MATTER AND ENERGY

MATTER AND CLASSIFICATION

- Matter can be classified as either a

a. **Substance :** Uniform in composition of ONE kind of matter. Either element or compound

b. **Mixture:** A physical blend of two or more pure substances. Can be a homogeneous mixture or heterogeneous mixture

LATE WORK

- Before we start class, be sure all late work and completed labs are turned in before class starts!
- *If absent, remember it is your responsibility to submit all work into bin before class starts!

WARM-UP: PLEASE TAKE OUT CALCULATORS AND REFERENCE TABLES!

- 1. What is the equation you would use to find the heat of vaporization for a substance?
- 2. Define heat of vaporization
- 3. What is the heat of vaporization value for water?
- 4. How many joules of heat are needed to vaporize 100 grams of water at its boiling point?

MATTER CONTINUED

2 kinds of substances:

- 1. **Element**: a pure substance that cannot be broken down into simpler substances by chemical reactions. On the periodic table!
- 2. **Compound:** A chemical combination of two or more different elements. * Can be broken down into simpler substances by chemical means

MIXTURES

- **Mixture:** A physical blend of 2 or more substances (aren't combined chemically) and keep its own properties. Composition can vary

- Can be element+ different element, Element + compound, or compound + compound

MIXTURES

- 2 kinds of mixtures:

Homogeneous Mixture	**Heterogeneous mixture**
AKA solution A mixture that has a uniform composition throughout Ex) Ice tea, NaCl (aq), tap water	A mixture in which the ingredients are not uniformly dispersed. Examples: Chicken soup, _______________________

PHYSICAL VS. CHEMICAL CHANGES

Physical Change	Chemical Change
A change in matter where the object may look different, but its chemical composition remains the same	A change in matter where the object may look different and its chemical composition is different than the original
Verbs associated: Melting, freezing, boiling, evaporating, cutting, crushing, condensing http://www.youtube.com/watch?v=hHSuXCaUni4	**Verbs often associated:** Explode, RUST, ferment, corrode, tarnish, reacts, burn, rot/decompose

MODEL OF MATTER CONTINUED

- **<u>Substance:</u>** Look for only ONE type of matter. Only 1 kind of compound or 1 kind of element

MODELING OF MATTER

- **Homogeneous Mixture**: Look for 2 or more elements/compounds uniform in distribution
- **Heterogeneous Mixture**: Look for 2 or more elements/compounds not uniformly dispersed. Almost layered/ clustered/

- Bill Gates anyone?

- https://www.youtube.com/watch?v=FHgsL0dpQ-U

SEPARATION OF A MIXTURE

- **Mixtures can be physically separated. Here are 4 ways :**

- 1. **Filtration:**
- -Solids that have not been dissolved in the liquid will remain behind in the filter paper
- Dissolved particles go through paper
- Ex) Coffee beans in filter
- Ex) Filter in air conditioner filters dust in air

SEPARATION CONTINUED..

- 2. **Distillation:** Can separate liquids with different boiling points
- Can separate solids in liquids (liquid is evaporated out, leaving solid behind)
- Can separate the salt from saltwater
- https://www.youtube.com/watch?v=PYMWUz7TC3A

- 3. **Chromatography:** Components of a mixture move at different rates. They separate as they move up the paper. http://www.youtube.com/watch?v=4I9065A_6UY&index=2&list=PLkikvDyD7It7m6yUiolBSb_bH7VH5OFjl

- 4**. Centrifugation**: Separates by centrifugal force- spinning causes solids to move to the bottom and separate from the liquid. In blood analysis
- https://www.youtube.com/watch?v=9u4azf206T0

KELVIN TEMPERATURE CONVERSION

- **Kelvin scale**: temperatures on this scale are designated by the letter K. The freezing point of water is 273.15 K.
- **Absolute zero**: A temperature that is theoretically the lowest possible temperature.
- **Temperature conversions**:
- **K= Celsius + 273**
- **Celsius= K-273**

DO-NOW
AGENDA: CALCULATING ENERGY!
FINISHING LAB(?)

- 1. Convert 20 C to Kelvin
- 2. After filtering an aqueous solution of potassium nitrate, list anything that would pass through the filter
- 3. If absolute zero is 0K, what is this temperature in celsius?

ENERGY……….

- Describe energy……
- Where do you get your energy?
- What is a unit of energy?
- What is a unit of heat?

SHARK TANK ANYONE?

- https://www.youtube.com/watch?v=f1eAOygDP5s
- Bill Nye

- https://www.youtube.com/watch?v=YXmAUEt1r_4
- Kick starter Joulies

- https://www.youtube.com/watch?v=zuFKODDYmFk

- Shark tank

SPECIFIC HEAT

- **Specific heat**: The amount of energy needed to raise 1 gram of a substance 1 degree Celsius

- Q=
- M=
- C=
- Change in temperature:

CALORIMETRY

- Measuring the amount of heat transferred during a reaction
- Reaction occurs in a chamber or insulated container surrounded by a known mass of water
- The reaction may gain or release energy and temperature will change depending on the reaction

