WEDNESDAY, JANUARY 28, 2026 AP CHEMISTRY

SNOW DAY M 1/26

SCHEDULE: NOTES FOR CH. 11/12 + 13 ON 1/28, 1/30, 2/3, AND 2/5

CH. 11/12 PSET DONE BY Tu 2/3

CH. 13 PSET DONE BY Th 2/5

COMBINED QUIZ M 2/9

MINILAB X Tu 2/3 Y Th 2/5

NEW FRQ REVIEW No. 1 DUE M 2/9

NOTE: WE WILL NO LONGER SPEND AN ENTIRE BLOCK GOING OVER PROBLEM SET PROBLEMS. INSTEAD, PLEASE USE THE SOLUTIONS MANUAL AND CHECK WITH ME IN AEAST. (SUGGESTION: TAKE TURNS PHONE-SCANNING THE SOLUTIONS MANUAL FOR EACH CHAPTER AND SHARE IT ON GC)

TOPICS OF FOCUS

CH. 11 STATES OF MATTER

- TYPES OF INTERMOLECULAR FORCES AND REL. STRENGTH
- DESCRIPTIONS OF VISCOSITY, SURFACE TENSION, AND CAPILLARY ACTION
- PHASE CHANGES INCL. CALC. ENERGY
- VAPOR PRESSURE
- BOILING POINT

(REMOVING PHASE DIAGRAMS FROM OLD NOTES)

CH. 12 TYPES OF SOLIDS & ALLOYS

[CONSIDERED "PRIOR KNOWLEDGE" BY COLL. BOARD]

CH. 13 SOLUTION FORMATION INCL. SOLUBILITY

- GAS SOLUBILITY
- BASIC DESCR. OF COLLIGATIVE PROPERTIES

(REMOVING SOLN. CONC. UNITS CALC & CALC. OF COLLIG. PROPERTIES FROM OLD NOTES)

DEMOS: "FLOATING" STEEL PIN W/ MAGNET

CHAPTER 11 LIQUIDS AND INTERMOLECULAR FORCES

DEMO: "FLOATING" STEEL PIN

INTERMOLECULAR FORCES OR IMF (11.2)

DISTINCTION: COVALENT BOND $H-\underset{..}{\ddot{Cl}}:$ $\Delta H_{BOND} = 431\ kJ/mol$

INTERMOLECULAR BOND $H-Cl\cdots\underset{+\!\!\rightarrow}{H-Cl}$ $\Delta H_{BOND} = 16\ kJ/mol$

TYPES OF IMF

WEAKEST ① (LONDON) DISPERSION FORCES (LDF)
AKA VAN DER WAALS FORCES
(THE MAJORITY OF IMF BOND STRENGTH IN ALL MOLECULES IS DUE TO LDF).

② DIPOLE-DIPOLE FORCES

③ HYDROGEN BONDS

STRONGEST ④ ION-DIPOLE FORCES (IN SOLUTIONS)

WE USE TYPE AND STRENGTH OF IMF TO ACCOUNT FOR MELTING POINT (mp), BOILING POINT (bp), SOLUBILITY, SURFACE TENSION, VISCOSITY, VAPOR PRESSURE, AND CAPILLARY ACTION.

FOR EXAMPLE:

	TYPE OF BOND BROKEN	mp	bp	
CHEMICAL	IONIC	1118 K	1949 K	LiF
	COVALENT	3800 K	4300 K	DIAMOND
	METALLIC	1560 K	2742 K	Be
IMF	HYDROGEN BONDS	190 K	293 K	HF
	DIPOLE + LDF	158 K	188 K	HCl
	LDF ONLY	63 K	77 K	N_2

W 2026-01-26 AP Chem

LDF

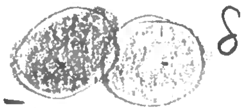
Dispersion forces apply to <u>all</u> molecules. All other IMF is <u>in addition to</u> the LDF.

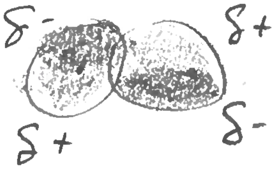
LDF arise due to small differences in electron density across the surface of molecules. The electron cloud, as we think of it, does not remain completely homogeneous. The temporary uneven distribution of e^- probability density leads to the formation of weak dipoles.

For ex. I_2 iodine $:\ddot{\underset{..}{I}}-\ddot{\underset{..}{I}}:$

Avg e^- distribution is completely even ∴ I_2 is non-polar

On short time scales, instantaneous dipoles can form and shift:





Molecules with temp. dipoles can induce a dipole in a neighboring molecule in such a way that they attract.

Balloon demo: Charged balloon sticks to oppositely charged head (Dipole-dipole force)
It also sticks to the wall, where it has induced an opposite charge.

Iodine (I_2) is a solid at room temp. and nitrogen (N_2) is not: it's 80% the air. Why?

THE STRENGTH OF LDF DEPENDS ON THE SIZE OF MOLECULES. THE LARGER A MOLECULE IS, THE LARGER ITS e^- CLOUD AND THE MORE <u>POLARIZABLE</u> IT IS. THAT IS, ~~the~~ MORE TEMP. DIPOLES CAN FORM AT A GIVEN TIME — OR STRONGER TEMP. DIPOLES.

N_2 IS JUST A LOT SMALLER THAN I_2 SO ITS LDF ARE NOT AS STRONG.

WE USE MOLAR MASS AS A WAY TO DIFFERENTIATE MOLECULES BY SIZE: LARGER MOLAR MASS = STRONGER LDF

(STOPPED HERE GROUP X W 2026-01-28)

FOR EX.

		bp
20.1g/mol	Ne	27K
39.9g/mol	Ar	87K
84g/mol	Kr	121K
131g/mol	Xe	166K

SHAPE ALSO PLAYS A ROLE IN THE STRENGTH OF LDF. MORE SURFACE AREA MEANS MORE POINTS OF POSSIBLE CONTACT AND STRONGER LDF.

