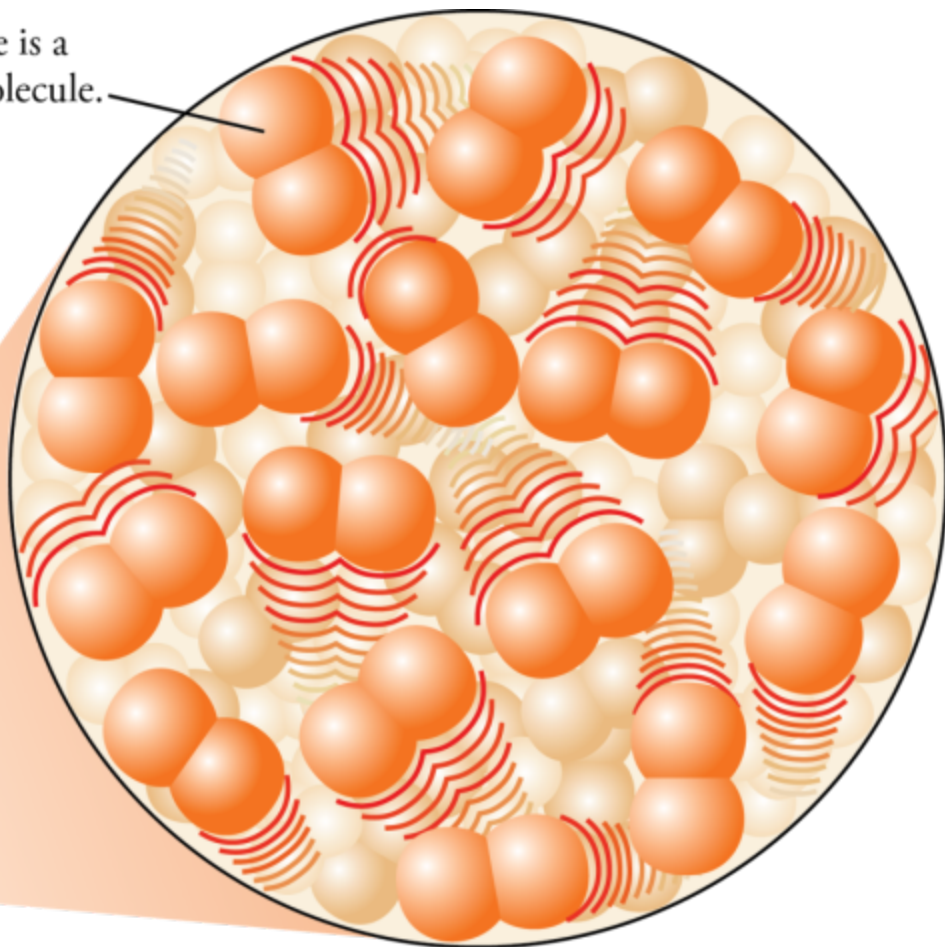
# Description of Liquid

- Particles constantly moving.
- Up to 70% of volume occupied by particles...30% empty
- Attractions are strong but not strong enough to keep particles from moving throughout the liquid.
- Constant collisions that lead to changes in direction and velocity.
- Constant volume, due to significant attractions between the particles that keeps the particles at a constant average distance, but not constant shape, due to the freedom of motion.

# Bromine Liquid, $\text{Br}_2$



Each particle is a diatomic molecule.