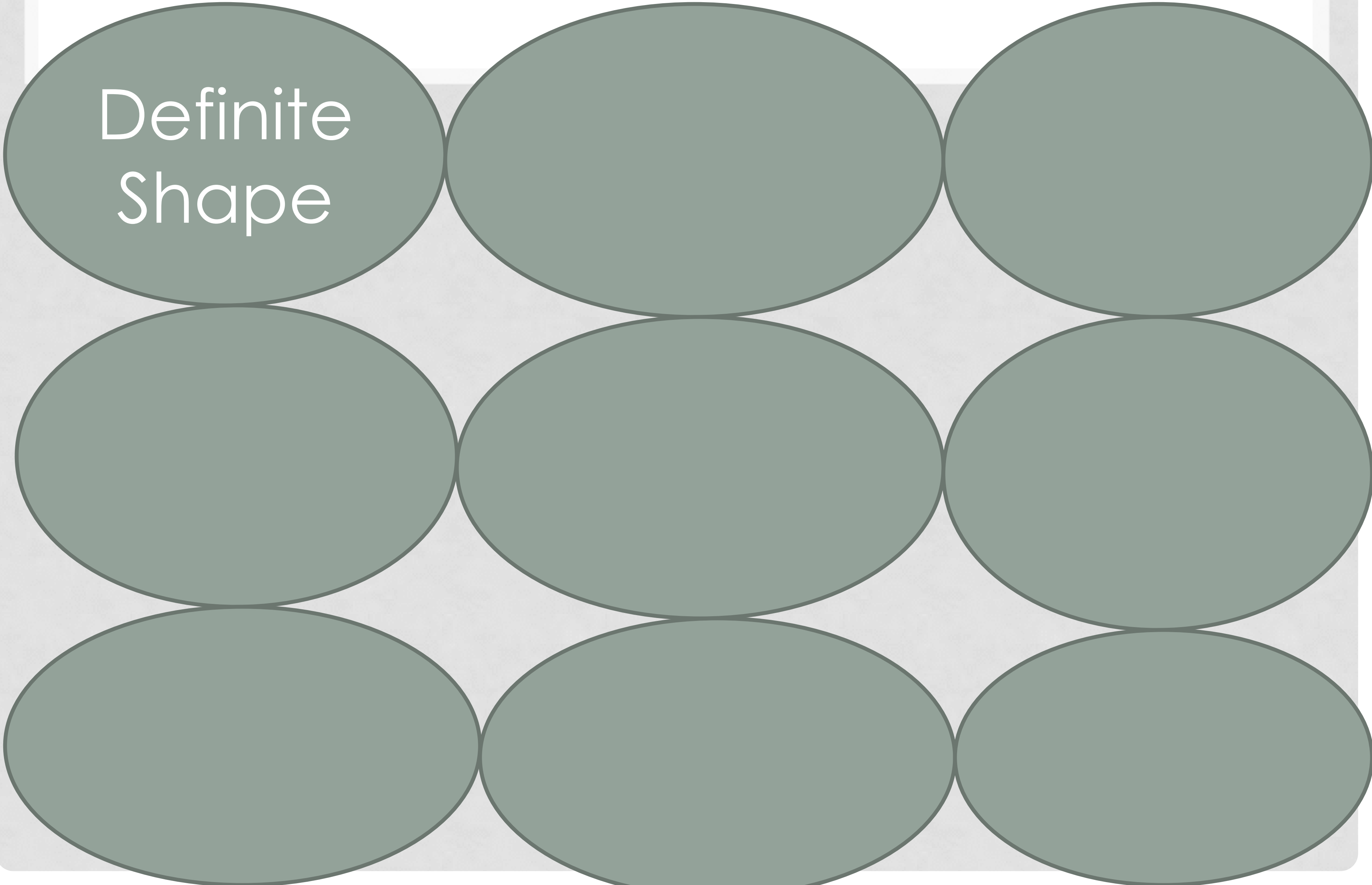
OTHER HEAT EQUATIONS

- **<u>Heat of fusion</u>**:
- the amount of heat energy required to change the matter of a substance from a solid to a liquid. Its units are usually Joules per gram (J/g). Used calculate the amount of energy required to melt a substance.
- The heat of fusion of water is ____________________
- **<u>Heat of vaporization:</u>**
- the amount of heat energy required to change the matter of a substance from a liquid to a gas. Its units are usually Joules per gram (J/g). Used calculate the amount of energy required to vaporize a substance.

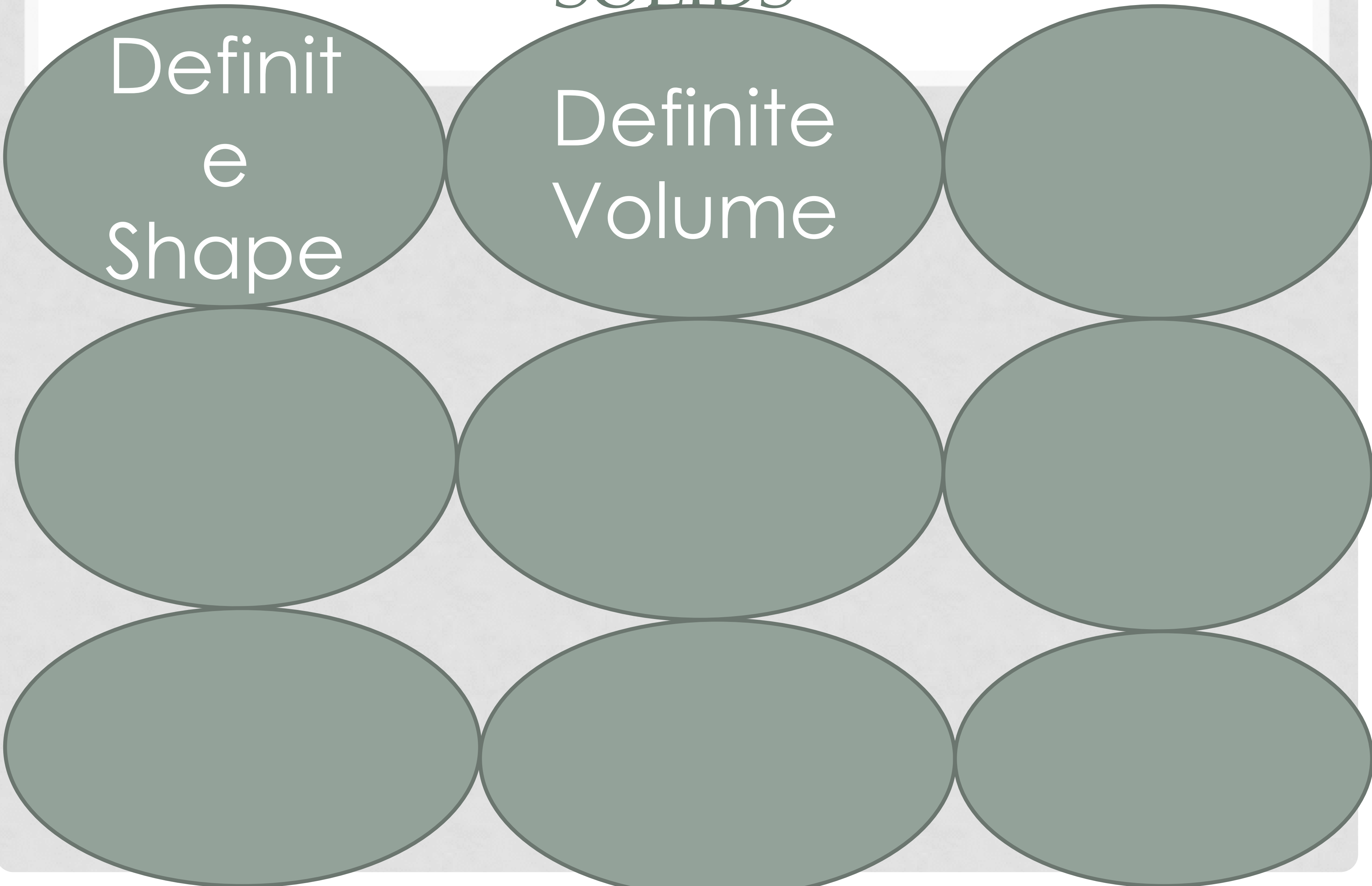
The heat of vaporization of water is ______________

