CHAPTER 13

INTERMOLECULAR FORCES

OBJ 2, 3, 4

1. LONDON FORCES OR DISPERSION FORCES

weakest force. Exist between all molecular substances. Gets stronger as the size of the molecule increases. Is the force of attraction between temporary (momentary) dipoles. The bp increases as the size of the molecule increases. DEWEY p 371 in blue.

Substance	MW	bp, K
He	4	5
Ne	20	27
Ar	40	87
Kr	84	120
Xe	131	165
F_2	38	85
Cl_2	71	238
Br_2	160	332
I_2	254	457

2. DIPOLE - DIPOLE ATTRACTION is the forces of attraction between permanent dipoles found in polar compounds

alt 235 is δ

$$^{\delta+}H - Cl^{\delta-}$$

$$^{\delta-}Cl - H^{\delta+}$$

Dewey Figure 13.1 p 368

3. HYDROGEN BONDS are the force of attraction that a hydrogen atom which is bonded to a F, O, or N has for a F, O or N in another molecule

a. One molecule has a hydrogen bonded to a F, O or N atom

b. The other molecule has a F, O or N atom

$^{\delta+}H - F^{\delta-}$

: <---- HYDROGEN BOND

$^{\delta-}F - H^{\delta+}$

Approximate Energy

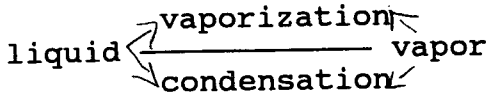
Interaction	Energy kcal per mol
Covalent Bond	50 - 100
Hydrogen Bond	5 - 10
Dipole - Dipole Attraction	0.1 - 1
London Forces	0.001 - 0.2

Substance	MW	bp, K
HI	137	236
HBr	81	203
HCl	36	189
HF	20	290
SbH_3	125	256
AsH_3	78	218
PH_3	34	186
NH_3	17	240
O_2	32	90
HCl	36	188
H_2O_2	34	424
N_2	28	77
CO	28	81
SiH_4	32	161
PH_3	34	185
GeH_4	77	183
AsH_3	78	211
Br_2	160	332
ICl	162	370

CHAPTER 13

VAPORIZATION OF A LIQUID

A substance in the gaseous state above its liquid is called a VAPOR



It requires energy to vaporize a substance, endothermic

The HEAT OF VAPORIZATION is the energy required to vaporize a given amount of substance

Energy is given off when a substance condenses, exothermic

When the rate of vaporization equals the rate of condensation a state of EQUILIBRIUM has been reached

VAPOR PRESSURE OF A LIQUID is the pressure of a vapor in equilibrium with its liquid

It increases with increasing temperature for a given liquid

and

It decreases with increasing intermolecular forces for different liquids at the same temperature

DEWEY FIGURE 13.5 p 373

The HEAT OF VAPORIZATION increases with increasing intermolecular forces

DEWEY TABLE 13.1 p 375

The boiling point of a liquid is the temperature at which its vapor pressure equals the pressure of the atmosphere

The boiling point when the atmospheric pressure is 1.0 atm is the normal or standard bp

In the mountains the atmospheric pressure is low and thus water boils at a lower temperature

DEWY TABLE 13.2 p 375

CHAPTER 13

THE SOLID STATE

The close packing of the particles of a solid results in strong forces of attraction which restrict motion. The particles are held together in a defined and highly organized fashion called the crystal lattice. This results in a fixed shape and volume

IONIC SOLIDS are held together by electrostatic forces between ions. They have high mp and bp. They are hard and brittle

Dewey Figure 13.1 p 379

MOLECULAR SOLIDS are held together by the three intermolecular forces

1. dipole-dipole attraction
2. hydrogen bonding
3. London forces

and usually are soft and have low mp. They are frequently volatile and are good insulators

EXAMPLES: Water, BUCKYBALL is a molecular form of carbon

NETWORK SOLIDS are atoms held together by covalent bonds.

1. High mp, often above 1,000 °C, since covalent bonds must be broken
2. Insoluble in all common solvents, since covalent bonds would have to be broken
3. Poor electrical conductors, since there are no mobile electrons to carry a current (except for graphite)
4. Are extremely hard

EXAMPLES: QUARTZ Figure 13.14 p 382 DEWEY
GRAPHITE & DIAMOND page 381 FIGURE 13.13 DEWEY

METALLIC SOLIDS are composed of metal atoms held together by metallic bonding, the forces of attraction between the metallic core (nucleus + nonvalence electrons) and the valence electrons which form a sea of electrons.