FOR EX. C_5H_{12} CAN HAVE 3 DIFF. SHAPES OR ISOMERS


N-PENTANE

bp 309K


ISO PENTANE

~~283K~~

301K ← LOWER B/C THIS MOLECULE IS MORE COMPACTLY STRUCTURED


NEOPENTANE ← LOWER STILL!

283K

DIPOLE-DIPOLE FORCES

MOLECULES WITH A PERMANENT DIPOLE EXPERIENCE AN ADDITIONAL IMF ON TOP OF LDF.

ORIENTATION MATTERS: H–F oooo H–F ATTRACTION | H–F F–H

+→ +→ | +→ ←+

REPULSION

SPIN UNTIL ATTRACT

④

W 2026-01-28 AP CHEM

IN THE SERIES HF, HCl, HBr, HI THE DIPOLE STRENGTH DECREASES WHILE LDF INCREASES

	HF	HCl	HBr	HI
bp	293K	189K	206K	238K

LDF ACCOUNTS FOR ABOUT 80% OF THE TOTAL STRENGTH OF IMF BTWN POLAR MOLECULES.

← THIS IS WHY WE LEARNED HOW TO TELL WHETHER A MOLECULE IS POLAR IN CH. 9.

HYDROGEN BONDING

AN H-BOND IS A SPECIAL KIND OF DIPOLE-DIPOLE FORCE WHICH AFFECTS MOLECULES CONTAINING

F O AND N BONDED TO H

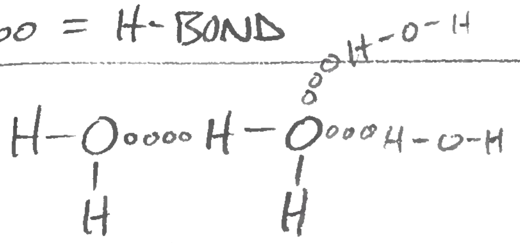
H-BONDING SCENARIOS:

F–H oooo F–R
oooo O–R
oooo N–R

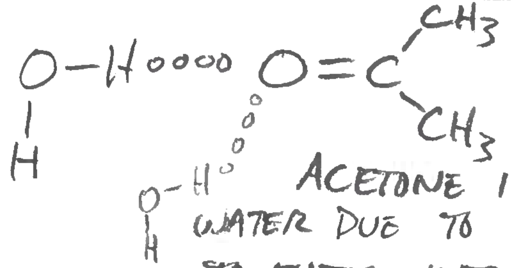
R–N–H oooo F–R
oooo O–R
oooo N–R

R–O–H ooo F–R
ooo O–R
ooo N–R

R = REST OF MOLECULE
0000 = H-BOND



BTWN. H_2O MOLECULES



ACETONE IS SOLUBLE IN WATER DUE TO ITS ABILITY TO ENTER INTO H-BONDS

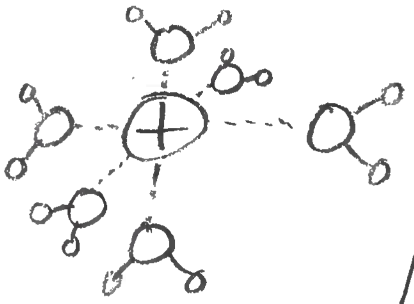
H-BONDS HAVE A STRENGTH OF 5-25 kJ/mol
(COMPARE: COVALENT BOND STRENGTH IS 150 -1100 kJ/mol)

BIO-CONNECTION - H-BONDS HOLD TOGETHER THE TERTIARY STRUCTURE OF PROTEINS, THE OPPOSITE BASES IN DNA, AND THEY ALLOW PROTEINS TO BIND TO EACH OTHER. WATER CAN INTERFERE WITH H-BONDS IN KERATIN IN HAIR BY PROVIDING AN ALTERNATE MOLECULE TO BIND WITH. THIS REDUCES BONDING BTWN PROTEINS, ALLOWING YOU TO COMB UNRULY HAIR FLAT.

WHAT MAKES H-BONDS A SPECIAL KIND OF DIPOLE FORCE IS THE EXTREME NATURE OF THE DIPOLES INVOLVED. H IS A VERY SMALL ATOM, N, O, AND F ARE ALSO SMALL AND ARE THE MOST ELECTRONEGATIVE ELEMENTS.

ION-DIPOLE FORCES

WHEN IONIC COMPOUNDS DISSOLVE IN POLAR SOLVENTS LIKE H_2O THEY FORM ION-DIPOLE BONDS WITH A STRENGTH OF ABOUT 50 kJ/mol.



6 BONDS PER ION IS 300kJ/mol OF RELEASED ENERGY

SO, WHAT DO YOU NEED TO BE ABLE TO DO?

- BE ABLE TO ID IMF BASED ON THE MOLECULAR FORMULAS OF SUBSTANCES.
- BE ABLE TO COMPARE RELATIVE STRENGTH OF IMF (QUALITATIVELY).
  - 1 ID TYPE OF IMF
  - 2 MOLECULAR WEIGHT
  - 3 POLARITY

N 2026-01-28 AP CHEM

IMF FITS INTO A BROADER SPECTRUM OF PARTICLE INTERACTIONS AND BONDING. WHEN COMPARING THE STRENGTH OF FORCES HOLDING MATERIALS TOGETHER AS LIQUIDS OR SOLIDS, WE INCLUDE:

① IONIC, COVALENT, METALLIC, OR JUST IMF BTWN MOLECULES

② FOR MOLECULES HELD TOGETHER WITH IMF ONLY THE ONE WITH A LARGER MOLECULAR WEIGHT GENERALLY HAS STRONGER FORCES.

③ IF MOLECULES HAVE PERMANENT DIPOLES IT COMES DOWN TO RELATIVE DIPOLE STRENGTH, INCL. WHETHER H-BONDING IS POSSIBLE.

