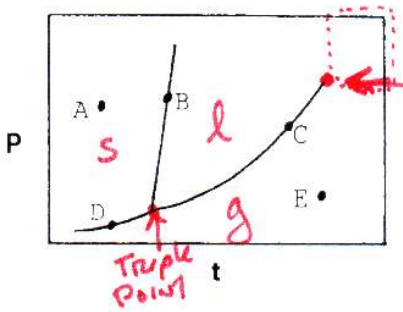
South Pasadena • AP Chemistry

Name _____
Period ___ Date ___/___/___

13 • IMF's, Liquids & Solids

Station 1 – PHASE DIAGRAMS



Label the "triple point" on the diagram.
Label the "critical point" on the diagram.

Boiling liquid would be found at Point C.

The name of the phase change that occurs by increasing temperature at Point D is s → g "sublimation"

Which two phases are in equilibrium at Point B? solid & liquid

Indicate the region where the gas can no longer be liquefied by increasing the pressure.
AFTER THE CRITICAL POINT. DOTTED LINES....

Is this a phase diagram of H_2O? NO Explain. H_2O has a negative sloped line between solid & liquid.

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Station 2 – IMF's

Match the statement with the IMF:

A. Dipole-Dipole
B. Covalent network
C. Hydrogen-bonding
D. Ionic
E. Metallic
F. London Dispersion Forces

F 1. Is used to explain why BP of Xe > Kr > Ar > Ne > He
F 2. Is present in $C_{(graphite)}$ but not in $C_{(diamond)}$
E 3. Is used to explain why Cu is a good conductor
D 4. Is used to explain why NaCl(l) is a good conductor
A 5. Is used to explain why ICl has a higher BP then Br_2
C 6. Is used to explain why vapor pressure of CH_3OH is less than CH_4.

List the 8 substances that are covalent network solids:

C(diamond)	C(graphite)	SiO_2	Si
SiC	WC	BN	B

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Station 3 – MORE IMF's

Match the IMF with its description:

D 1. hydrogen bonding
B 2. dipole-dipole attractions
E 3. London dispersion forces
C 4. ionic interactions
A 5. metallic bonding

A. a lattice of positive ions in a sea of delocalized electrons
B. positive ends of polar molecules attract negative ends of other polar molecules
C. lattice of alternating positively and negatively charged particles
D. polar interactions in molecules with especially polar intramolecular attractions
E. polarized electron clouds induce dipoles in their neighboring atoms

Write these attractive forces in order from weakest to strongest:

Covalent Network / Hydrogen-Bonding / Metallic / Dipole-Dipole / Ionic / London Dispersion Forces

LONDON DISPERSION FORCES	DIPOLE-DIPOLE	HYDROGEN BONDING	metallic	IONIC	COVALENT NETWORK

Indicate the **strongest** IMF in each of the following:

SO_2 dipole-dipole
CO_2 London
CH_3OH H-bonding
Na metallic
NH_3 H-bonding
KOH IONIC
K_2S IONIC
H_2S dipole-dipole
Xe London
XeF_4 London
SF_4 dipole-dipole
CH_4 London

SQ. PLANAR

SEE-SAW

polar

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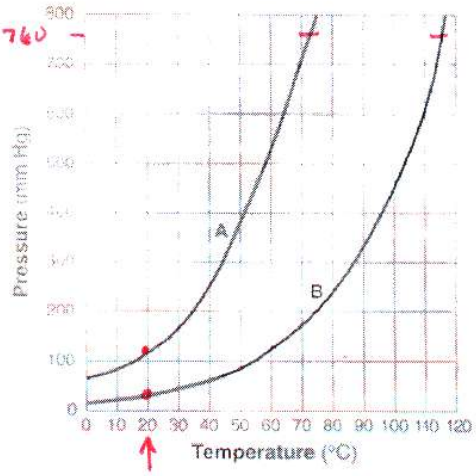
Station 4 – BOILING

A liquid will boil when it's vapor pressure is equal to the pressure above the liquid.



