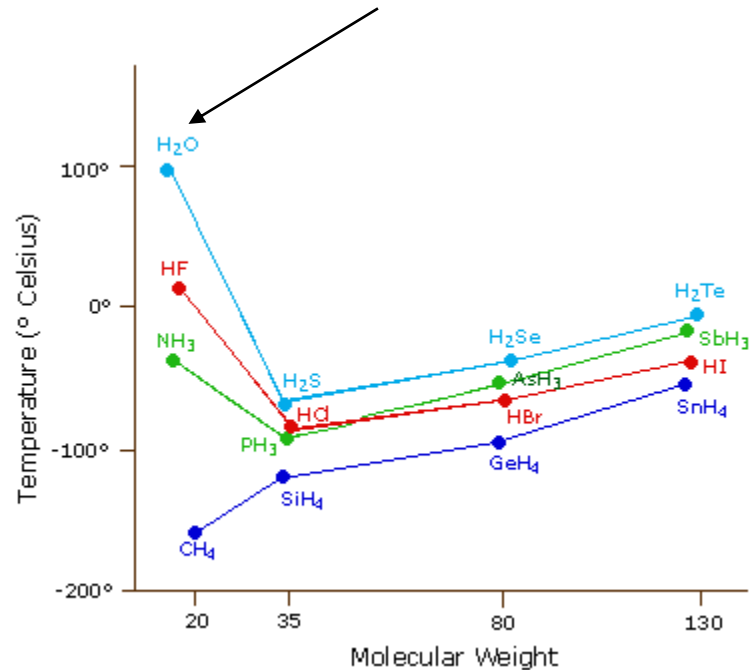


Intermolecular  
Forces

# Intermolecular Forces: Introduction

Why is the boiling point of water so much higher than the other molecules?



- Many physical properties, such as **melting point, volatility, boiling point, odor, and solubility** are related to the strength of the attractive forces between molecules. (Intermolecular Forces)
- There are 3 Types of Intermolecular Forces: **Dispersion Forces, Dipole-Dipole Forces, and Hydrogen Bonding**





# Melting Points of Different Substances

CH <sub>4</sub>	van der Waal's	-182 <sup>o</sup> C
CH <sub>3</sub> F	dipole-dipole	-141 <sup>o</sup> C
CH <sub>3</sub> OH	hydrogen bonds	-93 <sup>o</sup> C
Al	metallic	660 <sup>o</sup> C
AlF <sub>3</sub>	ionic	1291 <sup>o</sup> C
C	covalent	3550 <sup>o</sup> C

Although molecular compounds have lower melting points than any of the other types of compounds, there is still a considerable range in these melting points because of the different types of intermolecular forces present.

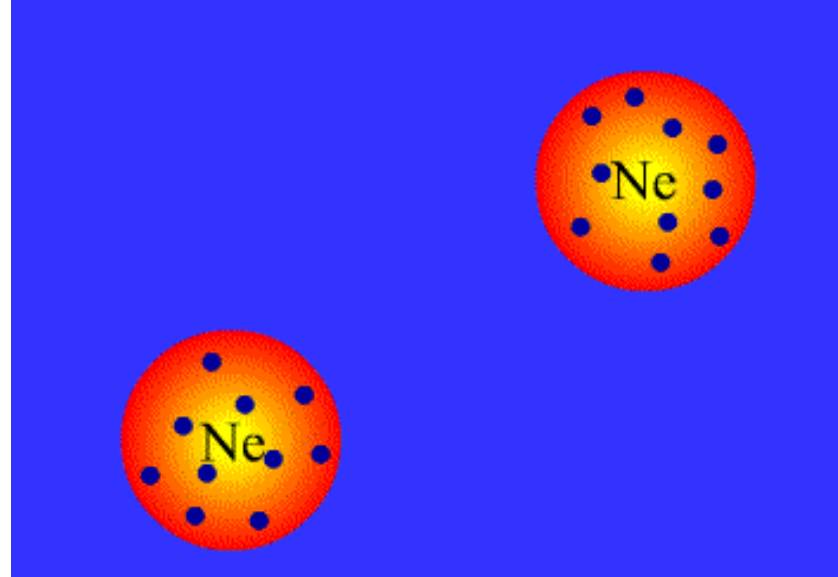
# Halogen States of Matter @ STP

Intermolecular Forces can also help explain why Iodine is a solid at STP, Bromine is a liquid, and Fluorine and Chlorine are gases.