FOR EX. H_2O VS H_2S

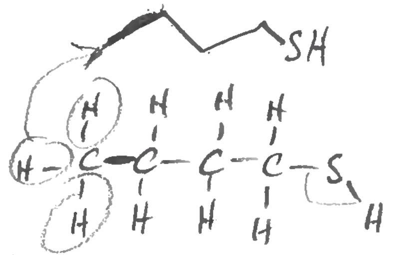
	H_2O	H_2S
	18 g/mol	34 g/mol
	H-BONDING	NO H-BONDING
	(BOTH ARE	POLAR)
	STRONGER	WEAKER IMF
bp	100°C	-60°C

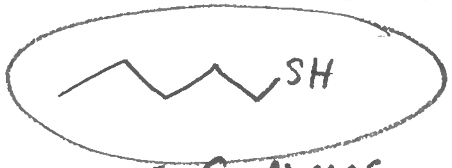
NO. 22 FROM PSET COMPARING STRENGTH OF LDF

(a) Br_2 VS. O_2 CIRCLE THE ONE WITH STRONGER LDF

158 g/mol 32 g/mol

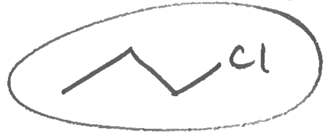
(b) $CH_3CH_2CH_2CH_2SH$ VS. $CH_3CH_2CH_2CH_2CH_2SH$

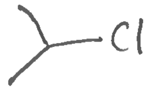




MORE C ATOMS

(c) $CH_3CH_2CH_2Cl$ VS. $(CH_3)_2CHCl$





LESS SURFACE AREA

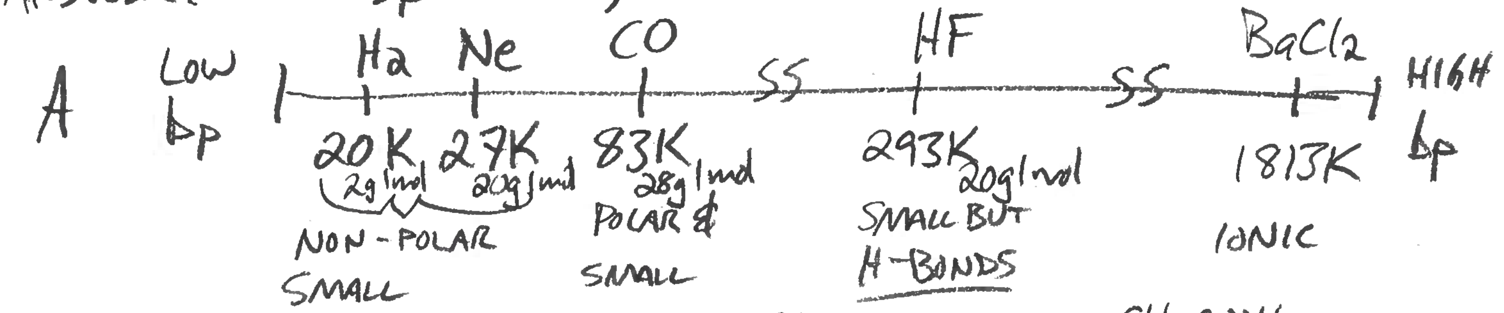
TRY THIS

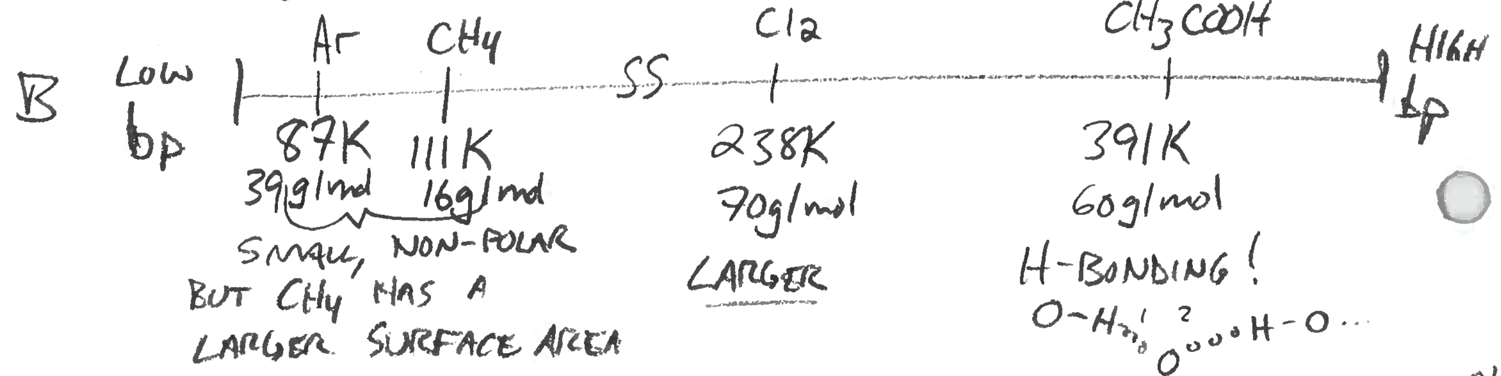
PUT THESE TWO LISTS IN ORDER FROM LOWEST IMF (LOWEST bp) TO HIGHEST.

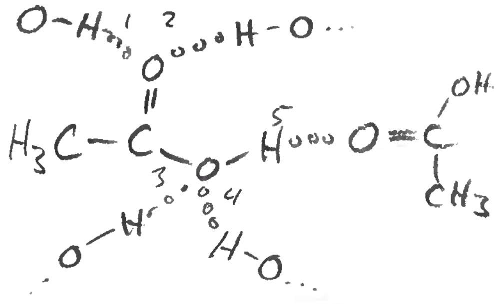
A: $BaCl_2$ Ne H_2 CO HF

B: Ar Cl_2 CH_4 CH_3COOH

ANSWER (WITH bp VALUES)







DEMO:
- ~~SURFACE TENSION IN DROPS ON A TABLE~~
- SIPHON
- CAPILLARY DEMO
- STROBE AND WATER DROPS

W 2026-01-28 APCHEM

11.3 PROPERTIES OF LIQUIDS

VISCOSITY
SURFACE TENSION
CAPILLARY ACTION

THE HIGHER THE IMF IN A SUBSTANCE THE HIGHER THE VISCOSITY, AND THE STRONGER THE SURFACE TENSION. CAPILLARY ACTION ALSO DEPENDS ON ADHESION TO THE CAPILLARY MATERIAL.

