Subatomic Particles

Octet Rule

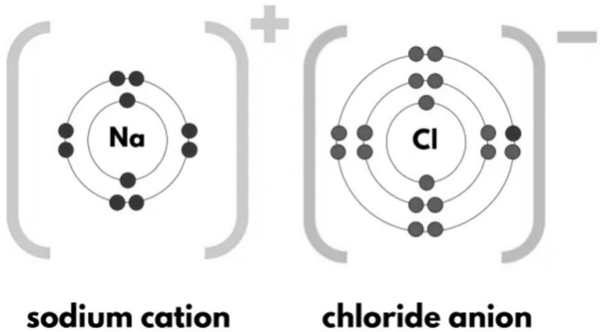
Atoms are the most stable when they have 0 or 8 valence electrons.

Ion – Atom that has lost or gained e^- to fulfil the octet rule

Sodium (Na) loses $1e^-$ to form a **cation**

1 val e^- → 0 val e^-

Cation = + Ion



Chlorine (Ca) gains $1e^-$ to form an **anion**

7 val e^- → 8 val e^-

Anion = - Ion

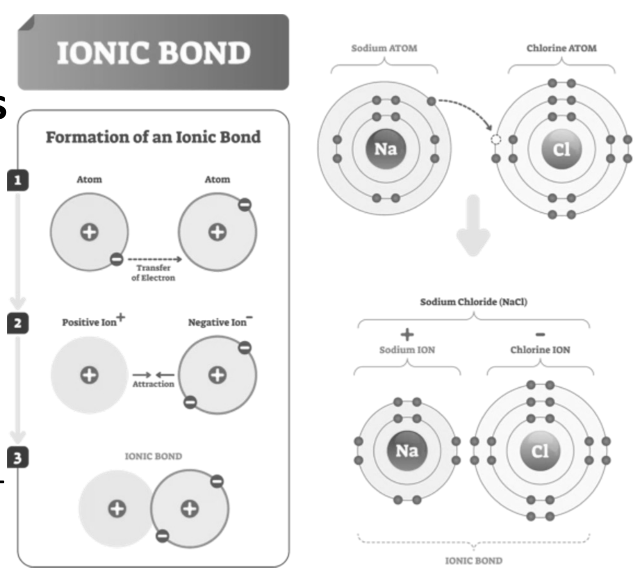
2

Ionic Bonding

From Ions to Ionic Bonds

Ionic Bonds are the connection between to atoms due to the transfer of electrons between a metal (*+ ion*) and a non-metal (*- ion*)

Ionization energy is the energy required to split apart two atoms into individual ions. The + and – ions give ionic bonds a very high ionization energy.

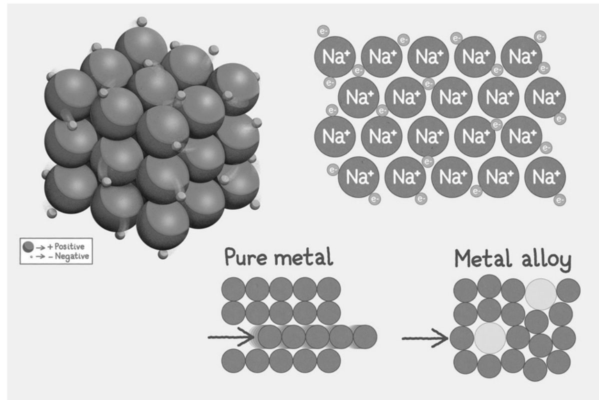


3

Metallic Bonding

Metallic Bonding is the process of positive ions (*cations, metals*) being held strongly together due to a group of *negative free electrons* (-) between atoms.

The free electrons form an **electrostatic force** (*strong connection between ions*) due to the positive ion (*+ metal ions*) and the negative electrons.



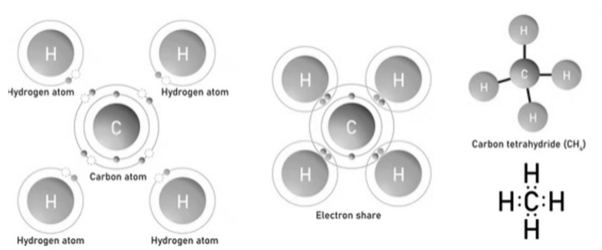
An **alloy** is a metal mixture where a different metal (*yellow in the diagram above*) that sits in the middle of other metal atoms.

4

Covalent Bonding

Covalent Bonding is the process of two non-metals **sharing electrons** to allow both atoms to obey the *octet rule* part of the time within the atomic structure

A atoms desire to obtain electrons is an atoms **electronegativity**. With non-metals high electronegativity requires atoms to share electrons to obey the *octet rule*



Covalent bonds can occur anytime there is a single electron available to share between electrons. In the example above, each hydrogen in CH_4 (*carbon tetrahydride*) is attached to carbon with a single covalent bond (*sharing of 2 electrons*)

5

Writing Lewis Dot Structures

Filling Order

1 5

8 X 2

4 X 6

7 3

1 val. e^- each side then pair

Al

(13, 3 val e^-)

Al

Se

(16, 6 val e^-)