Here is a graph of the vapor pressures of two liquids, A and B.

Which compound has the greater IMF's? B
Pick a temp. Smaller V.P. = larger IMF
Could A or B be H_2O? NO Justify your answer.
H_2O would have a vapor pressure of 760 mmHg at 100°C.

What is the normal boiling point of A? 74°C
What is the normal boiling point of B? 115°C
Look for Temp when V.P. = 760 mmHg

If beakers of liquids A and B were placed in a bell jar connected to a vacuum pump at room temperature (20°C), which liquid would begin to boil first when the vacuum pump was turned on? A At what pressure would this occur? 110 mmHg. ?

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Station 5 – PROPERTIES OF SUBSTANCES

In each case, circle the choice with the HIGHER value for the property listed:

Boiling Point:	Cl_2	London	or	Br_2 (more e⁻'s)
Melting Point:	Si (Covalent network)		or	S (London)
Melting Point:	KBr		or	LiF (smaller ions)
$\Delta H_{vaporization}$:	HF (H-bonding)		or	HCl
Vapor Pressure:	C_3H_8		or	CH_4 (fewer e⁻ clouds)
Boiling Point:	H_2O (l)	(Both H-bonding)	or	NH_3 (is a gas!)
Vapor Pressure:	CH_3OH		or	C_2H_5OH
$\Delta H_{vaporization}$:	HCl		or	HBr

IMF = BP, MP, ΔH_{vap} ∴ small V.P.

BOTH DIPOLES ∴ more London forces due to more e⁻'s and more polarizable electron cloud.

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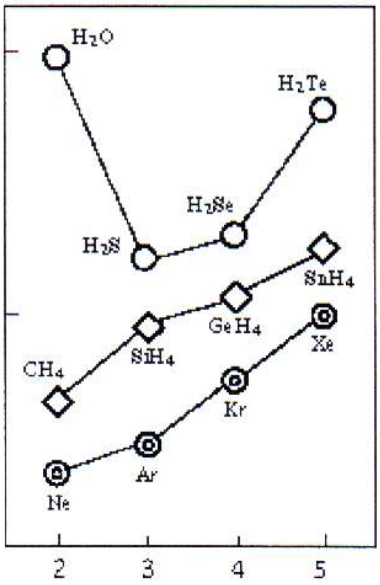
Station 6 – EXPLAINING TRENDS



This graph shows the BP's of analogous compounds using elements from periods 2, 3, 4, and 5.

Explain why the BP of Xe > Kr > Ar > Ne:

Xe has more e⁻'s than Kr, etc.
Xe has a more polarizable e⁻-cloud and therefore stronger London forces.

Explain why the BP of H_2Te > H_2Se > H_2S:

Te has more e⁻'s than Se or S
∴ Stronger London forces because the larger e⁻ cloud is more polarizable

Why is the BP of H_2O > the others in its group?

H_2O has hydrogen-bonding while H_2S, H_2Se, & H_2Te have dipole-dipole ∴ London forces only.

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Station 7 – ENERGY OF PHASE CHANGES

1. The heat of vaporization of methane, CH_4, at its boiling point is 9.20 kJ/mol.
How much heat energy is required to vaporize 100. G of methane at its boiling point?

$100.\ g\ CH_4 \times \frac{1\ mol\ CH_4}{16.05\ g} \times \frac{9.20\ kJ}{1\ mol} = 57.3\ kJ$

2. Methanol, CH_3OH, (molar mass 32.04 g/mol) has a heat of vaporization of 39.2 kJ/mol and a density of 0.7914 g/mL. How much energy is needed to vaporize 350. mL of methanol?