VISCOSITY IS RESISTANCE TO FLOW. THE STRONGER THE MOLECULES CLING TO EACH OTHER, THE MORE SLOWLY THEY WILL PULL APART AS A LIQUID FLOWS.

VISCOSITY IS A FUNCTION OF TEMPERATURE: AS THE KE OF MOLECULES INCREASES THEY ARE MORE ABLE TO BREAK IMF-BONDS AND A LIQUID FLOWS FASTER (IN OTHER WORDS, VISCOSITY DECR. WITH INCR. TEMP).

HIGH				LOW VISCOSITY
MOLASSES		VEG. OIL		ALCOHOL
HONEY	→	MAPLE SYRUP	→	GASOLINE
CORN SYRUP				WATER

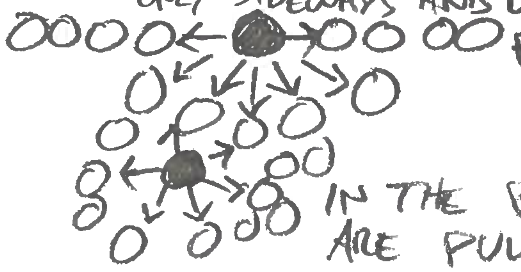
(STOPPED HERE GROUP Y W 2026-01-28)

SURFACE TENSION

... IS THE ENERGY REQUIRED TO INCREASE SURFACE AREA.

DUE TO IMF LIQUIDS ACT TO REDUCE THEIR SURFACE AREA. SEE ALSO, THE STROBE LAMP DEMO WHICH SHOWED THAT FALLING DROPS OF WATER ARE ROUGHLY SPHERICAL:

(GEOMETRICALLY SPEAKING, A SPHERE HAS THE MINIMUM SURFACE AREA FOR A GIVEN VOLUME).



ONLY SIDEWAYS AND DOWNWARD FORCE, WHICH REDUCES SA

IN THE BULK OF MATERIAL, PARTICLES ARE PULLED IN ALL DIRECTIONS.

IT'S B/C IT TAKES ENERGY TO BREAK SURFACE TENSION THAT LIQUIDS CAN BE SUPERCOOLED (COOLED BELOW MP) AND SOME SOLUTIONS CAN BE SUPERSATURATED.

CAPILLARY ACTION

... IS THE TENDENCY OF LIQUIDS TO CLIMB NARROW TUBES OR MOVE BTWN. FIBERS.

IN CLIMBING A TUBE, OR BEING WICKED BY THE FIBERS IN A TOWEL, TWO FORCES PLAY A ROLE:

① IMF BTWN LIQ. MOLECULES WHICH COHESIVELY HOLD MOLECULES TOGETHER

② ADHESIVE FORCES WHICH ATTRACT MOLECULES TO THE WALLS OF THE TUBE

RELATED PHENOMENA: TOWELS, SWEAT-WICKING CLOTHING
U-SHAPED MENISCUS IN A GRAD. CYL.

(BTW - THINNER CAPILLARIES ALLOW HIGHER CLIMBING DUE TO THE INCR. OF THE $\frac{\text{AREA}}{\text{VOLUME}}$ RATIO AS RADIUS DECREASES: $\frac{A}{V} \propto \frac{r^2}{r^3}$ SO AS r DECR THIS RATIO INCR.)

11.4 PHASE CHANGES

STATES OF MATTER DEPEND ON ENERGY EXCHANGES AND <u>NOT</u> TEMPERATURE.

IT'S A BALANCE BTWN. ① THE KE OF PARTICLES
② THE BOND ENERGY OR STRENGTH OF IMF

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SOLID KE < BOND ENERGY (IMF BOND OR IONIC, ETC)
LIQUID KE $\cong$ BOND ENERGY
GAS KE >> BOND ENERGY (>> MEANS MUCH GREATER THAN)

PRESSURE ALSO PLAYS A ROLE IN THE PHASE OF MATTER. GASES AND SOLIDS CAN EXIST AT ANY PRESSURE, DEPENDING ON THE MATERIALS. LIQUIDS REQUIRE A MINIMUM PRESSURE EVEN TO EXIST — FOR MOST SUBSTANCES. THIS IS B/C THE MOLECULES NEED TO BE HELD CLOSER TOGETHER AND AS PRESSURE INCREASES, VOL. DECR. ($P_1V_1 = P_2V_2$) WHICH PLACES PARTICLES CLOSER TOGETHER. THEY NEED TO BE CLOSE ENOUGH FOR THEIR IMF BONDS TO FORM.

WITH SUFFICIENT COMPRESSION AND COOLING YOU CAN TURN GASES LIKE N_2 OR Ar INTO LIQUIDS.

SOLID CO_2 (OR DRY ICE) HAS NO LIQUID PHASE AT 1atm: ONLY SOLID & GAS. IN A FIRE EXTINGUISHER CO_2 IS A LIQUID DUE TO VERY HIGH PRESSURE.

EXCHANGES OF HEAT ARE WHAT DRIVES OR ALLOWS PHASE CHANGES.

MELTING ΔH_{fus} ENTHALPY OF FUSION (kJ/mol)

$+\Delta H_{fus}$ HEAT FOR MELTING (BREAK BONDS)

$-\Delta H_{fus}$ HEAT FOR FREEZING (FORM BONDS)

VAPORIZATION ΔH_{vap} ENTHALPY OF VAPORIZATION (kJ/mol)

$+\Delta H_{vap}$ EVAPORATION (BONDS BREAK)

$-\Delta H_{vap}$ CONDENSATION (BONDS FORM)

HEAT IN PHASE CHANGES

MELTING POINT (mp) AND BOILING POINT (bp) ARE A FUNCTION OF PRESSURE BUT "NORMAL" VALUES ARE FOR 1 atm.

IN ORDER TO MELT A SOLID IT MUST FIRST BE HEATED UP TO THE mp.