- **<u>THERE IS NO TEMPERATURE CHANGE!!!!</u>**
- $q=mH_f$ Used when a substance is MELTING
- $q=mH_v$ Used when a substance is BOILING

SOLIDS



SOLIDS



SOLIDS

Definit
e
Shape

Definite
Volume

Vibration
movement

SOLIDS

Definit
e
Shape

Definite
Volume

Vibration
movement

Particles are close together, crystalline structure

Strong attractive forces between particles keep solids in rigid form

SOLIDS

Definit
e
Shape

Definite Volume

Vibration movement

Particles are close together, crystalline structure

Strong attractive forces between particles keep solids in rigid form

High boiling points and melting points

SOLIDS

Definite Shape

Definite Volume

Vibration movement

Particles are close together, crystalline structure

Strong attractive forces between particles keep solids in rigid form

High boiling points and melting points

High P.E

Very Dense

Low compressibility

LIQUIDS

- Definite Volume
- Shape is indefinite
- Intermediate KE and PE
- Somewhat compressible
- Particles are closer together than gas, but farther than solids
- Less dense than solids
- -Has rotational movement

GAS

Indefinite Shape

GAS

Indefinite Shape

Indefinite volume

GAS

Indefinit
e Shape

Indefinite
volume

Low
density

GAS

Indefinit
e Shape

Indefinite
volume

Low
density

Weak intermolecular forces = low boiling/melting points

GAS

Indefinite Shape

Indefinite volume

Low density

Weak intermolecular forces = low boiling/melting points

High Compressibility (far apart)

GAS

Indefinit
e Shape

Indefinite
volume

Low
density

**Weak
intermolecular
forces = low
boiling/melting
points**

High
Compressibilit
y (far apart)

High K.E. low P.E

KINETIC THEORY OF GASES

- **Kinetic Theory of Gases**

1. Gases are composed of individual, invisible particles. The molecules are much smaller than the volume

   Mostly empty space= compressibility

2. Gases move in a constant straight-line random motion. Collisions with container and each other is constant
3. Elastic Collisions result in a TRANSFER of energy. Total energy remains the same under constant conditions
4. No forces of attraction or repulsion are considered to exist between gas particles

IDEAL GASES

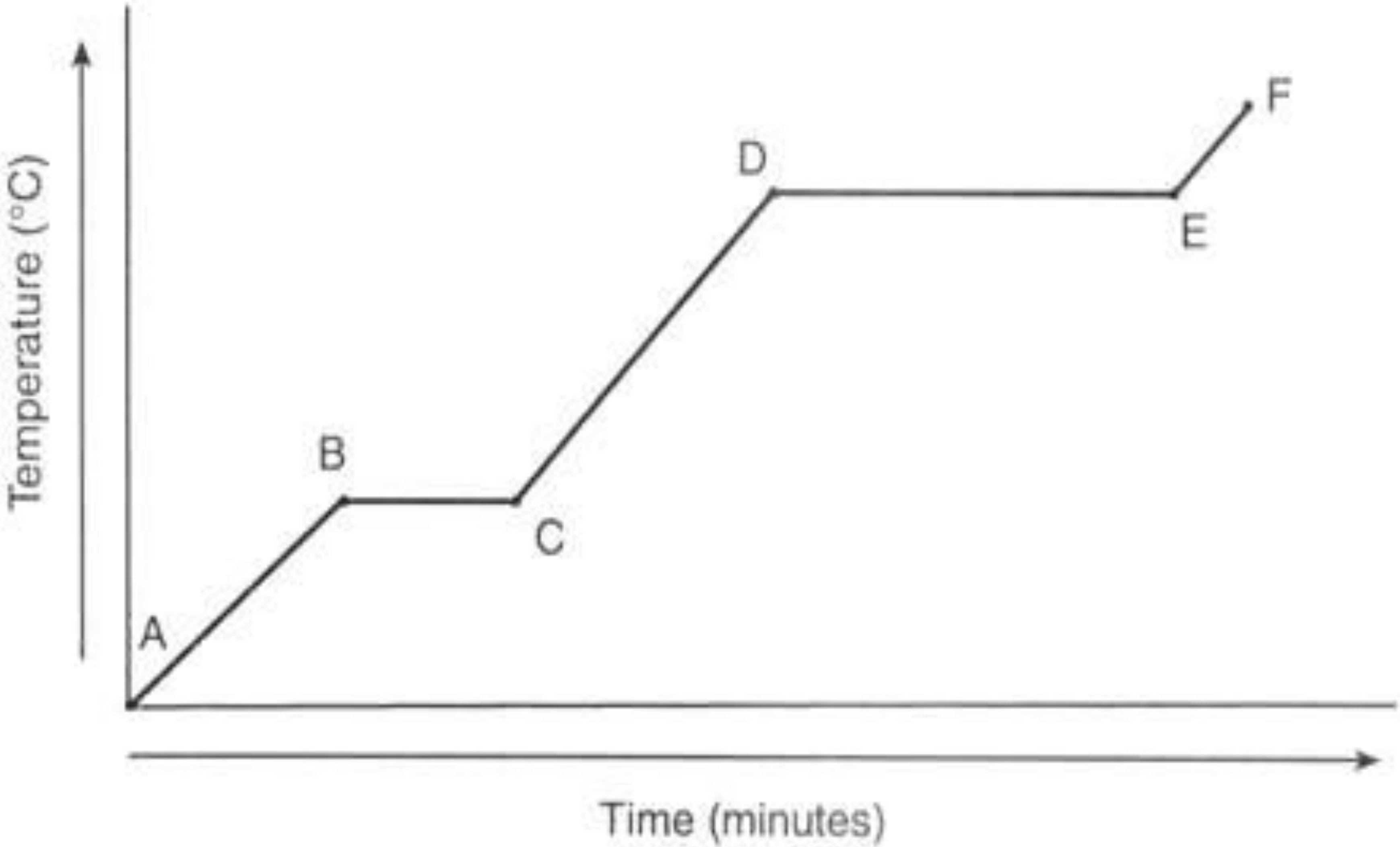
- - Gases that behave exactly as predicted by the kinetic theory of gases (H and He are closest to ideal)
- - Gases show ideal behavior when they are farthest from each other. This means low pressure and high temperatures