Element	Colour	Size	Melting Point (°C)	Boiling Point (°C)	Physical State
Fluorine	Yellow		-220	-188	GAS
Chlorine	Green		-101	-35	GAS
Bromine	Orange-brown		-7	59	LIQUID
Iodine	Purple		+114	184	SOLID

How do nonpolar molecules have intermolecular forces if they do not have permanent dipoles?

# Even monoatomic atoms have dispersion forces!



**Weakest**

**1. Dispersion  
(Van der  
Waals)  
Forces**

# The 3 Types of Intermolecular Forces

**Dispersion Forces (also known as Van der Waals Forces) occur between ALL atoms and molecules.** Generally, they are the weakest of the intermolecular forces.

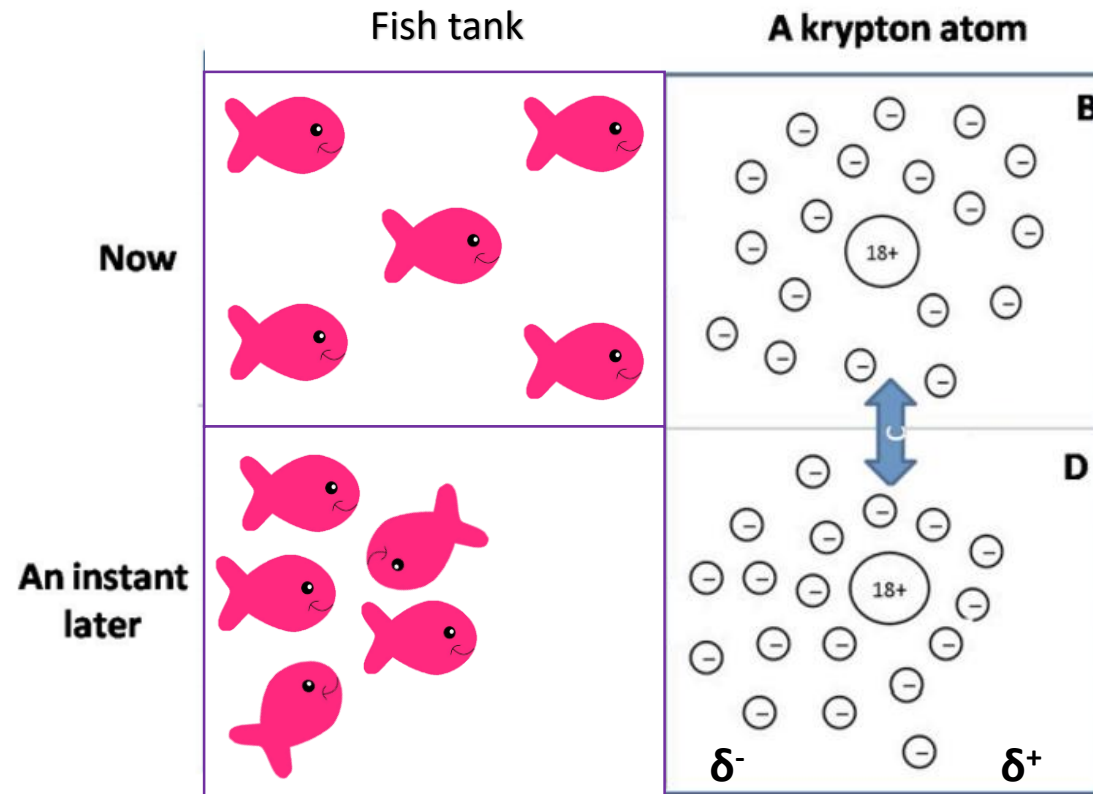
They are the **ONLY** intermolecular forces that exist between nonpolar molecules. ( $\text{CO}_2$ ,  $\text{N}_2$ ,  $\text{H}_2$ ,  $\text{CH}_4$ )

When the electrons of an atom happen to be momentarily more on one side of an atom, rather than being evenly spread out, a small partial separation of charge (**temporary dipole**) is created. This temporary dipole creates an attraction between molecules that is similar to, but much weaker than, the force between permanently polar molecules.