Se

Na

group 1

1 val. e^-

Na Na

Na

Ca

group 2

2 val e^-

Ca Ca

Ca ~~Ca~~

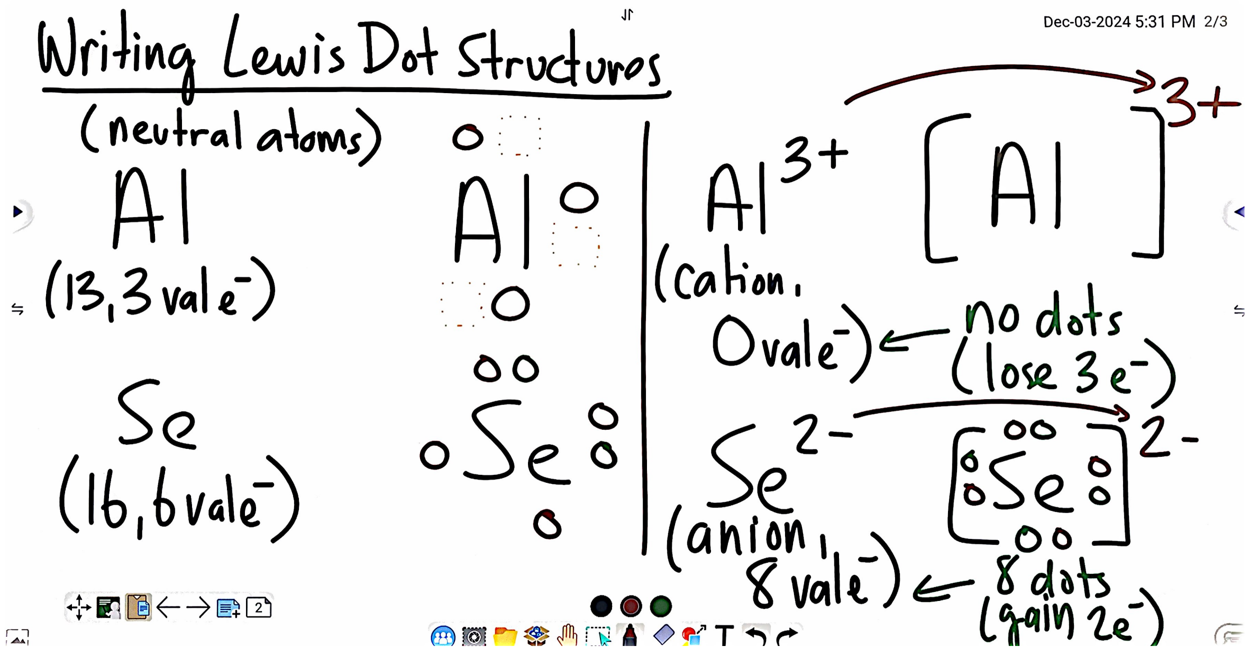
P

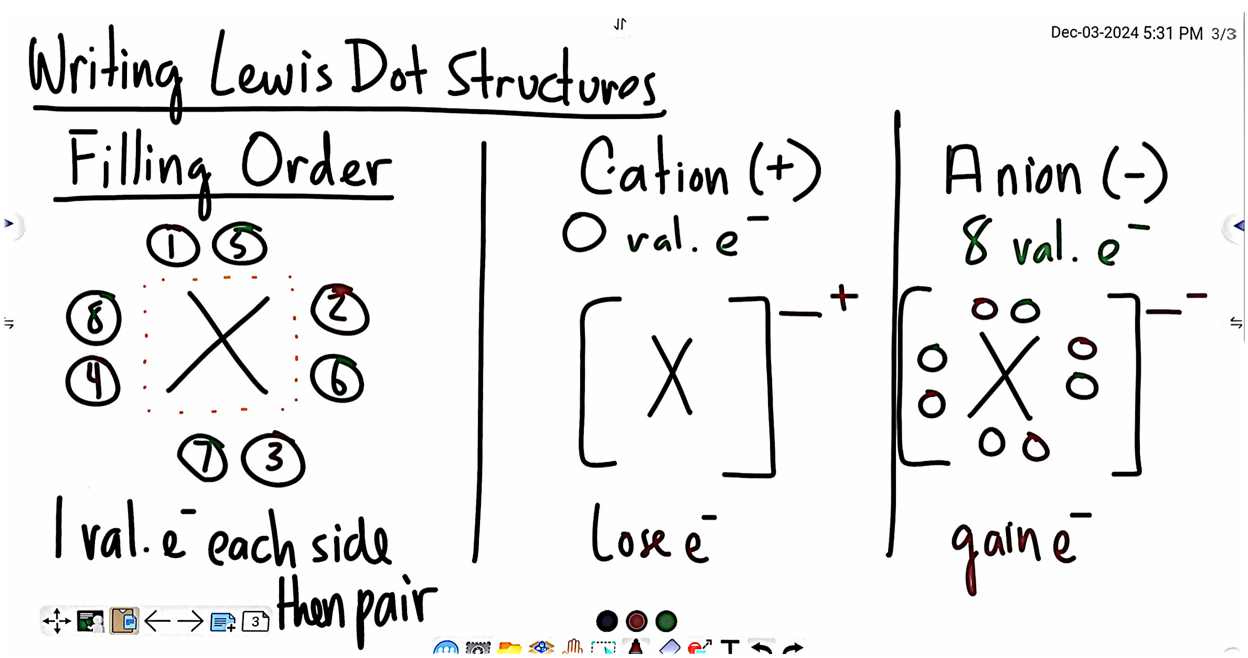
group 15

5 val e^-

P P P

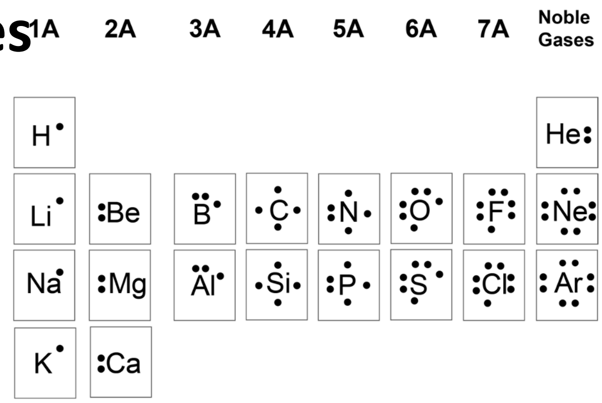
~~P~~ ~~P~~

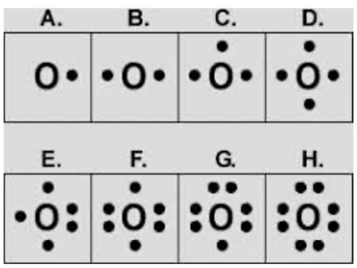

Writing Lewis Dot Structures
Dec-03-2024 5:31 PM 2/3
(neutral atoms)
Al
(13, 3 val e⁻)
Se
(16, 6 val e⁻)
Al 3+
(cation, 0 val e⁻)
no dots (lose 3 e⁻)
[Al] 3+
Se 2−
(anion, 8 val e⁻)
[Se] 2−
8 dots (gain 2e⁻)


Writing Lewis Dot Structures
Dec-03-2024 5:31 PM 3/3
Filling Order
1 5 8 2 4 6 7 3
X
1 val. e⁻ each side then pair
Cation (+)
0 val. e⁻
[X] +
Lose e⁻
Anion (−)
8 val. e⁻
[X] −
gain e⁻

Lewis Dot Structures

A **lewis dot structure** is a visual representation of the valance electrons within an atoms atomic structure. Each dot represents a single valence electron.





The **valence electrons** within a lewis dot structure have a specific *filling order*. First one electron is placed on each side of the atom, then electrons are paired in the same order.

7

Ion Dot Structures

An **ion** is formed when an atom loses or gains electrons to fulfill the octet rule (*0 or 8 valence electrons*).