- Real gases deviate from this theory because:
- 1. gas particles do have volume (very little)
- 2. Gas particles do have so attraction between particles

HEATING CURVE

- - Diagram representing the heating of a substance
- -Endothermic= absorbs heat energy from solid-> liquid-> gas
- Horizontal segment= change in PE and 2 phases in equilibrium
- Diagonal= change in KE and l phase only

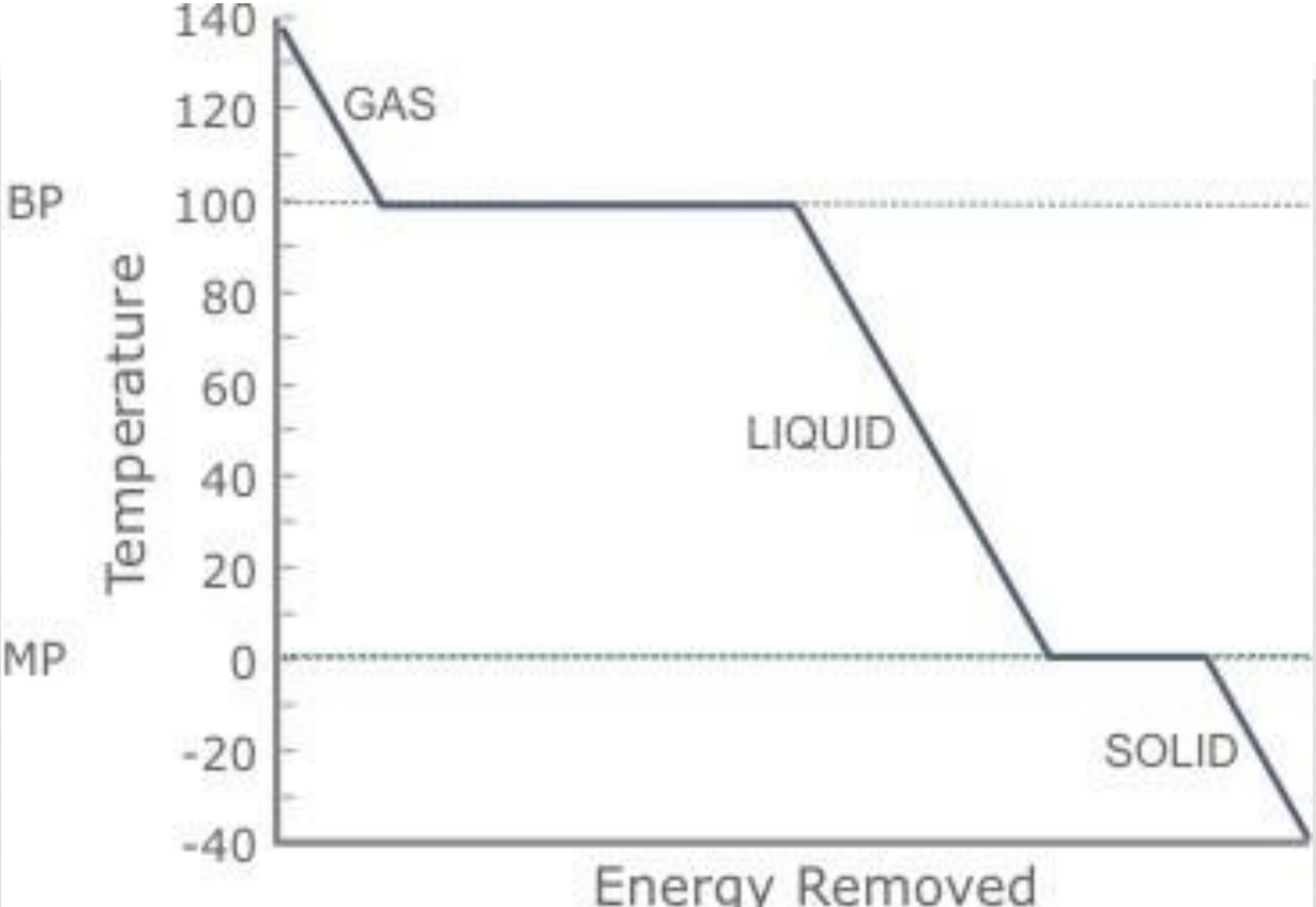
HEATING CURVE



COOLING CURVE

- Diagram representing the cooling of a substance
- -Exothermic (release of heat energy)
- - Gas->liquid->solid
- Diagonal= change in KE and only 1 phase
- Horizontal= change in PE and 2 phases in equilibrium
- Melting point=freezing point