ENERGY $q = m C_{solid} \Delta T$ (CHANGE IN TEMP)

MELTING ENERGY $q = n \cdot \Delta H_{fus}$ (CHANGE IN PHASE)

IN THE IDEAL CASE THIS TAKES PLACE AT CONSTANT T.

HEAT LIQUID TO ITS bp $q = m C_{liq} \Delta T$

BOILING $q = n \cdot \Delta H_{vap}$

HEAT THE GAS $q = m C_{gas} \Delta T$

$\boxed{\text{BOILING DEMO}}$ WITH HANDOUT

STOPPED HERE GROUP X F 2026-01-30

F 2026-01-30 AP CHEM

EX. CALC. (BE ABLE TO DO THIS FOR THE QUIZ :))

DATA

$C_{ice} = 2.03\ J/g°C$ $\Delta H_{fus} = 6.01\ kJ/mol$ AT 0°C

$C_{water} = 4.184\ J/g°C$ $\Delta H_{vap} = 40.7\ kJ/mol$ AT 100°C

$C_{steam} = 1.84\ J/g°C$ mp = 0°C bp = 100°C

CALC. HEAT INVOLVED, STEP BY STEP, AND OVERALL TO HEAT ICE (18g) THROUGH ITS PHASE CHANGES STARTING AT −25°C AND STOPPING AT 125°C

HEAT ICE $q = mC\Delta T$ $C = 2.03\ J/g°C$ $\Delta T = 0°C - (-25°C)$ $+25°C$

$q = (18g)(2.03\ \frac{J}{g°C})(+25°C) = 914J$

$\boxed{0.914kJ}$

MELT ICE (NO ΔT) $q = n\Delta H_{fus} = (1mol)(6.01\ kJ/mol) = \boxed{6.01kJ}$

$18g = 1mol\ H_2O$

HEAT WATER $q = mC\Delta T$ $C = 4.184\frac{J}{g°C}$ $\Delta T = 100°C - 0°C$

$q = (18g)(4.184\frac{J}{g°C})(+100°C) = 7520J$

$\boxed{7.52kJ}$

VAPORIZE WATER $q = n \cdot \Delta H_{vap} = (1mol)(40.7kJ/mol)$

$\boxed{40.7kJ}$

HEAT STEAM $q = mC\Delta T$ $C = 1.84\ J/g°C$ $\Delta T = 125°C - 100°C$

$(18g)(1.84\frac{J}{g°C})(25°C) = 830J$

$\boxed{0.830kJ}$

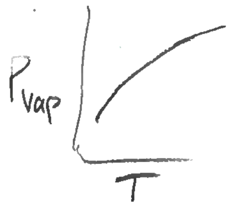
ADD IT ALL UP: $\boxed{55.94\ kJ}$

STUDY THE GRAPH ON THE TEMP & HEAT IN PHASE CHANGES HANDOUT :)

STOPPED AT BOTTOM OF PAGE, (GROUP) F2026-01-30

11.5 VAPOR PRESSURE

P_{vap} IS THE PARTIAL PRESSURE OF THE GAS PHASE IN EQUILIBRIUM WITH THE LIQUID PHASE. IT IS A FUNCTION OF TEMP. AND P_{vap} RISES AS TEMP. RISES.

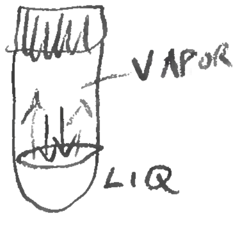


P_{vap} IS A RESULT OF THE EVAPORATION RATE.

BECAUSE IT IS THE PRESSURE AT EQUILIBRIUM, WHICH MEANS WHEN EVAPORATION RATE EQUALS CONDENSATION RATE, IT IS HIGHER FOR SUBSTANCES WITH WEAKER IMF. THESE CAN EVAPORATE FASTER AT A GIVEN TEMP. AND SO THEIR VAPOR PHASE HAS A HIGHER PARTIAL PRESSURE WHEN IT GETS TO EQUILIBRIUM.

IT TAKES ENERGY TO BREAK BONDS AND SO WHEN THOSE BONDS ARE WEAKER, MORE BONDS CAN BREAK AT A GIVEN TEMP. THIS IS WHY RUBBING ALCOHOL ($CH_3-\overset{OH}{\underset{H}{C}}-CH_3$) FEELS COLD ON YOUR SKIN — ITS HIGH VAPOR PRESSURE MEANS IT EVAPORATES RAPIDLY. (DEMO)

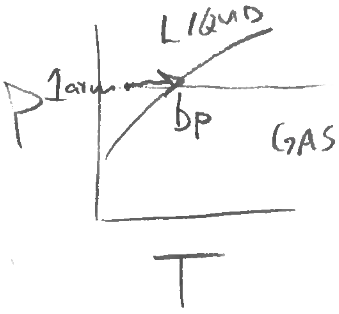
HUMIDITY IS MEASURED IN %, THAT IS, % OF MAXIMUM WATER CONTENT OF AIR. THE MAX. WATER CONTENT OF AIR IS THE VAPOR PRESSURE OF WATER WHEN IT CONDENSES AS FAST AS IT EVAPORATES. WHEN HUMIDITY IS 100% NO NET EVAPORATION CAN HAPPEN B/C WATER CONDENSES AS FAST AS IT EVAPORATES.



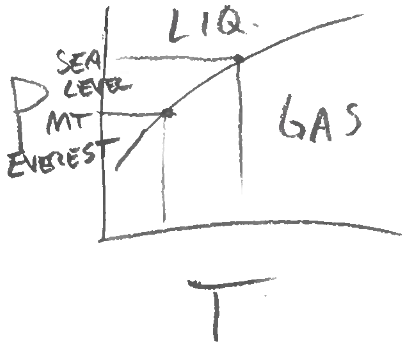
TU 2026-02-03 AP CHEM

P_{vap} AND BOILING POINT

A LIQUID WILL BOIL, THAT IS, FORM BUBBLES OF ITS OWN VAPOR WITHIN THE LIQUID, WHEN IT EVAPORATES FAST ENOUGH THAT THE PRESSURE IN THE BUBBLES EQUALS THE EXTERNAL PRESSURE (AIR PRESSURE). SO, A LIQUID BOILS WHEN ITS P_{vap} EQUALS THE AIR PRESSURE.