A **cation** (*+ ion*) has lost electrons and will have no dots with a positive ion charge

An **anion** (- *ion*) has gained electrons and will have 8 dots (octet) with a negative ion charge

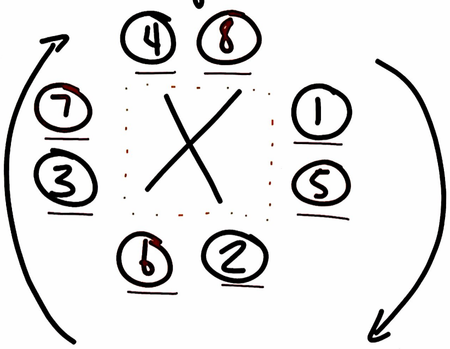
Ions are always represented with a bracket around the electrons

The electron dot structures shown above illustrate a positive Sodium Ion (+ 1 charge, lost 1 electron), and a negative Chlorine Ion (-1 charge, gained 1 electrons).

Notice the brackets around the two ions, showing each is in the ion Lewis Dot Structure form.

8

Filling Order

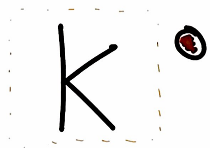


1 per side then pair

K : group 1, 1 val e^-

+1 charge

Dot Structure



1 val. e^-

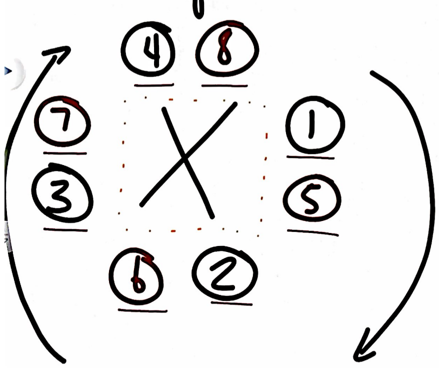
Ion Structure

$[K]^{1+}$

+1 cation

No Dots!