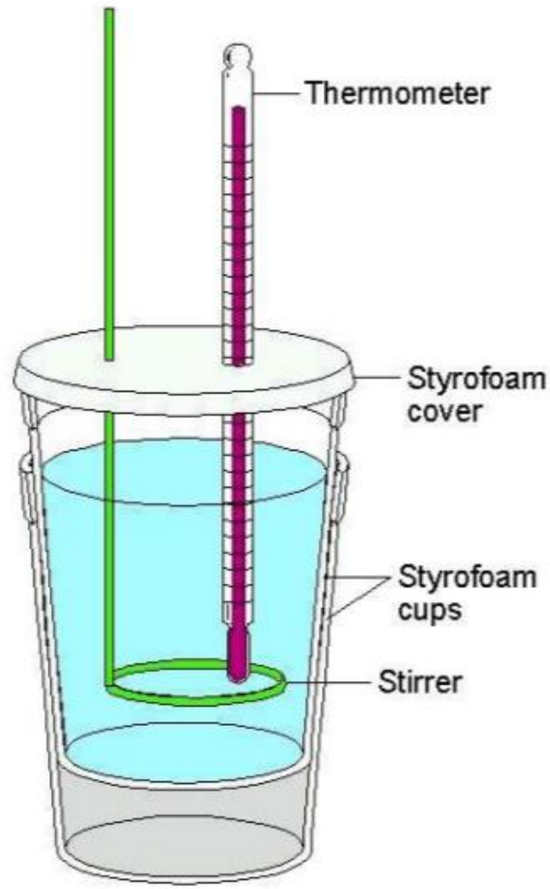
COOLING CURVE



Calorimetry – Part 2

Applications

A calorimeter is used to measure the heat absorbed or released in a chemical (or other) process by measuring the temperature change of an insulated mass of water.



Specific Heat

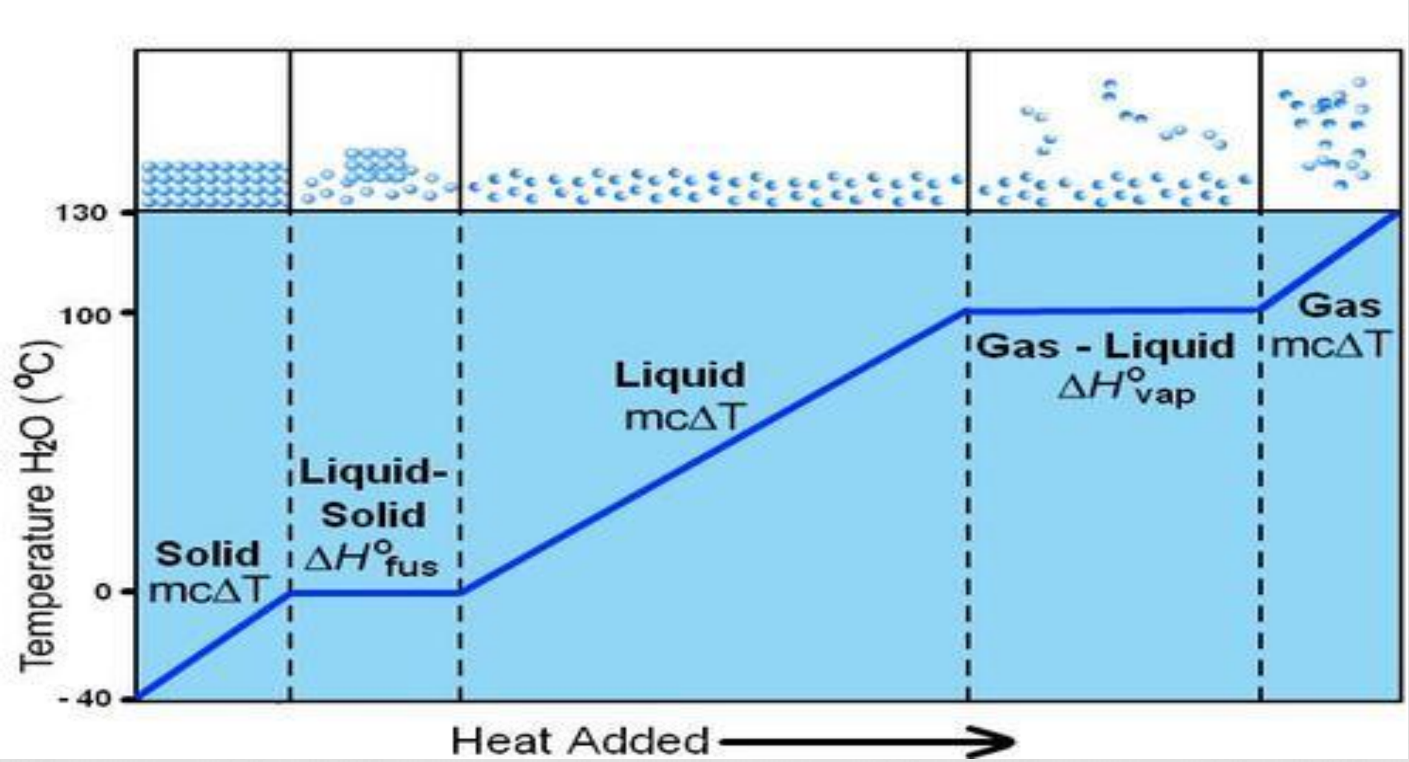
Specific heat is the amount of heat (calories or Joules) that raises the temperature of 1 g of a substance by 1°C.

Table 5.1 Specific Heats of Some Substances

	Specific Heat	
Substance	(cal/g °C)	(J/g °C)
Water	1.00	4.18
Ethanol	0.58	2.4
Aluminum	0.22	0.92
Sand	0.19	0.79
Iron	0.11	0.46
Copper	0.093	0.39
Silver	0.057	0.24
Gold	0.031	0.13

DENSITY

- Mass/Volume



SPECIFIC HEAT

- -Measure heat transfer
- Q=mc T
- Q= heat in joules
- M=mass in grams
- C= specific heat capacity in J/g C

- Specific heat for water is on table B!

TABLE T: BACK OF REFERENCE TABLES

Heat	$q = mC\Delta T$ $q = mH_f$ $q = mH_v$	q = heat m = mass C = specific heat capacity ΔT = change in temperature	H_f = heat of fusion H_v = heat of vaporization

TABLE B: FRONT OF REFERENCE TABLES

Table B
Physical Constants for Water

Heat of Fusion	334 J/g
Heat of Vaporization	2260 J/g
Specific Heat Capacity of $H_2O(\ell)$	4.18 J/g•K

PERCENT ERROR

- Can be large!
- Can be negative!