**THE DISPERSION FORCES GET STRONGER AS THE MOLECULE GETS BIGGER**

# Temporary Dipole Created by Unequal Distribution of Electrons in an Atom

Dispersion Forces



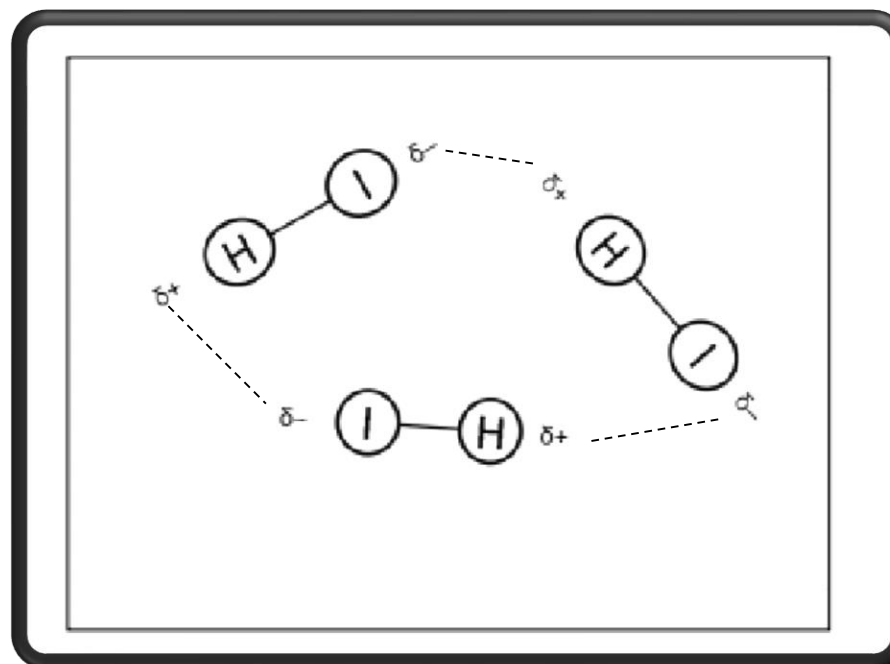
\*Notice the partial charges on the atom in box D



# The 3 Types of Intermolecular Forces

A permanent **Dipole (separation of charge)** is found in all *polar* molecules ( $\text{H}_2\text{O}$ ,  $\text{NH}_3$ ,  $\text{HCl}$ ) in which the charge is unevenly distributed. This uneven charge distribution gives one side of the molecule a permanent partial positive charge ( $\delta^+$ ) and one side of the molecule a permanent partial negative charge ( $\delta^-$ ).