Filling Order



1 per side then pair

Si : group 14, 4 val e^-

+4 charge

Dot Structure

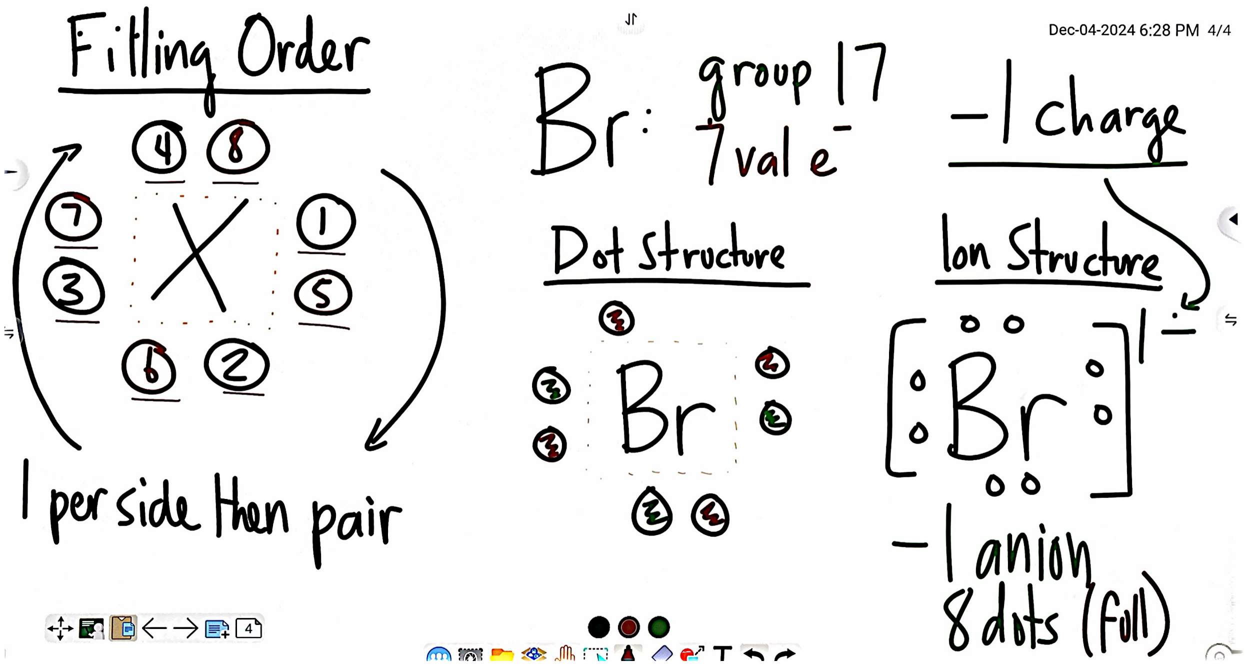
4 val e^-

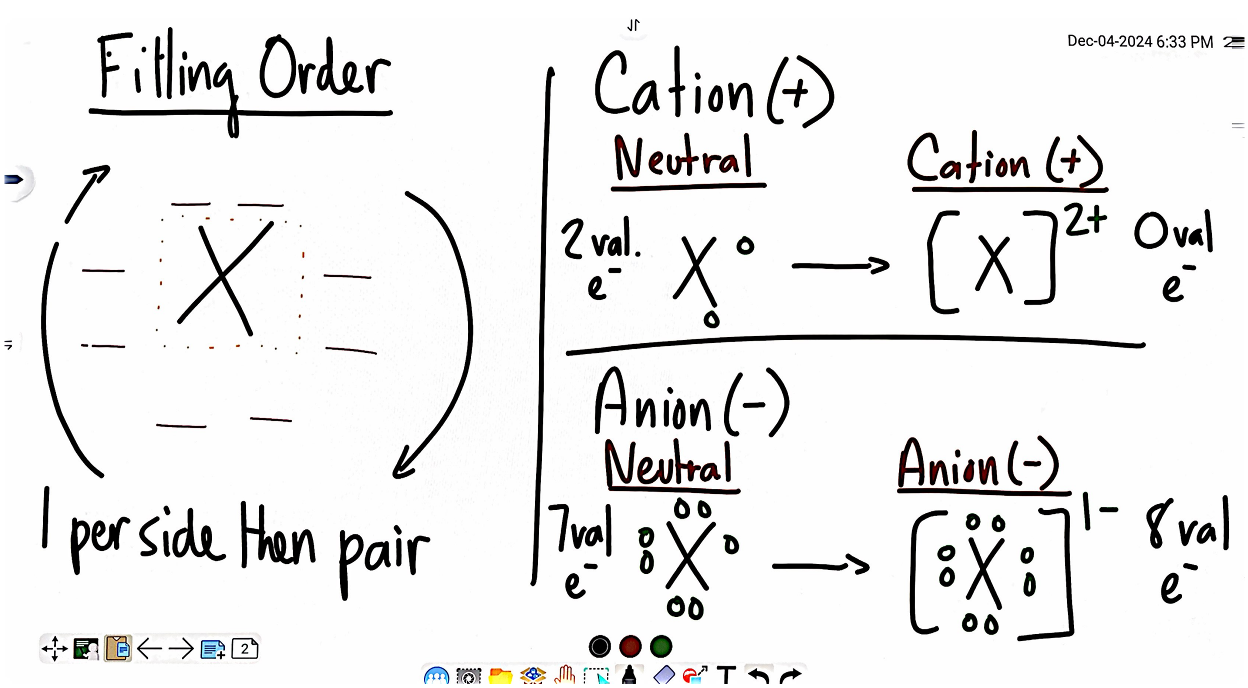
Ion Structure

$[Si]^{4+}$

+4 Cation

no dots

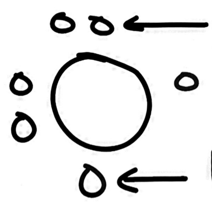

Dec-04-2024 6:28 PM 4/4
Filling Order
4 8
7 1
3 X 5
6 2
1 per side then pair
Br: group 17
7 val e-
-1 charge
Dot Structure
Br
Ion Structure
[Br]1-
-1 anion
8 dots (full)


Dec-04-2024 6:33 PM
Filling Order
X
1 per side then pair
Cation (+)
Neutral
Cation (+)
2 val. e-
X
[X]2+
0 val e-
Anion (-)
Neutral
Anion (-)
7 val e-
X
[X]1-
8 val e-

Var. Filling Orders

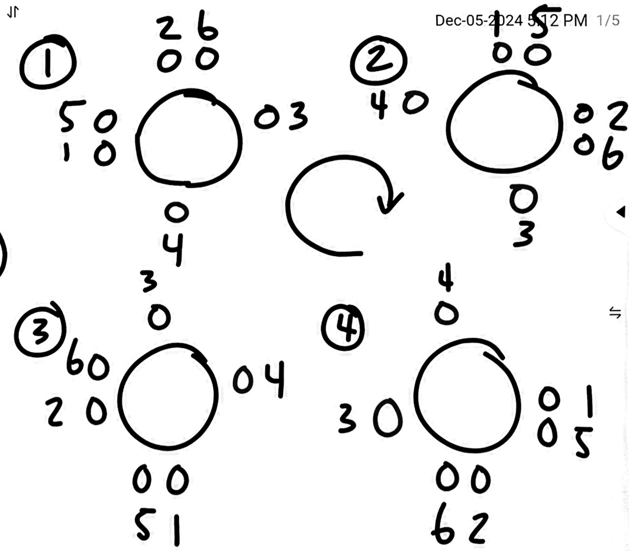
goal: Put unpaired e⁻ in location for bonds.

6 val. e⁻ (can form 2 bonds)

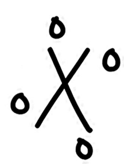
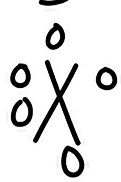
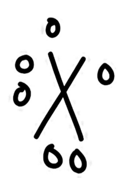
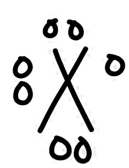
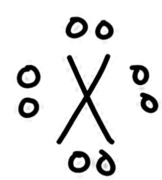


paired e⁻ (no bonds)

unpaired e⁻ (form single bonds)

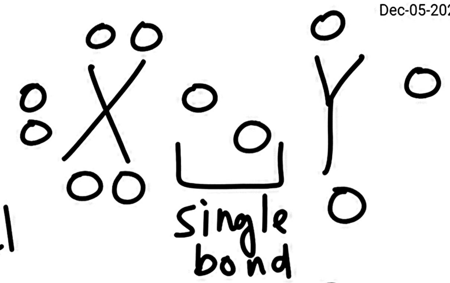


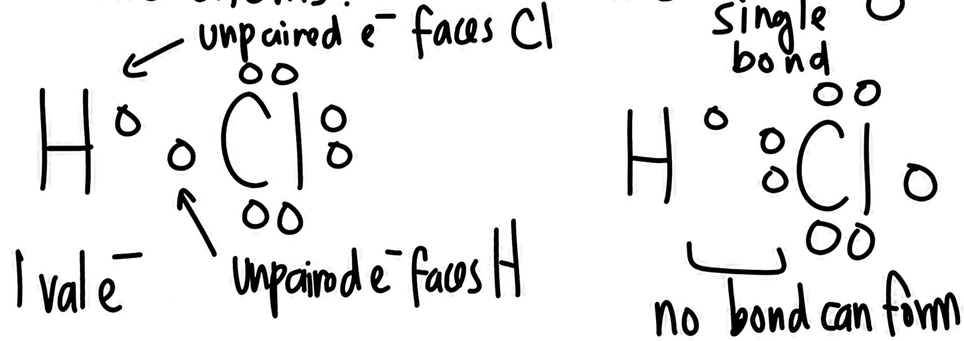
groups and dot structures

group	14	15	16	17	18
# val e⁻	4	5	6	7	8
# pairs	0	1	2	3	4
# unpair	4	3	2	1	0
dotstructure					

Single Covalent Bond

Sharing of 2 unpaired e^- between two atoms.

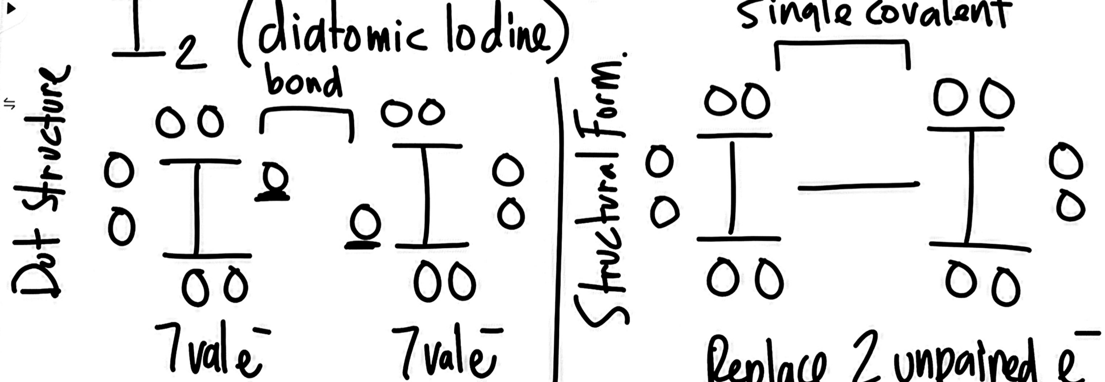




Diatomic Elements (single bond)