- Measured value-accepted value
- -- X 100

Accepted

Measured: What you calculated or from data

Accepted: The real value

ENDOTHERMIC VS EXOTHERMIC

- Endothermic
- Surrounding temperature will decrease

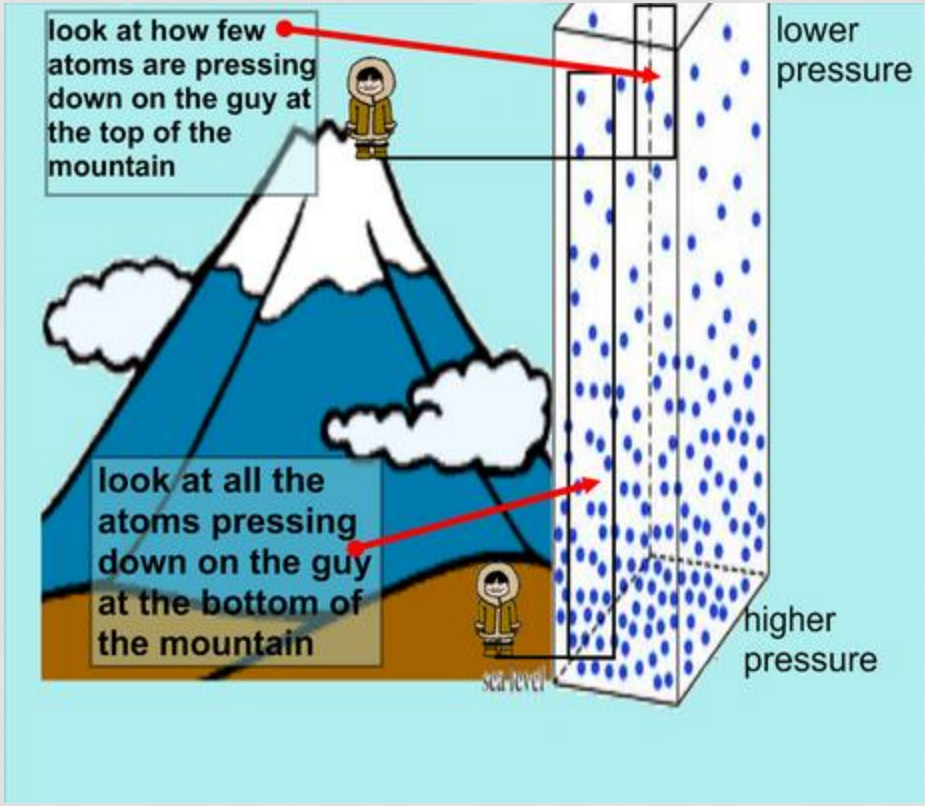
- Exothermic
- Surrounding temperature will increase due to release of heat to surroundings
- http://www.middleschoolchemistry.com/lessonplans/chapter5/lesson9
- Check first

ENDOTHERMIC

- -Absorbs energy
- Surroundings feel cold/lower temperatures!

- Examples:
- Sweating!
- Rubbing alcohol on hands
- Melting!
- Boiling!

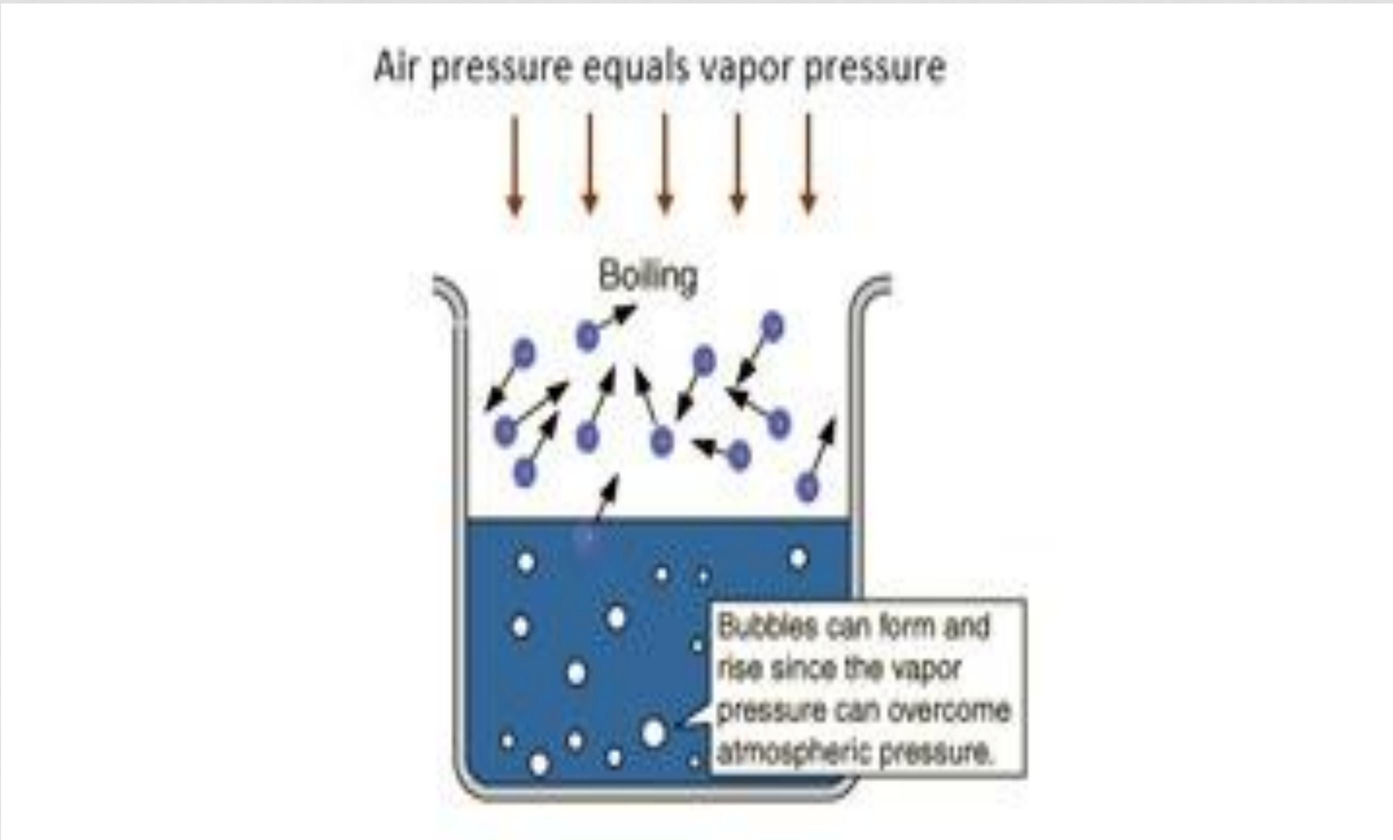
ATMOSPHERIC PRESSURE



ATMOSPHERIC PRESSURE AND BOILING POINTS

- **Boiling**: The formation of bubbles of vapor when the liquid changes to a vapor in the liquid itself and on the surface of it.