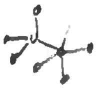
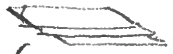
WE CAN MAKE A LIQUID BOIL BY HEATING IT SO THAT ITS TEMP IS HIGH ENOUGH THAT ITS VAPOR PRESSURE EQUALS AIR PRESSURE. FOR WATER, ITS VAPOR PRESSURE AT 100°C IS 1 atm (760 torr) AND THIS IS WHY ITS NORMAL bp IS 100°C.

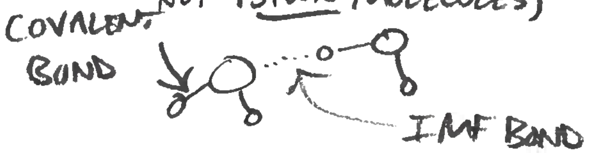


AT HIGH ELEVATION, AIR PRESSURE IS LOWER SO THE BOILING POINT IS ALSO LOWER. THIS IS B/C THE P_{vap} OF THE LIQUID IS HIGH ENOUGH TO EQUAL AIR PRESSURE AT A LOWER TEMP.

SOLIDS CH. 12

SOLIDS' PARTICLES MAY BE HELD TOGETHER BY METALLIC, COVALENT, IONIC, OR IMF BONDS.

TYPE	UNIT PARTICLES	FORCES BTWN PARTICLES	PROPERTIES	EXAMPLES
METALLIC	ATOMS	METALLIC BONDS	HIGHLY VARIABLE SOFT TO VERY HARD LOW TO VERY HIGH mp EXCELLENT THERMAL & ELECTRICAL CONDUCTORS MALLEABLE & DUCTILE	Na Fe Al Hg Ag Au ALLOYS
IONIC	IONS CATIONS (+) ANIONS (−) POLYATOMIC OR MONATOMIC	IONIC BONDS (ELECTROSTATIC ATTRACTION)	 HARD & BRITTLE POOR THERMAL & ELEC. CONDUCTIVITY IF SOLUBLE, THE AQ SOLN IS CONDUCTIVE	NaCl $CaCl_2$ K_3PO_4 $Mg(NO_3)_2$
COVALENT NETWORK	ATOMS CONNECTED BY DIRECTIONAL COVALENT BONDS	COVALENT BONDS	VERY HARD HIGH MP ELEC. & THERMAL PROP. VARY	DIAMOND (C)  GRAPHITE (C)  QUARTZ/GLASS (SiO_2) BAKELITE (PLASTIC)
MOLECULAR.	MOLECULES OR ATOMS (MOLECULES INVOLVE COVALENT BONDS BUT NOT <u>BTWN</u> MOLECULES)	IMF BONDS LDF DIPOLE-DIPOLE H-BONDS	FAIRLY SOFT LOW TO MODERATE MELTING POINT SOLNS. DO NOT CONDUCT ELECTRICITY	NOBLE GASES CH_4 CO_2 H_2O O_2 SUCROSE $C_{12}H_{22}O_{11}$



ALSO W2022-02-02 (

M2021-02-01 AP CHEM

ALLOYS

MIXTURES OF ELEMENTS, USUALLY METALS, IN THE SOLID PHASE. PROPERTIES OF THE MIXTURE ARE DIFF. FROM ANY COMPONENT BUT UNLIKE A CHEMICAL COMPOUND A WIDE RANGE OF COMPOSITIONS IS POSSIBLE.

SUBSTITUTIONAL — A SOLID SOLUTION MADE BY MIXING MOLTEN METALS. ATOMS ARE SIMILAR IN SIZE AND SO THEY SUBSTITUTE FOR ONE ANOTHER IN THE USUAL CRYSTAL LATTICE. ATOMS DON'T DIFFER IN RADIUS BY MORE THAN 15%.

INTERSTITIAL — A SOLID SOLUTION IN WHICH ATOMS OF VERY DIFFERENT SIZES ARE MIXED. THE HOLES BTWN. LARGER ATOMS CONTAIN THE SMALLER ATOMS. THIS TYPE OF ALLOY IS USUALLY STRONGER, HARDER, AND LESS DUCTILE B/C OF THE ADDITIONAL BONDS WITH INTERSTITIAL ATOMS.

INTERSTICES — THE SPACES BTWN. THINGS.

HETEROGENEOUS ALLOY — OR MECHANICAL MIXTURE — WHEN METALS DO NOT DISSOLVE, OR DO SO ONLY PARTIALLY, IN THE SOLID PHASE EVEN THOUGH WHEN MOLTEN THEY WERE A HOMOGENEOUS SOLUTION. PROPERTIES DEPEND NOT JUST ON COMPOSITION BUT ALSO HANDLING SUCH AS HAMMERING OR ANNEALING.

INTERMETALLIC COMPOUNDS — AS THE NAME SAYS, NOT A MIXTURE BUT A COMPOUND WITH A FIXED COMPOSITION. ALWAYS ONLY ONE TYPE OF CRYSTAL SO THE COMPOUND GENERALLY HAS A HIGHER STRENGTH AND MELTING POINT THAN CONSTITUENTS.

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TUESDAY, FEBRUARY 3, 2026 AP CHEMISTRY

START WITH DEMO
HEAT OF SOLN OF $CaCl_2$

CH. 13 PROPERTIES OF SOLUTIONS

A SOLUTION IS A HOMOGENEOUS MIXTURE.

A SOLUTE DISSOLVES IN A SOLVENT.

SOLUTIONS CAN BE:		
	GAS IN GAS	AIR
*	GAS IN LIQUID	SOFT DRINKS
	LIQ. IN LIQUID	RUBBING ALCOHOL
*	SOLID IN LIQUID	SALT WATER
OR	SOLID IN SOLID	ALLOYS

A GAS MIXES WITH ANOTHER GAS SPONTANEOUSLY AND COMPLETELY. NO ENERGY IS INVOLVED B/C NO BONDS NEED BE BROKEN AND NO BONDS FORMED.