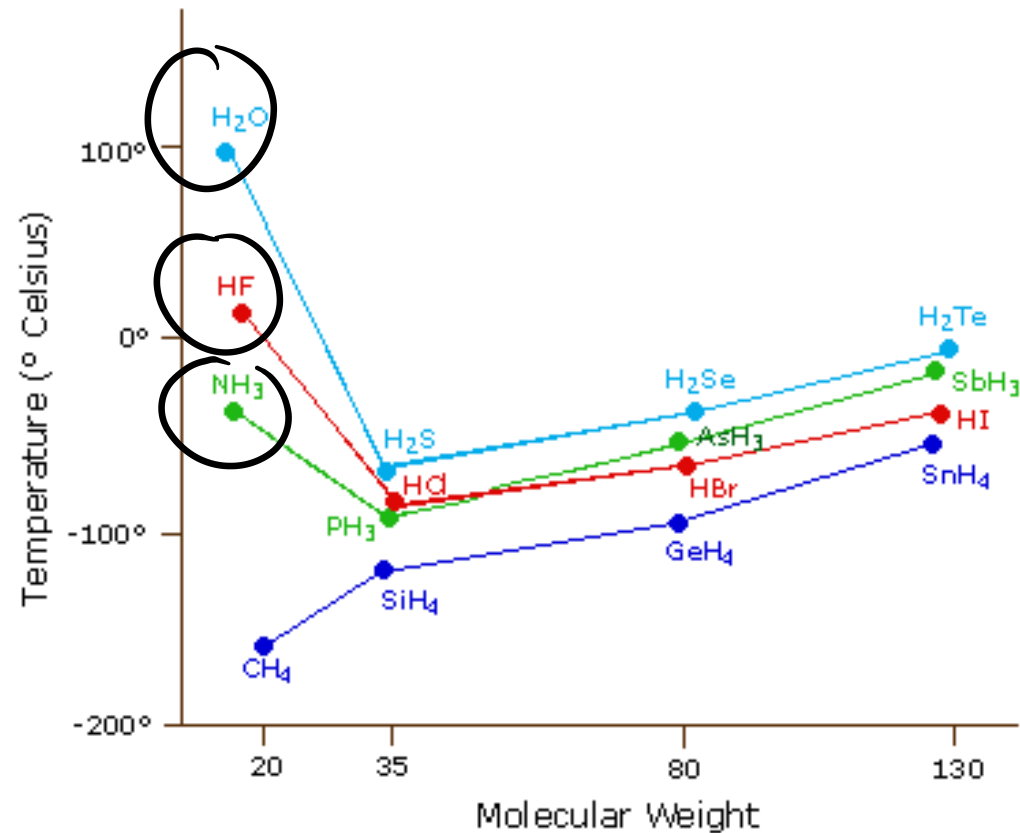
## 2. Dipole-Dipole Forces



Dipole-Dipole Forces

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# What's going on with H<sub>2</sub>O, HF, and NH<sub>3</sub>?

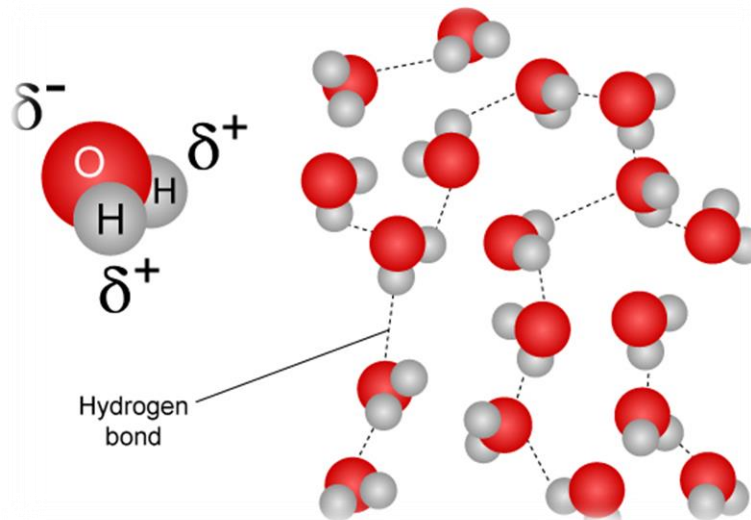


# Strongest

## 3. Hydrogen Bonding

# The 3 Types of Intermolecular Forces

When a **hydrogen** atom is covalently bonded to **nitrogen**, **oxygen**, or **fluorine** (highly electronegative atoms), a very strong dipole is formed. The dipole-dipole interactions that result from these dipoles are known as **hydrogen bonding**. Hydrogen bonding is an especially strong form of dipole-dipole interaction and is the strongest type of intermolecular force in covalent molecules.