- **Vapor Pressure:** the pressure exerted by evaporation
- **Boiling point:** Vapor pressure = atmospheric pressure
- **Normal boiling point**: the boiling point of a liquid at standard pressure (101.3 kPa or 1 atm)


Air pressure equals vapor pressure
Boiling
Bubbles can form and rise since the vapor pressure can overcome atmospheric pressure.

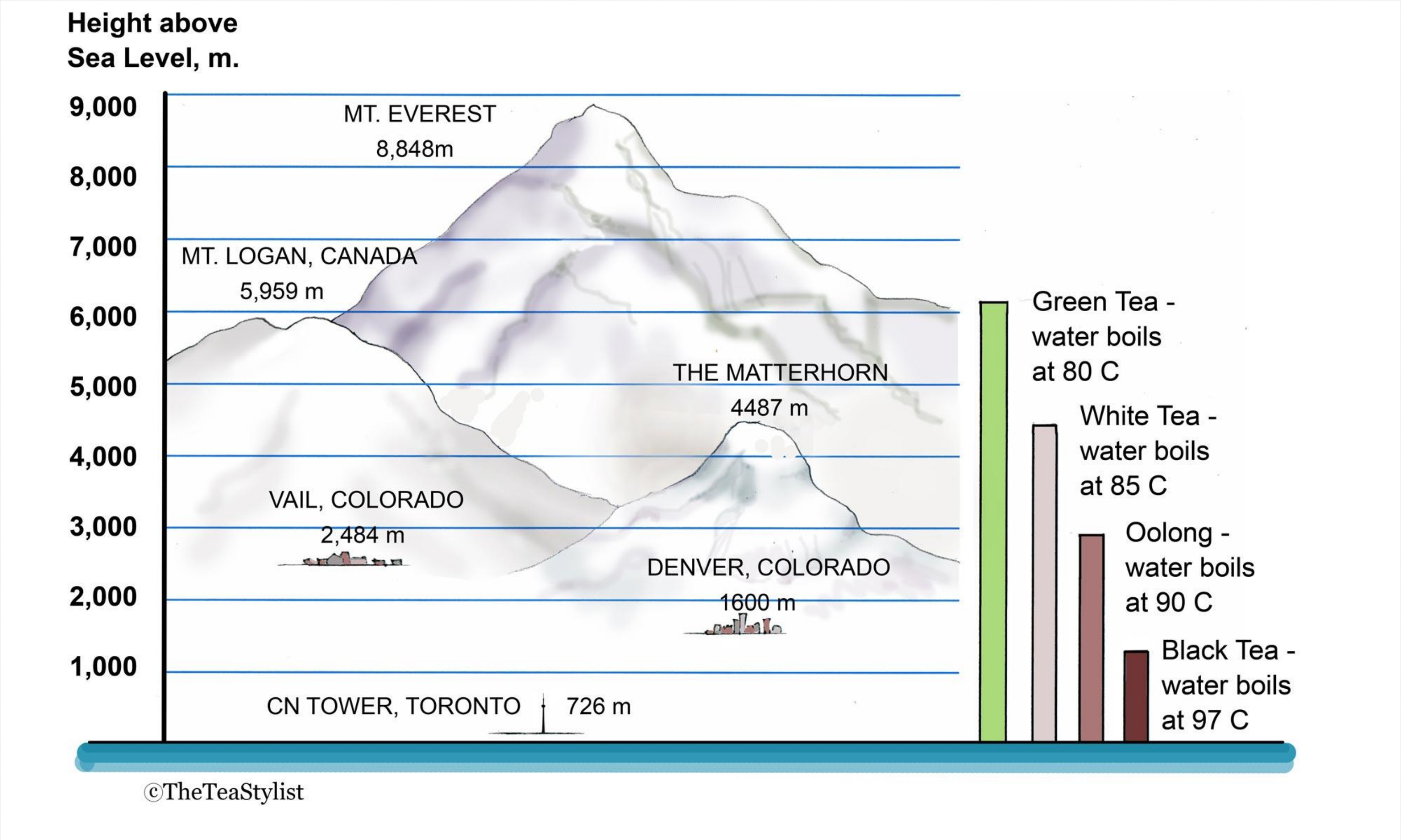
HOW DOES ATMOSPHERIC PRESSURE AFFECT BOILING POINTS?

- **Atmospheric pressure:** the pressure exerted by all the gases in the atmosphere

Above sea level= lower boiling points

Why? Air pressure is less, so the vapor pressure is lower for it to boil. (recalll: Vapor pressure = atmospheric pressure)

