Answer Key
11/19/25

Intermolecular Forces

What determines states of matter?

- Kinectic energy of particles
- strength of attraction blw particles

What state of matter has the highest kinetic energy?

Gas

Gas > liquid > solid

What is the difference between a crystalline solid and an amorphous solid?

Crystalline solid = particles in a definite repeating pattern
- Ex: NaCl

Amorphous solid = particles lack an organized structure

Type of Solid	Interaction – how molecules bonded
Ionic	Ionic
Molecular – molecules held together by van der Waal forces	Hydrogen bonding Dipole-dipole London dispersion
Metallic	Metallic bonding
Network	Covalent bonding

What are allotropes? What are the allotropes of carbon?

Allotropes: Different structural forms of the same element

C – graphite, graphene, diamond

Red & white phosphorus

What is the major difference between states of matter?

Strength of intermolecular forces

What kind of forces keep molecules close together?

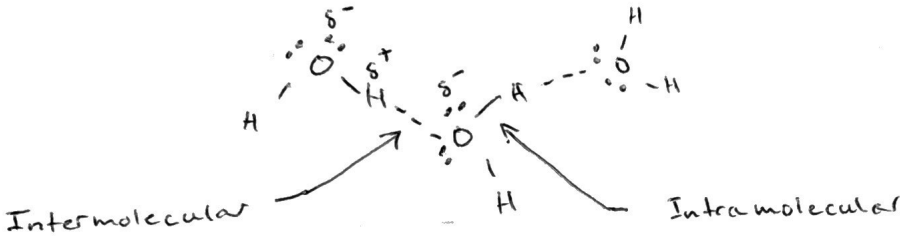
Strong forces

What is the difference between intermolecular forces and intramolecular forces?

Intermolecular: attraction blw compounds, atoms, + molecules

Intramolecular: Forces that hold atoms in a molecule (within)

Show the intermolecular and intramolecular forces between two atoms of water.



What are London dispersion forces? What affects London dispersion?

- Temporary attractive force
- Has polarizability = how easy e- cloud can be distorted
  - potential for a temporary dipole to happen
- present in all molecules

Factors that affect:

- # of e- in atom
- size of atom / molecule
- shape of molecule

What are dipole-dipole forces?

- polar molecules
- Permanent dipoles ($\delta^- + \delta^+$)

$\delta^+ H - F^{\delta^-}$ ← dipoles

↖ H bonding

What is hydrogen bonding? What elements cause hydrogen bonding to occur?

Dipole - dipole interaction w/ hydrogen + high electronegative atom

O, N, F = only H bonding

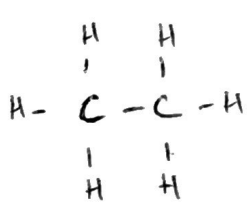
	Nonpolar	Polar	Special Bonds (OH, NH, or HF)	Ionic Compounds
London Dispersion	✓	✓	✓	✓
Dipole-Dipole		✓	✓	
Hydrogen Bonding			✓	
Ion-Dipole				✓

Van der Waals forces

List the London dispersion, dipole-dipole, hydrogen bonding, and ionic bonding in order of increasing boiling point.

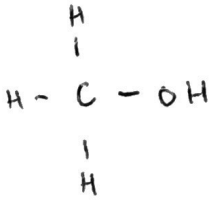
London dispersion < dipole - dipole < hydrogen bonding < ionic

Identify the type of intermolecular attractions in the following compounds: CH_3CH_3, CH_3OH, and CH_3CH_2OH. What is the substance with the highest boiling point?



non polar

LD

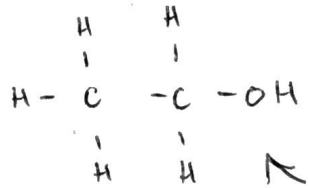


Polar

LD

D-D

HB



Polar

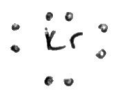
LD

D-D

HB

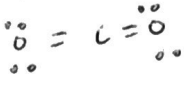
↑ highest boiling point b/c HB + larger molecular weight

Determine the type of intermolecular forces for each compound: Kr, H_2O, CO_2. List the compounds in order of increasing boiling point.



LD

HB

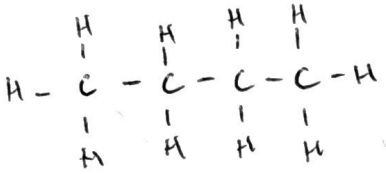


LD

↑ Larger weight

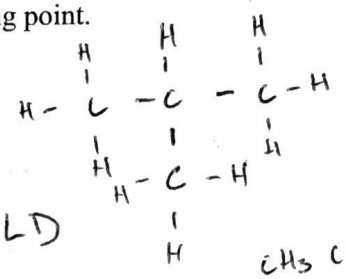
Kr < CO_2 < H_2O

Determine the type of intermolecular forces for each compound: C_4H_{10} and $CH_3CH(CH_3)CH_3$. List the compounds in order of increasing boiling point.