WHEN LIQUIDS MIX TOGETHER OR A SOLID DISSOLVES IN A LIQUID, BONDS ARE BOTH BROKEN AND FORMED.

ΔH_{soln} THE ENTHALPY OF SOLUTION

THERE ARE THREE CONCEPTUAL COMPONENTS WHICH CONTRIBUTE TO THE VALUE AND SIGN OF ΔH_{soln}.

ΔH_1 (+) ENDOTHERMIC BREAKING OF SOLUTE BONDS

ΔH_2 (+) ENDOTHERMIC BREAKING OF SOLVENT BONDS

ΔH_3 (−) EXOTHERMIC FORMATION OF SOLUTE-SOLVENT BONDS

SOLUBILITY DEPENDS ON THE SIZE (OR MAGNITUDE) AND SIGN (+ OR −) OF THE OVERALL ΔH_{soln}.

$$\Delta H_{soln} = \Delta H_1 + \Delta H_2 + \Delta H_3$$

$$\Delta H_{soln} = \underbrace{\Delta H_1 + \Delta H_2}_{\text{BREAKING BONDS}} + \underset{\text{FORMING BONDS}}{\Delta H_3}$$

IF $(\Delta H_1 + \Delta H_2) > \Delta H_3$ THEN ΔH_{soln} IS POSITIVE.

WHEN ΔH_{soln} IS POSITIVE:

1. THE SUBSTANCE IS INSOLUBLE IN THIS SOLVENT.
   FOR EX: OIL & WATER "HYDROPHOBIC"
2. THE SUBSTANCE ISN'T SOLUBLE AT THIS TEMP. AND HEATING IT UP WILL DISSOLVE THE SOLUTE, OR AT LEAST MORE OF IT.
   FOR EX.: IT'S EASIER TO DISSOLVE CAKED ON STUFF WHEN WASHING DISHES WITH HOT WATER

   ALSO, MOST SOLIDS INCR. THEIR SOLUBILITY WITH INCR. TEMP.
3. THE SUBSTANCE WILL DISSOLVE AND THE TEMP WILL DROP. THIS IS POSSIBLE WHEN THE INCR. IN ENTROPY IS SUFFICIENTLY LARGE TO COMPENSATE FOR THE POSITIVE ΔH_{soln}.

[ENTROPY IS A WAY TO QUANTIFY THE TENDENCY OF MATTER TO ADOPT THE MOST PROBABLE ARRANGEMENT.]

WHEN A SOLID DISSOLVES THERE ARE MORE WAYS FOR ITS ATOMS TO BE SPREAD THROUGHOUT A SOLVENT THAN FOR THEM ALL TO BE BOUND IN THE SOLID.

IF ΔH_{soln} IS NEGATIVE, OR EXOTHERMIC THEN WE EXPECT A SOLUTION TO FORM SPONTANEOUSLY.

Tu 2026-02-03 AP Chem

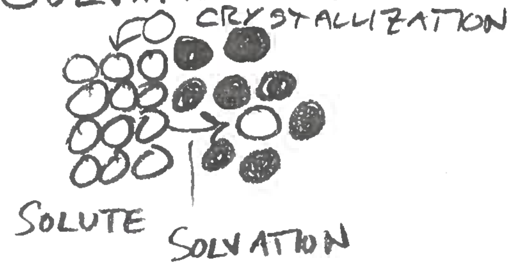
AS A GENERAL RULE, **LIKE DISSOLVES LIKE.**

① POLAR + POLAR
② POLAR + IONIC
③ NON-POLAR + NON-POLAR

NOTE: WHEN A METAL DISSOLVES IN ACID IT IS A CHEMICAL CHANGE. THE NEUTRAL METALS TURN INTO CATIONS.

13.2 SATURATED SOLUTIONS AND SOLUBILITY

SOLVATION VS. CRYSTALLIZATION



SOLVATION IS THE PROCESS IN WHICH A SOLUTE PARTICLE BECOMES COMPLETELY SURROUNDED BY SOLVENT MOLECULES. FOR WATER IT IS CALLED HYDRATION.

CRYSTALLIZATION IS WHEN DISSOLVED PARTICLES REJOIN THE SOLID.

SATURATED SOLUTION: WHEN SOLVATION & CRYSTALLIZATION HAPPEN AT THE SAME RATE A SOLUTION IS SAID TO BE SATURATED.

THIS IS A PHYSICAL EQUILIBRIUM: BOTH PROCESSES CONTINUE WITH NO NET CHANGE.

SOLUTION DILUTION LAB

① 20% NaCl 100g
$20g\ NaCl \quad 80g\ H_2O$

$$100g \cdot \frac{1mL}{1.15g} = 86.96\ mL$$

$$20g\ NaCl \cdot \frac{1mol}{58.44g} = 0.3422\ mol\ NaCl$$

$$\frac{0.3422mol}{0.08696L} = \boxed{3.936M}$$

② $M_1V_1 = M_2V_2$
STOCK DESIRED

$$(3.936M)V_1 = (0.10M)(100mL)$$
$$V_1 = 2.54\ mL$$

③ SEE THE PROCEDURE

④ $AgNO_3 + NaCl \rightarrow NaNO_3 + AgCl_{(s)}$
NET: $Ag^+ + Cl^- \rightarrow AgCl$

⑤ $$1mL \cdot \frac{0.10mol}{1\cancel{L}} \cdot \frac{1Ag^+}{1Cl^-} \cdot \frac{1\cancel{L}}{0.20mol\ Ag^+} = \boxed{0.5mL}$$

⑥ . . .

STOP W/ GROUP Y Tu 2026-02-03

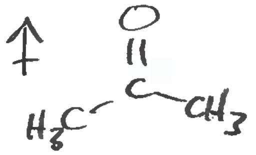
A SUPER-SATURATED SOLUTION IS ONE WHICH HAS A GREATER AMOUNT DISSOLVED THAN WOULD BE EXPECTED FOR A SATURATED SOLUTION. THIS CAN HAPPEN, FOR EX., FOR A SUBSTANCE WITH MORE THAN ONE CRYSTALLINE FORM — ONE IS SATURATED BUT THE OTHER IS NOT.