Some elements form single bonds w/ each other

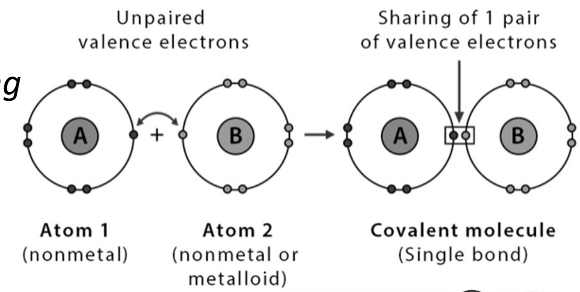
I_2 (diatomic Iodine)



Writing Covalent Bonds

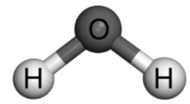
Single Covalent Bond

A covalent bond (*bond due to sharing of electrons*) where two atoms each share a single electron to form a bond between the two atoms

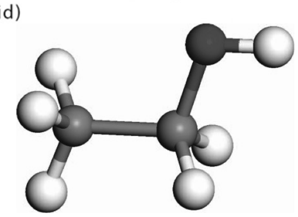


Covalent Molecule

A structure consisting of two or more atoms connected by covalent bonds. Molecules can contain either a small or large number of atoms



Water H_2O

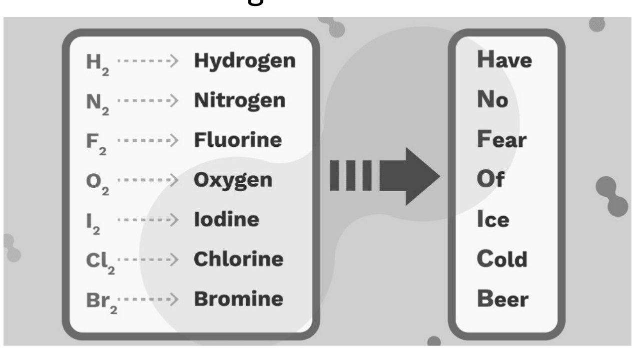

Ethanol, C_2H_5OH

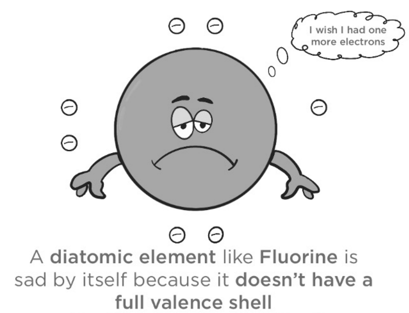
2

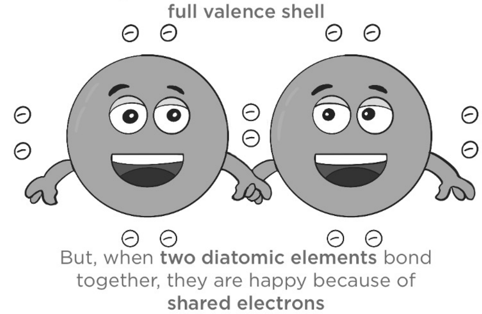
Writing Covalent Bonds

Diatomic Elements

Elements that always exist as a pair of atoms as opposed to single atoms due to covalent bonding.



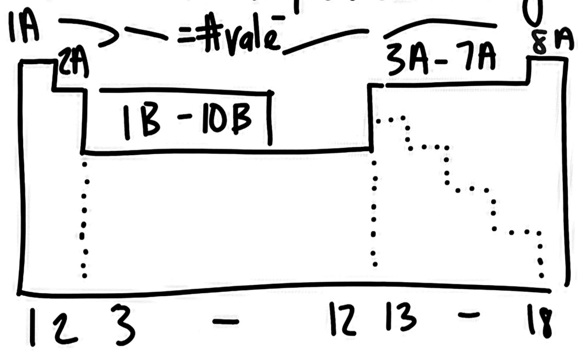




3

Dot Structure Review

\# val e^- = # dots, based on group



Ex: (val e^- = # dots)

F : group 17 (7A)
: 7 val e^-

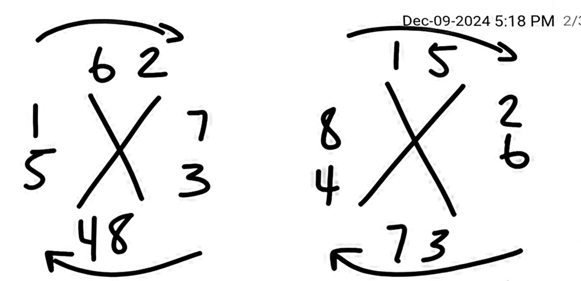
C : group 14 (4A)
: 4 val e^-

Ca : group 2 (2A)
: 2 val. e^-

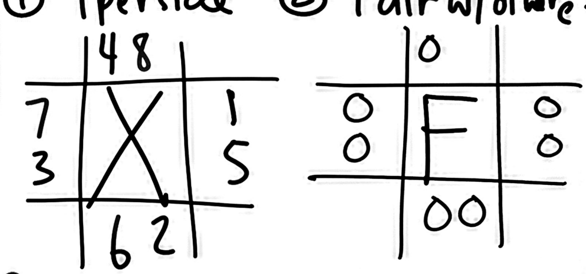
Dot Structure Review

Filling order

1. Pick starting side
2. Move clockwise
3. 1 e^- per side (dot)
4. After 4 e^- (dots) pair (same order)



① 1 per side ② Pair w/ others



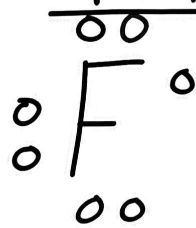
Dot Structure Review

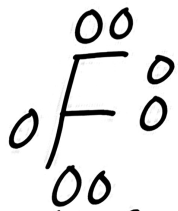
Examples	option 1		Correct

F

(7 vale$^-$, 7A, 17)

option 1



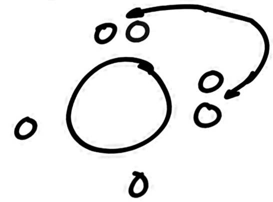


option 2

O

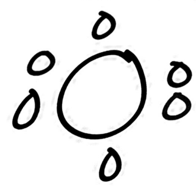
(6 vale$^-$, 6A, 16)