$350.\ mL\ CH_3OH \times \frac{.7914\ g}{1.00\ mL} \times \frac{1\ mol}{32.04\ g} \times \frac{39.2\ kJ}{1\ mol} = 338.88 = 339\ kJ$

3. The greatest change in energy for a substance is seen with which process? D "SUBLIMATION"
a) vaporization (l → g) b) condensation (g → l) c) fusion (s → l) d) sublimation (s → g) e) melting (s → l)

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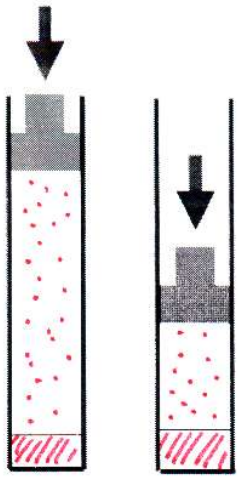
Station 8 – EQUILIBRIUM VAPOR PRESSURE

Which of the following has the lowest equilibrium vapor pressure? D (HIGHEST IMF)
a) F_2 b) H_2O c) HF d) NaCl (IONIC) e) Br_2



Liquid "X" is at equilibrium with its vapor in a cylinder and piston apparatus. When the volume of the space above the liquid is 100 mL and the temperature 25°C, the vapor pressure of "X" is 120 torr.
What will the vapor pressure of "X" be when the volume above the liquid is 50 mL and the temperature is 25°C? B

a) 240 torr b) 120 torr c) 60 torr d) 480 torr e) 30 torr

THE ONLY THING THAT CHANGES EQUILIBRIUM VAPOR PRESSURE IS TEMPERATURE.

WHEN THE VOLUME IS FIRST CHANGED, THE PRESSURE WILL INCREASE, BUT AT EQUILIBRIUM, IT RETURNS TO 120 torr.

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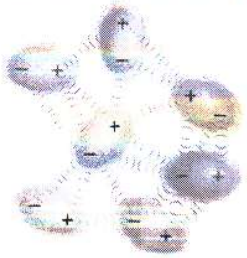
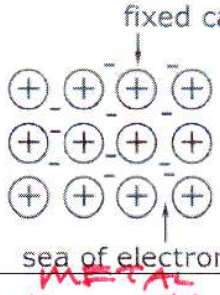
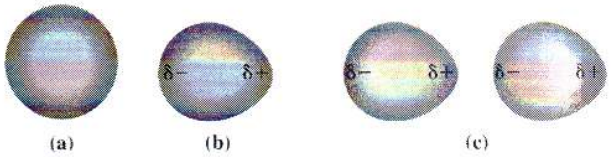
Station 9 – VISUALIZING SOLIDS

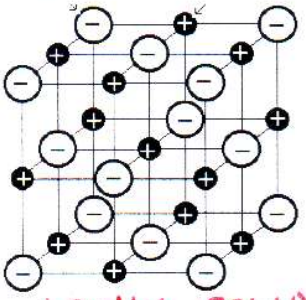
For each image, name the type of solid and the IMF(s) illustrated.

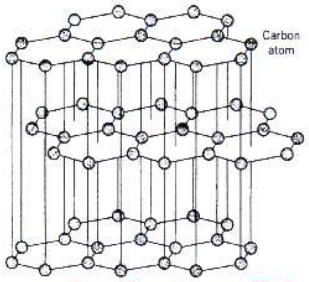


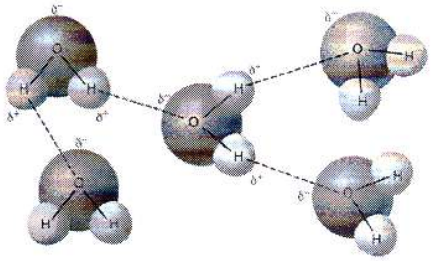




MOLECULAR (dipole-dipole)	METAL (metallic)	MOLECULAR (London Forces)







IONIC SOLID (ion-ion)	COVALENT NETWORK (covalent Bond & London Forces)	MOLECULAR (H-binding and London Forces)