RAPID CRYSTALLIZATION OF A SUPER-SAT. SOLN CAN OCCUR WITH THE INTRODUCTION OF A CRYSTAL, A ROUGH SURFACE, OR EVEN A PHYSICAL DISTURBANCE. IN ORDER TO START CRYSTALLIZING, NUCLEATION IS NECESSARY: SOME SMALL DISTURBANCE OR ROUGH PARTICLE WHICH BREAKS SURFACE TENSION. (SODIUM ACETATE DEMO)

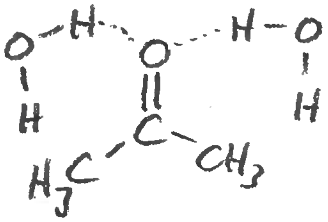
13.3 FACTORS AFFECTING SOLUBILITY (OF LIQUIDS AND SOLIDS)

DEGREE OF SOLUBILITY DEPENDS ON WHETHER A SOLUTE'S PARTICLES BIND MORE TIGHTLY TO THEMSELVES OR TO THE SOLVENT MOLECULES.

FOR EX, ACETONE MOLECULES BIND MORE STRONGLY TO WATER MOLECULES THAN TO EACH OTHER. ACETONE CAN FORM HYDROGEN BONDS WITH WATER BUT NOT AMONG ITS OWN MOLECULES.



POLAR BUT NO H-BONDS



BECAUSE OF THIS ACETONE IS SOLUBLE IN WATER IN ANY PROPORTION.

ALSO, REM. OIL DOES NOT DISSOLVE IN WATER. THIS ISN'T BECAUSE OIL REPELS WATER. IT'S B/C THE LDF FOR THE LARGE OIL MOLECULES IS VERY STRONG. IT'S MUCH STRONGER THAN THE WEAK BONDS OIL MOLECULES CAN FORM WITH WATER.

TERMINOLOGY FOR LIQUIDS

MISCIBLE — SOLUBLE IN ANY PROPORTION
IMMISCIBLE — NOT SOLUBLE IN ANY PROP.

Th 2026-02-05 AP CHEM

DO TAKE A MOMENT AND READ THE BOX ON PG 539 ABOUT WATER- AND FAT-SOLUBLE VITAMINS.

(SKIPPING MATH OF CONC. UNITS)

GAS SOLUBILITY

THE SOLUBILITY OF GASES DEPENDS ON THE PARTIAL PRESSURE OF THE GAS AND ON TEMPERATURE.

THE SOLUBILITY OF LIQUIDS AND SOLIDS IS NOT AFFECTED BY PRESSURE BECAUSE THEY ARE INCOMPRESSIBLE. THAT IS, THEY HAVE FIXED VOLUMES. SINCE VOL. CAN'T CHANGE, THE CONC. OF A SOLID AS A SOLID IS CONSTANT.

GAS SOLUBILITY DEPENDS ON PRESSURE (OF THE GAS) B/C GASES ARE COMPRESSIBLE. UNDER HIGHER PRESSURE A GAS A SMALLER VOL, WHICH MEANS A HIGHER CONC.

$$\text{MOLARITY} = \frac{mol}{L}\left(\frac{n}{V}\right) = \text{CONCENTRATION}$$

(M)

$$PV = nRT$$

$$\frac{n}{V} = \frac{P}{RT}$$

GAS SOLUBILITY, AS A FUNCTION OF PRESSURE IS CALLED HENRY'S LAW

AS $P\uparrow$, $\left(\frac{n}{V}\right)\uparrow$

AS $P\downarrow$, $\left(\frac{n}{V}\right)\downarrow$

$$S_g = kP_g$$

P_g = PARTIAL P OF A GAS

S_g = SOLUBILITY IN $\frac{mol}{L}$

k IS FOR CONSTANT WHICH DEPENDS ON WHICH GAS AND ON TEMP.

APPLICATION: A CAN OF SODA HAS $[CO_2] \cong 0.14\ mol/L$

$P_{CO_2} = 3.2\ atm$

AIR HAS $P_{CO_2} = 0.04\ atm$

SO WHEN YOU OPEN A CAN, THE SODA GOES FLAT B/C IT LEAVES SOLUTION UNTIL IT REACHES EQUILIBRIUM.

GAS SOLUBILITY: TEMPERATURE EFFECTS

MOST SOLIDS HAVE INCREASED SOLUBILITY AS TEMP. RISES. THIS B/C ADDT'L KE CAN BREAK MORE BONDS. AND SOLIDS DONT TURN INTO VAPOR AND ESCAPE.

GASES ARE <u>LESS</u> SOLUBLE WITH INCREASING TEMP.

WHY?

① AS TEMP. RISES AT CONSTANT P, THE VOL. INCREASES. WITH A CONSTANT NO. OF mol (n) AND A LARGER V, THE CONC. IS LOWER.

$$\frac{n}{V} = \frac{P}{RT} \qquad \text{AS } T\uparrow \left(\frac{n}{V}\right)\downarrow \qquad \text{AS } T\downarrow \left(\frac{n}{V}\right)\uparrow$$

② AT HIGHER TEMP. GAS MOLECULE KE IS LARGER, MEANING THEY MORE EASILY BREAK ANY SOLUTE-SOLVENT BONDS AND EXIT THE SOLUTION. IN ANY EVENT, WITH HIGHER SPEEDS GAS MOLECULES CAN LEAVE THE SOLUTION MORE RAPIDLY,

APPLICATIONS: ① WARM SODA GOES FLAT

② LIFE IS VERY ABUNDANT IN POLAR WATERS B/C COLD WATER DISSOLVES MORE OXYGEN.

(SKIPPING COLLIGATIVE PROPERTIES ☹ THOUGH I AM STILL ASSIGNING THE MARSHMALLOW PROJECT)