Correct

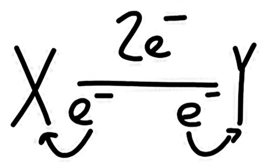


next to each other

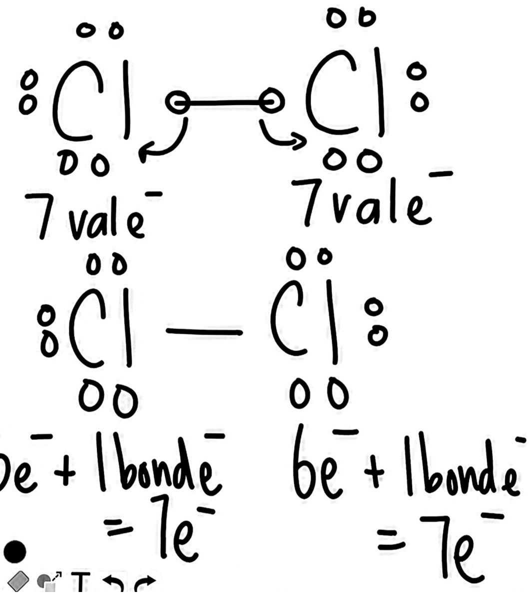
Incorrect



Structural Formula



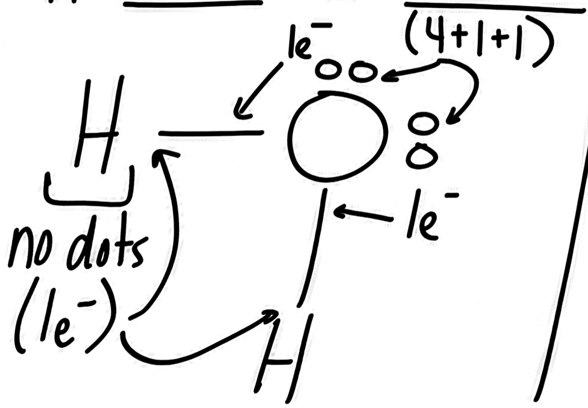
Single covalent bond
$2e^-$, 1 from each atom
X has $1e^-$ Y has $1e^-$
Both atoms share both e^-

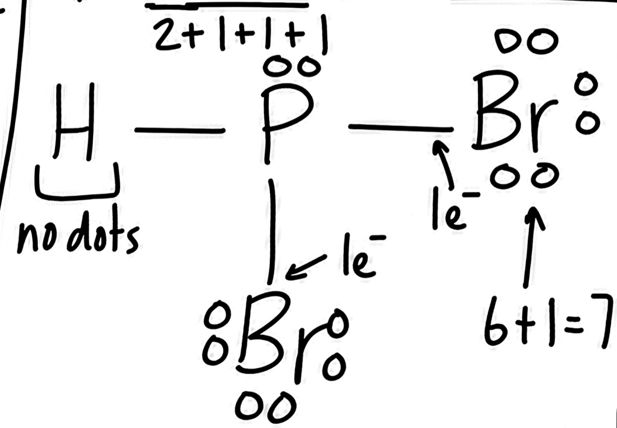


Structural Formula Example

H = 1 O = 6 (4+1+1)

P = 5 (2+1+1+1) Br = 7



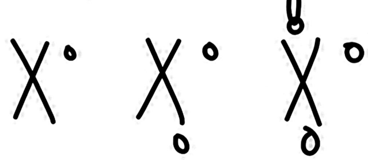


Electronegativity

An atoms ability to attract electrons (e^-) towards itself.

1-3 valence e^- (Ge Sn/Pb (4 vale$^-$))

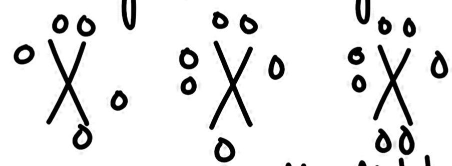
- Want to lose e^-
- Low Electronegativity



Electro. 0.7-1.9

5-7 valence e^- (C/Si (4 vale$^-$))

- Want to gain e^-
- High electronegativity



Non-Metals | Electro. 2.0-4.0

Electronegativity Difference

Metal = Ionic!

Difference in electronegativity values between atoms.

Ionic Bonds

*Metal

Transfer of e^-

Low Electro. Metal to High Electro. Non-Metal

ED between 1.91-3.50*

ED = High Electro - Low Electro.

Na	and	Cl
0.9		3.0

ED = 3.0 - 0.9 = 2.1

Ionic

Electronegativity Difference

Covalent = No metals!

Polar Bond

* No metals

Unequal sharing of e^-

Mid Electro Non-Metal to High Electro. Non-Metal

ED between 0.51 - 1.90*

ED = High Electro - Low Electro.

H	and	Cl
2.1		3.0

ED = 3.0 - 1.9 = 0.9

Polar Covalent

unequal sharing

Electronegativity Difference

Covalent = No metals!

Non-Polar Bond

* No metals

Equal sharing of e^-

High Electro Non-Metal to High Electro. Non-Metal

ED between 0.0 - 0.50*

ED = High Electro - Low Electro.

Cl	and	Cl
3.0		3.0

ED = 3.0 - 3.0 = 0.0

Non-Polar Covalent

equal sharing

Bond Dipoles

Dipole is an uneven sharing of electrons in bond

Polar = Dipole

Dipole

H — O

2.1 3.5

+end −end

ED = 1.4
Polar

Dipole

+ end −end

Lower Electro. Higher Electro.

gets e^- less gets e^- more

attracts −end attracts +end

Ionic vs. Polar Covalent

Ionic : Transfer of e^-

Metal / High ED

+end −end

0.9 Na^+ .... Cl^- 3.0

lose e^- gain e^-

Polar Covalent

Unequal sharing of e^-

No Metals / High ED

2.1 H — Cl 3.0

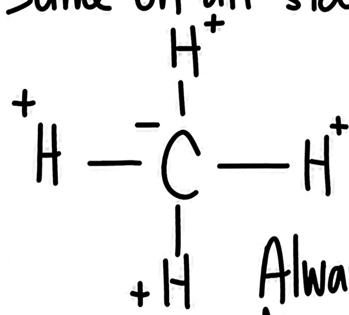
+end −end

less e^- share e^- more e^-

Symmetry in Molecules

Symmetrical molecule

Same on all sides

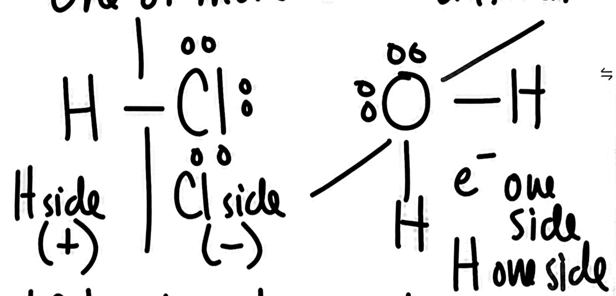


H on all 4 sides

Always Non-Polar

Asymmetric Molecule

One or more sides different



If bonds polar, molecule polar

Molecule Polarity

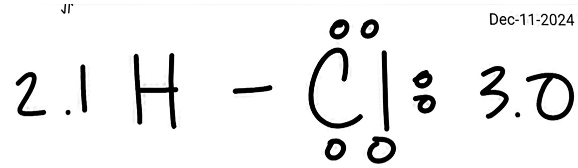
① Find bond ED

② NonPolar Bond = NonPolar Molecule

③ For Polar Bond

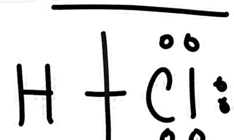
symmetrical molecule : NonPolar Molecule