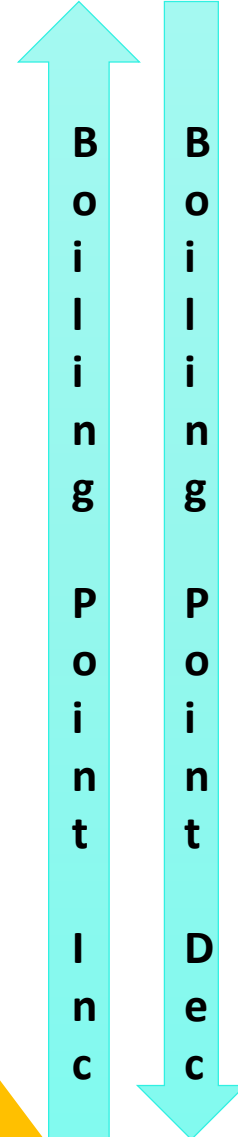
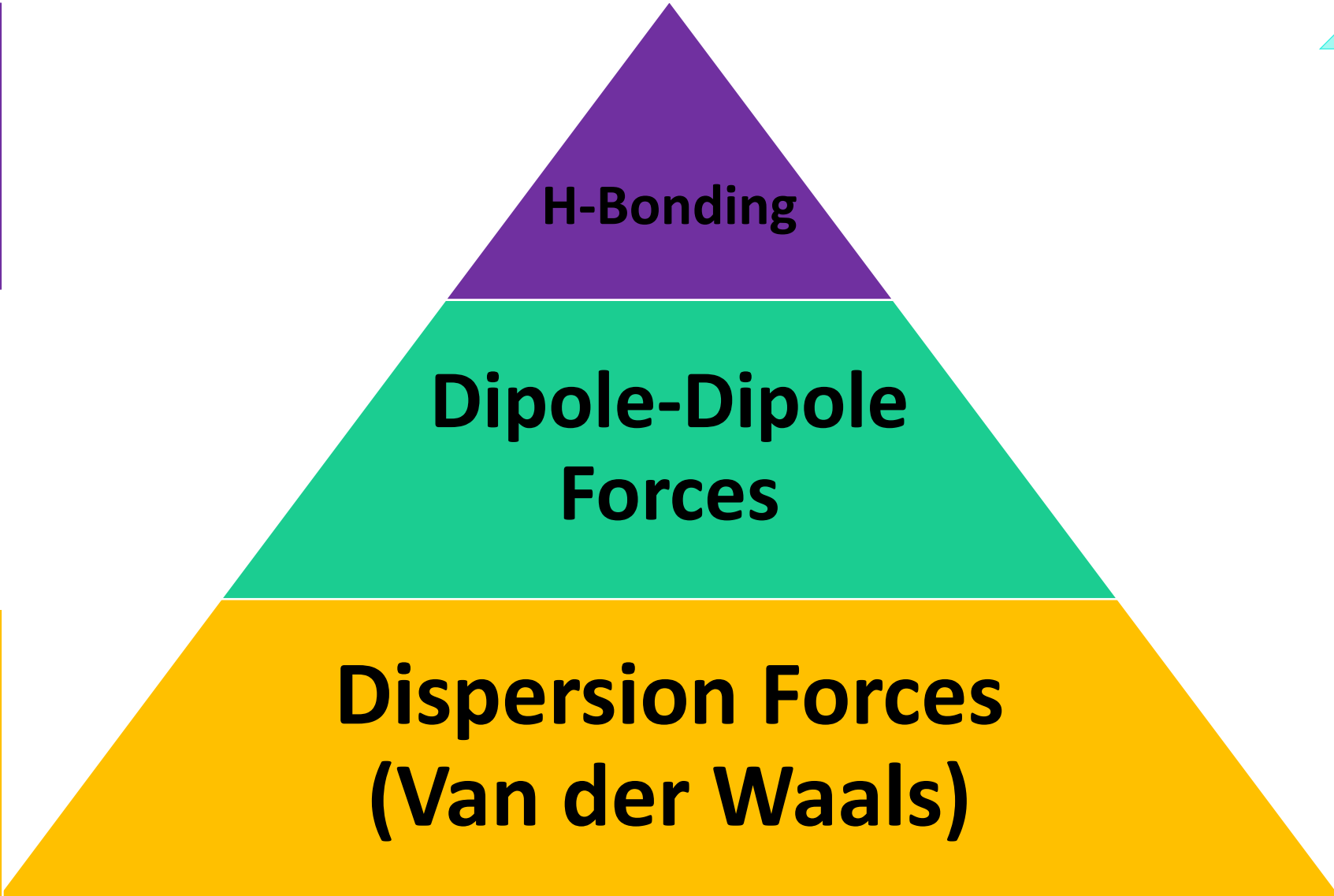


Hydrogen Bonding is the reason water has such a high boiling point!

Very Polar  
Molecules  
(H-F,O,N)

Polar  
Molecules,  
only

All  
molecules



# Practice Questions

- 1 . Chlorine is a gas, bromine is a liquid, and iodine is a solid because:
  - a) They have different types of intermolecular forces
  - b) Their bonds have different polarities
  - c) The strengths of the intermolecular forces differ in each compound
  - d) All of the above

# Practice Questions

2. Dry ice (solid  $\text{CO}_2$ ) is a molecular solid held together by \_\_\_\_\_ intermolecular forces, only, and easily \_\_\_\_\_ to form a vapor.

- a) Dipole-dipole, condenses
- b) H-Bonding, sublimates
- c) Dispersion forces, sublimates
- d) Dispersion forces, condenses

# Practice Questions

3. State the type(s) of intermolecular forces present in each of the following:



# Practice Questions

4. Rank the following compounds in order of lowest  $\rightarrow$  highest boiling point: NaCl, SiO<sub>2</sub>(Quartz), Cl<sub>2</sub>, HCl, H<sub>2</sub>O,