DEWEY FIGURE 13.15 p 383

CHAPTER 13

MOLECULAR	NETWORK	IONIC	METALLIC
X-X X-X	-X-X-X-X-	M+ X- M+ X-	M+ e- M+ e-
X-X X-X	-X-X-X-X-	X- M+ X- M+	e- M+ e- M+
X-X X-X	-X-X-X-X-	M+ X- M+ X-	M+ e- M+ e-
X-X X-X	-X-X-X-X-	X- M+ X- M+	e- M+ e- M+

ALLOTROPES are different forms of the same element

Dewey p 385 Heating Curve for Water

CHAPTER 13

18. INTERMOLECULAR FORCES

A. For the following substances indicate the type of intermolecular forces, London Forces (LF), Dipole-dipole attraction (DD) or hydrogen bonds (HB). There may be more than one type of force.

1. N_2
2. HCl
3. HF
4. CO_2
5. Cl_2
6. CH_4
7. NH_3
8. CCl_4
9. H_2O
10. NO
11. F_2
12. H_2S

CHAPTER 13

31. HYDROGEN BONDING

A. What is the force of attraction between nonpolar molecules?

B. What are the forces of attraction between polar molecules?

C. The following substances have similar size (similar molecular weights), which has the higher boiling point?

1. O_2 and HCl

2. HCl and H_2O_2

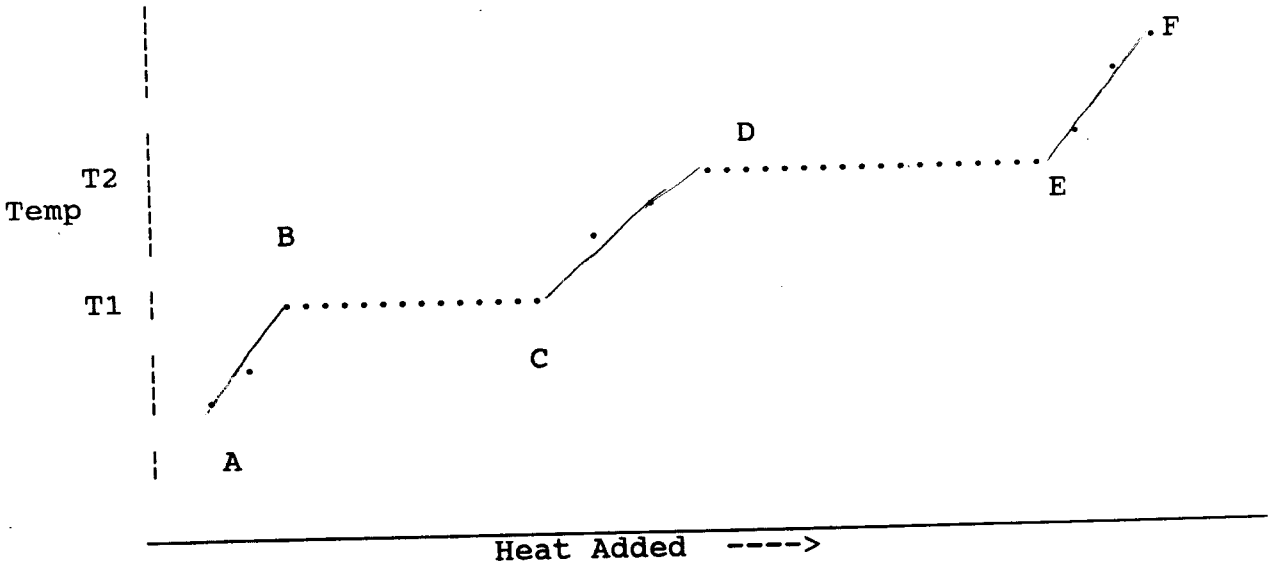
3. CH_4 and H_2O

D. Indicate if there are hydrogen bonds between molecules of the following substances

1. HCl
2. HF
3. H_2O
4. H_2S
5. CH_4
6. NH_3
7. H_2O_2
8. O_2
9. CH_3OH
10. CO_2

49. PHASE CHANGE

FIGURE 1. Heating Curve



From Figure 1 above:

1. Explain what happens in going from A to B

2. Explain what happens in going from B to C

3. Explain what happens in going from C to D

4. Explain what happens in going from D to E

5. Explain what happens in going from E to F

6. Which lines represent phase changes?

7. What temperature is the freezing point?