asymmetrical molecule : Polar Molecule



ED = 3.0 − 2.1 = 0.9

Bond is Polar Covalent Bond



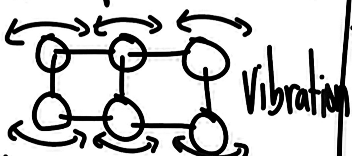
Asymmetrical

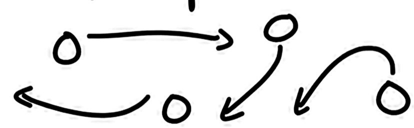
Polar Molecule

Energy and Change of State

State: The position and connections for part. in matter
atom, ion, compound, molecule

Solid	Liquid	Gas
Fixed Shape and Size	Var. Shape Fixed Size	Var. Shape and Size





Vibrate along the bonds	Flow but are still bonded to other part.	Flows w/no bonds to other particles

Energy and Change of State

Solid — State Change → Liquid

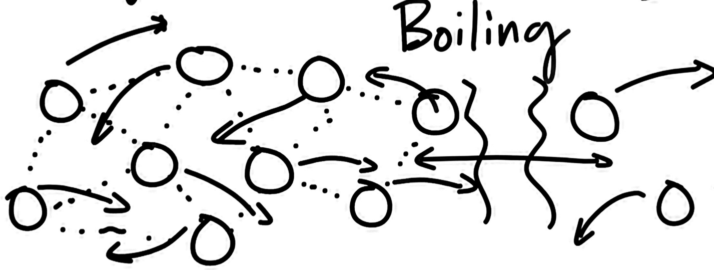
Heat of Fusion — Melting →

Heat of Solidification

Solid ← Freezing — Liquid (lost)

Energy and Change of State

Liquid	State Change	Gas
	Boiling →	Heat of Vaporization (add)



Liquid	← Condensing	Gas
		Heat of Condensation (lose)

Energy and Change of State

Solid	State Change	Gas
	Sublimation →	Heat of Sublimation

Solid	← Deposition	Gas
		Heat of Deposition

Energy and Change of State

Na – Cl
strong Ionic Bond
(Hard to break)

H – Cl
weaker polar Bond
(easier to seperate)

Stronger Bonds need more E to break

H – Cl ED = 0.9
stronger polar — stronger

H – C
weaker nonpolar — weaker

Larger ED, stronger bond / Harder to Break

Feb-26-2024 7:42 PM 1/1

Molecular Interactions

Intramolecular attractions:

Connections between atoms in a compound or molecule

Ionic: Transfer of e^-

metal $\xrightarrow{e^-}$ non-metal

strong + to − attraction | $A^+ — B^-$
+ to −

Polar: Unequal sharing of e^-

Low Electro $\xleftrightarrow{e^-}$ High Electro.
(less often) (more often)

Dipole: $\longrightarrow$
(+ end) [High ED] (− end)

Non-Polar: Equal or nearly equal sharing of e^-

Diatomic [ED < 0.5]

$A \xleftrightarrow{e^-} A$ equal

$A \xleftrightarrow{e^-} B$ nearly equal

Feb-26-2024 10:22 PM 2/4

Molecular Interactions

Intermolecular ~~Attractions~~

Connections between two or more molecules or ions (+ or −) from ionic compounds.

Re: Dipole

⊕ Polar ⊖

Re: Ionic

$A^+ — B^-$ (Ionic)

Ionic Interaction

+ and − crystal structure

$Na^+ — Cl^- \cdots Na^+ — Cl^-$

$Cl^- — Na^+ \cdots Cl^- — Na^+$

VIBRATION

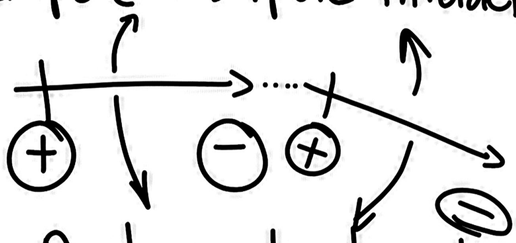
State: Solid

Intermolecular: strong

Molecular Interactions

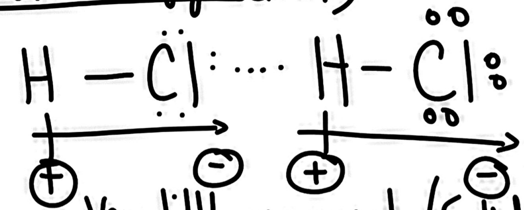
Polar - Polar Bond

Dipole - Dipole Interaction



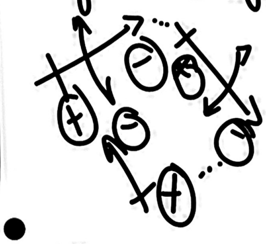
Dipole can break and reform.

Low Energy (Heat)



Very little movement / Solid

Higher Energy (Heat)



Flow: Break and Reform bonds

Liquid

Electroneg. and Bond Type (Review) [Intramolecular]

Bond Type?

3.5 4.0

ED

$4.0 - 3.5 = 0.5$

Bond: Polar (slightly)

Ionic: ED > 1.9
Metal = Ionic

Polar ED > 0.4
No Metals

Non-Polar ED < 0.4
No Metal

Feb-27-2024 7:38 PM 4/5

Molecular Interactions

Non-Polar - Non-Polar Bond

No Direct Interaction

nonpolar no charges | nonpolar no charges

Molecules can collide but don't bond

Low Energy (Heat)

Lower speed, gas

Higher Energy (Heat)

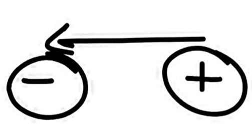
Higher Speed, gas

Feb-27-2024 7:47 PM 5/7

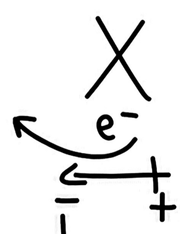
Molecular Interactions

Polar - Non-Polar Bond

Dipole - Induced Dipole



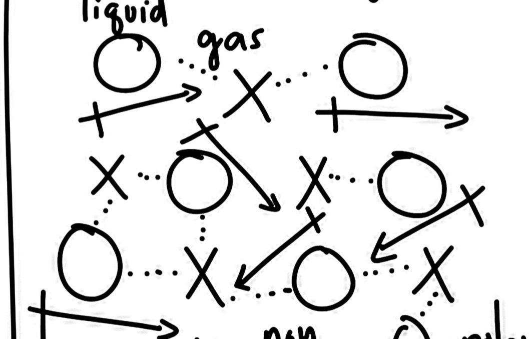
Permanent Dipole



e^- in X attracted to + dipole

temporary dipole (Induced)

Induced dipoles occur when non-polar gases mix in polar liquids

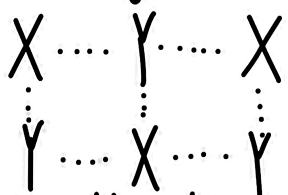


X = non polar O = polar

Bond Strength and States of Matter

Solid : Ionic

Strong Inter.