LD

same molecular weight

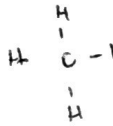


LD

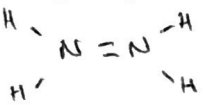
more branching = lower bp

$CH_3CH(CH_3)CH_3$ < C_4H_{10}

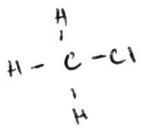
Which of the following compounds have hydrogen bonding? CH_4, H_2NNH_2, CH_3Cl, and H_2O.



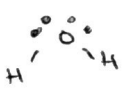
No



Yes



No

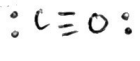


Yes

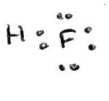
List the following compounds in order of increasing boiling point: $CaCl_2$, H_2, ~~CO~~ CO, HF, and Ne.

↳ Ionic

LD



D-D



HB

LD

H_2 < Ne < CO < HF < $CaCl_2$

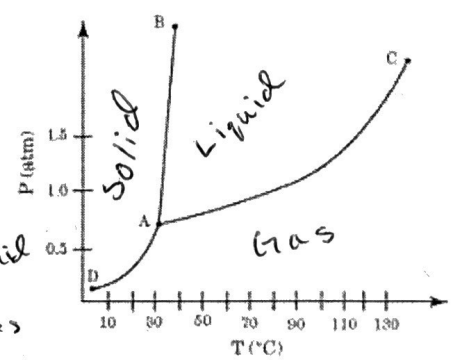
Label what spots A and C represent. Label solid, liquid, and gas in the diagram.

A = triple point

- All 3 equilibrium points meet

C = critical point

- Highest point where gas = liquid
- No distinction b/w liquid & gas



$$\frac{2 \text{ mol } H_2O \mid 18.015 \text{ g } H_2O}{1 \text{ mol } H_2O} = 36.0 \text{ g } H_2O$$

Calculate the enthalpy change by converting 2.00 mol of ice to steam. The specific heats of ice, liquid water, and steam are 2.03 J/g-K, 4.18 J/g-K, and 1.84 J/g-K. For water, the enthalpy of fusion is 6.01 kJ/mol, and the enthalpy of vaporization is 40.67 kJ/mol.

A-B: $q = mc\Delta T = (36.0 \text{ g})(2.03 \text{ J/g K})(40 \text{ K})$

$= 2.92 \times 10^3 \text{ J}$

B-C: $q = n\Delta H_{fus} = (2.00 \text{ mol})(6.01 \text{ kJ/mol})$

$= 12.0 \text{ kJ}$

C-D: $q = mc\Delta T = (36.0 \text{ g})(4.18 \text{ J/g K})(100 \text{ K})$

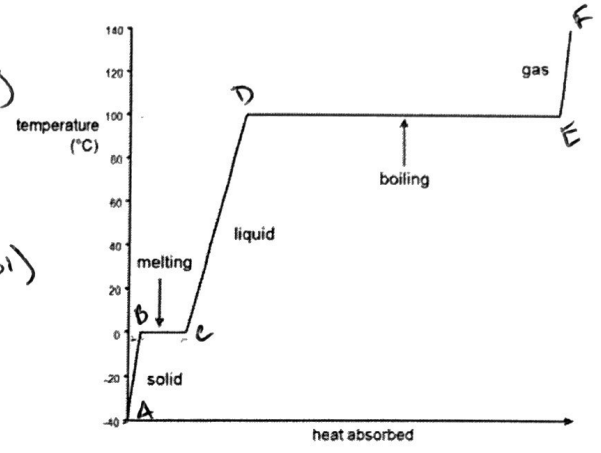
$= 1.50 \times 10^4 \text{ J}$

D-E: $q = n\Delta H_{vap} = (2.00 \text{ mol})(40.67 \text{ kJ/mol})$

$= 81.3 \text{ kJ}$

E-F: $q = mc\Delta T = (36.0 \text{ g})(1.84 \text{ J/g K})(40 \text{ K})$

$= 2.65 \times 10^3 \text{ J}$



ΔH_{fus} = enthalpy of fusion

- energy for a solid → liquid

ΔH_{vap} = enthalpy of vaporization

- energy for liquid → gas

Sublimation

- solid → gas
- doesn't become a liquid