# Iodine

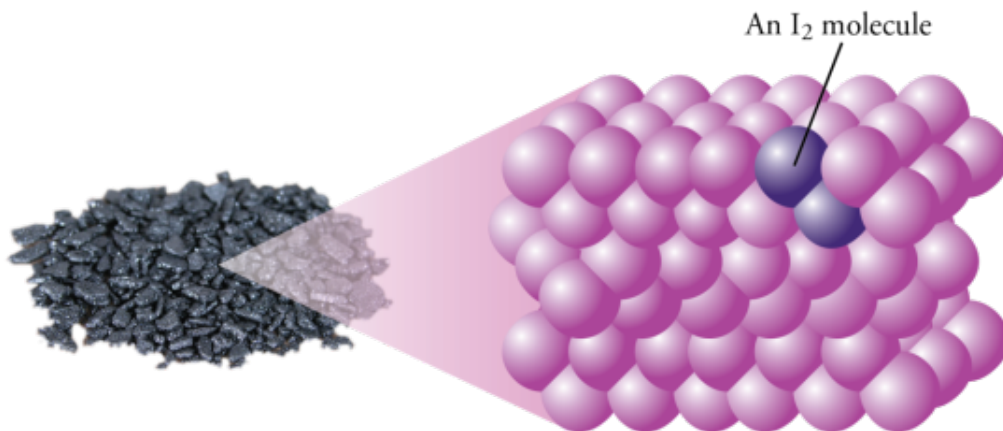
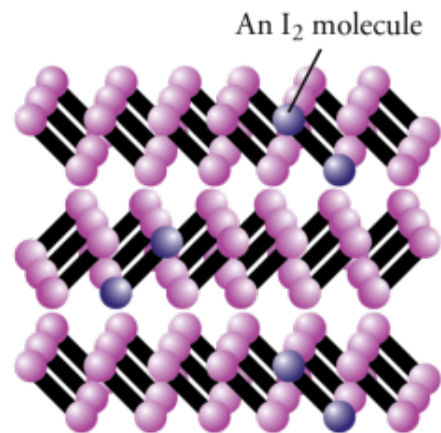
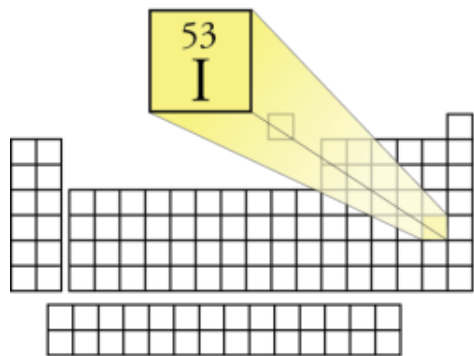


- Like all of the halogen (group 17), the element iodine,  $I_2$ , is composed of diatomic molecules.
- Because iodine is not on our list of gases or liquids, it must be a solid at room temperature and pressure.
  - Gases -  $H_2$ ,  $N_2$ ,  $O_2$ ,  $F_2$ ,  $Cl_2$ , He, Ne, Ar, Kr, and Xe
  - Liquids –  $Br_2$  and Hg
  - Solids – the rest

# Description of Solid

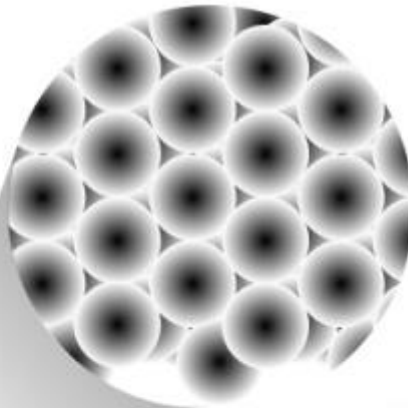
- Particles constantly moving.
- Up to 70% of volume occupied by particles...30% empty.
- Strong attractions keep particles trapped in cage.
- Constant collisions that lead to changes in direction and velocity.
- Constant volume and shape due to strong attractions and little freedom of motion.

# Iodine Solid

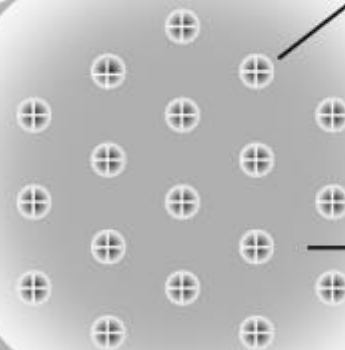


# Typical Metallic Solid and Its “Sea of Electrons”

Atoms are packed closely together.



Cations lie in planes.



Electrons move freely, forming a sea of negative charge.

Sea-of-Electrons Model