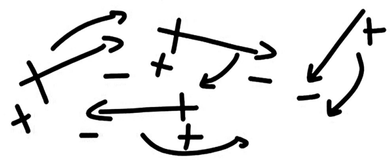


Low Heat/Energy

Vibration Only

Liquid : Polar

Medium Interact.



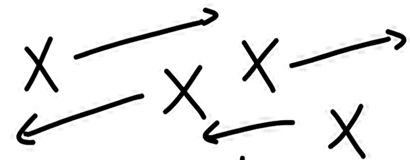
Medium Heat/Energy

Particles Flow over each other

Form/Break Bonds

Gas : Non-Polar

Weak Interact



High Heat/Energy

Particles Flow/No Bonds

States of Matter

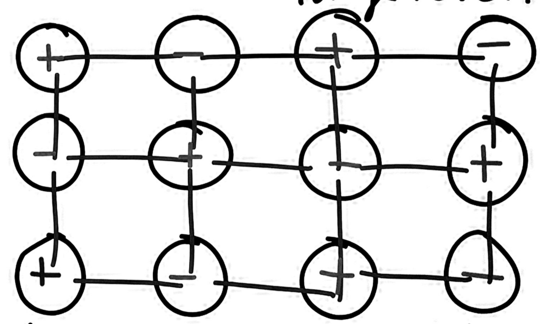
<u>State</u>: How particles interact with each other at a <u>macro</u> large level.

Solid

<u>Fixed</u> Shape

<u>Fixed</u> Volume

<u>Strong</u> Interactions



Ionic Compound as a solid

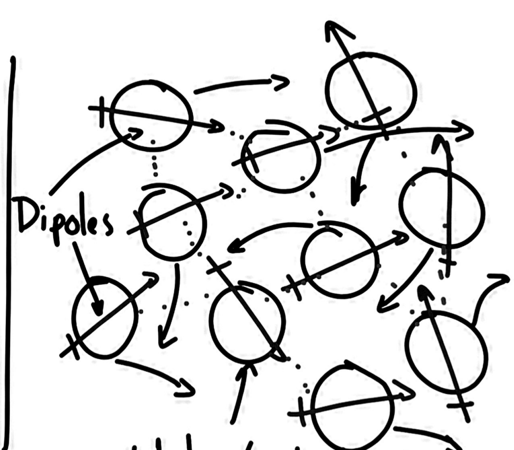
States of Matter

Liquid

<u>Variable</u> Shape

<u>Fixed</u> Volume

<u>Medium</u> Interactions



Water(polar) at room temp

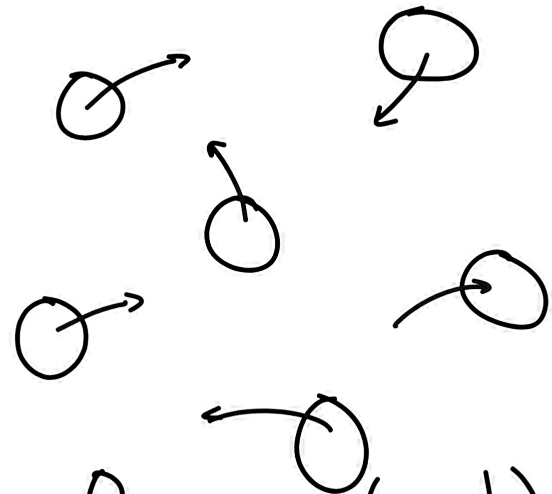
States of Matter

Gas

Variable Shape

Variable Volume

Weak Interactions



Oxygen gas (non-polar)

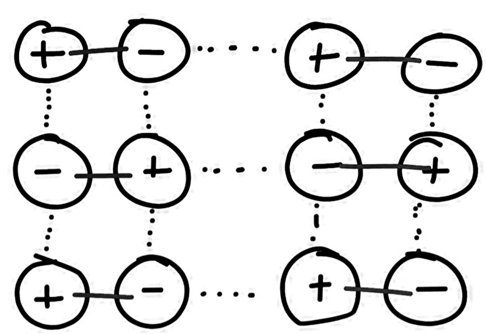
Molecular Interactions

Ionic - Ionic (Bond)

Type +/- crystal structure

State Solid

Strength Strong



Ionic +/-

Particle Connection

+/- charge attraction

Dec-13-2024 6:10 PM 5/

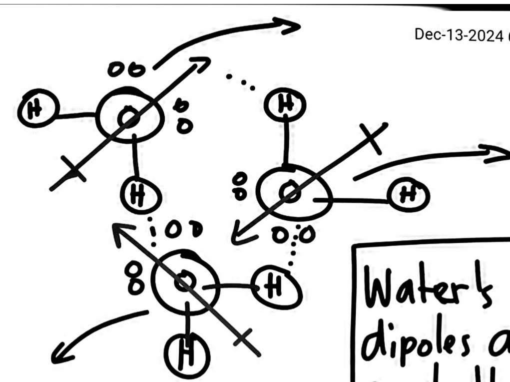
Molecular Interactions

Polar - Polar (Bond)

Type Dipole-Dipole

State Liquid

Strength Medium



Water's dipoles are constantly interacting

Particle Connection

Positive dipole end w/ negative (and - to +) dipole end

5

Dec-13-2024 6:10 PM 6/

Molecular Interactions

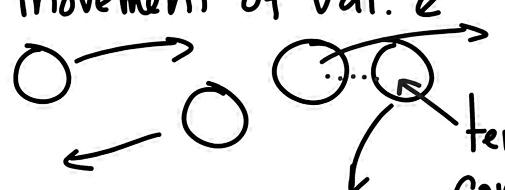
Non-Polar - Non Polar (Bond)

Type Induced Dipole / Induced Dipole

State gas

Strength Weak

Induced dipole: temporary (short) interaction due to movement of val. e^-



temp. Connect. (dipole)

Particle Connection

Quick connection when particles collide

6