Example: In Denver, water boils at 95 C due to lower atmospheric pressure

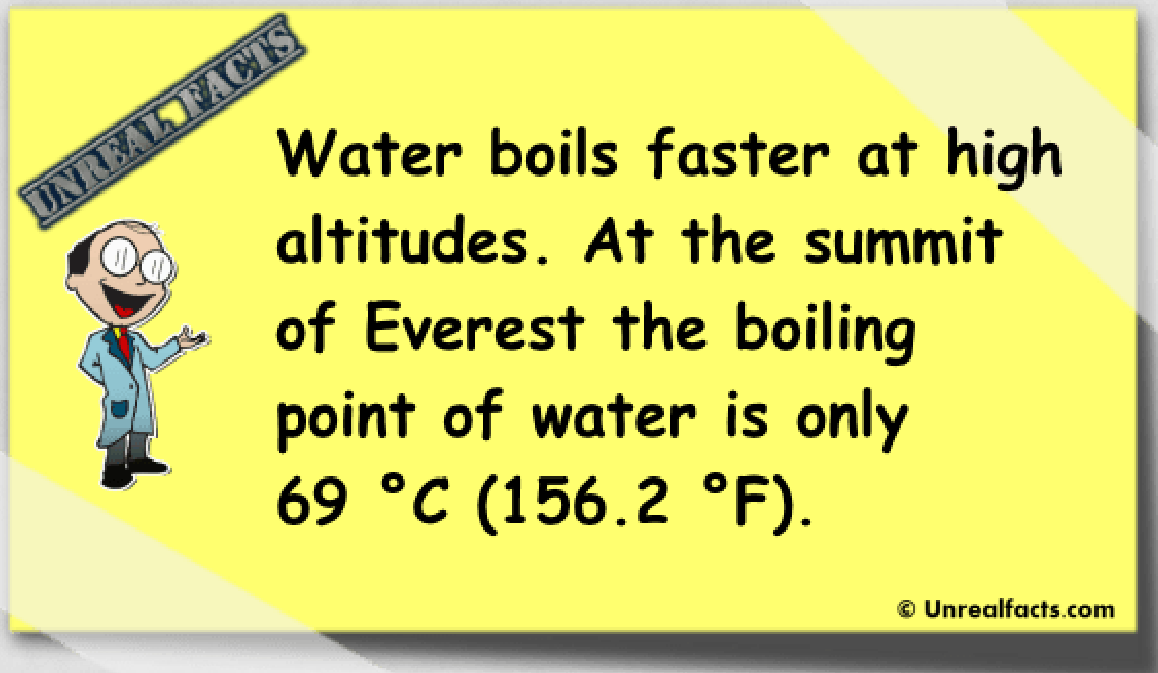


Height above
Sea Level, m.
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
MT. EVEREST
8,848m
MT. LOGAN, CANADA
5,959 m
THE MATTERHORN
4487 m
VAIL, COLORADO
2,484 m
DENVER, COLORADO
1600 m
CN TOWER, TORONTO
726 m
Green Tea - water boils at 80 C
White Tea - water boils at 85 C
Oolong - water boils at 90 C
Black Tea - water boils at 97 C
©TheTeaStylist

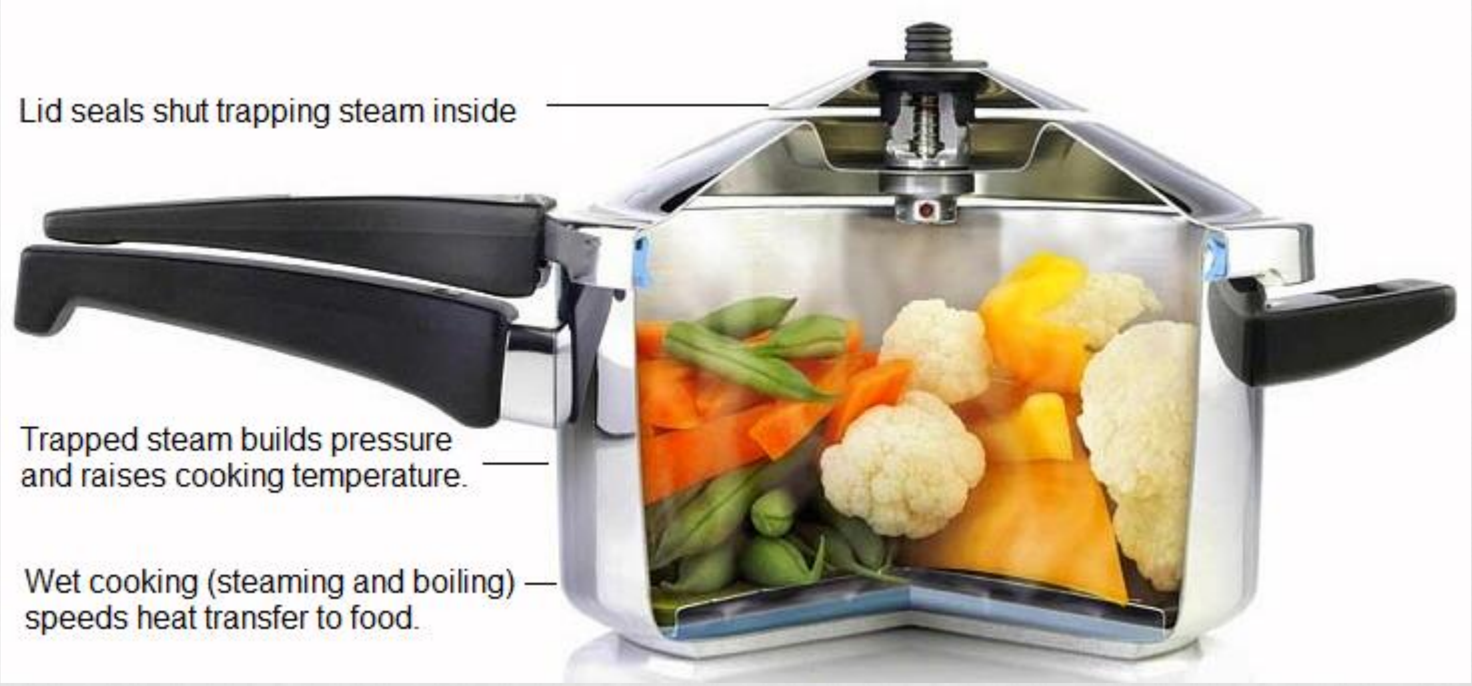
HOW DOES ATMOSPHERIC PRESSURE AFFECT BOILING POINTS CONTINUED

- Below sea level= higher boiling points
- Why? Atmospheric pressure is higher (image diving in a pool) so liquid will boil at a higher temperature
- How doe a pressure cooker work? Increase pressure and it will boil at a higher temperature)

Increase temperature = increased vapor pressure


UNREAL FACTS
Water boils faster at high altitudes. At the summit of Everest the boiling point of water is only 69 °C (156.2 °F).
© Unrealfacts.com

COOKING WITH PRESSURE COOKER



READING TABLE H

- -Look at the given temperature. Follow up until it reaches the curve of the indicated liquid. Read the pressure

OR

- - Look at the given pressure. Follow across until it reaches the curve of the indicated liquid. Read that temperature.
- 1. Boiling occurs when the atmospheric pressure = vapor pressure
- 2. Normal boiling point: Boiling at standard pressure

stronger imf= higher boiling points

TABLE H

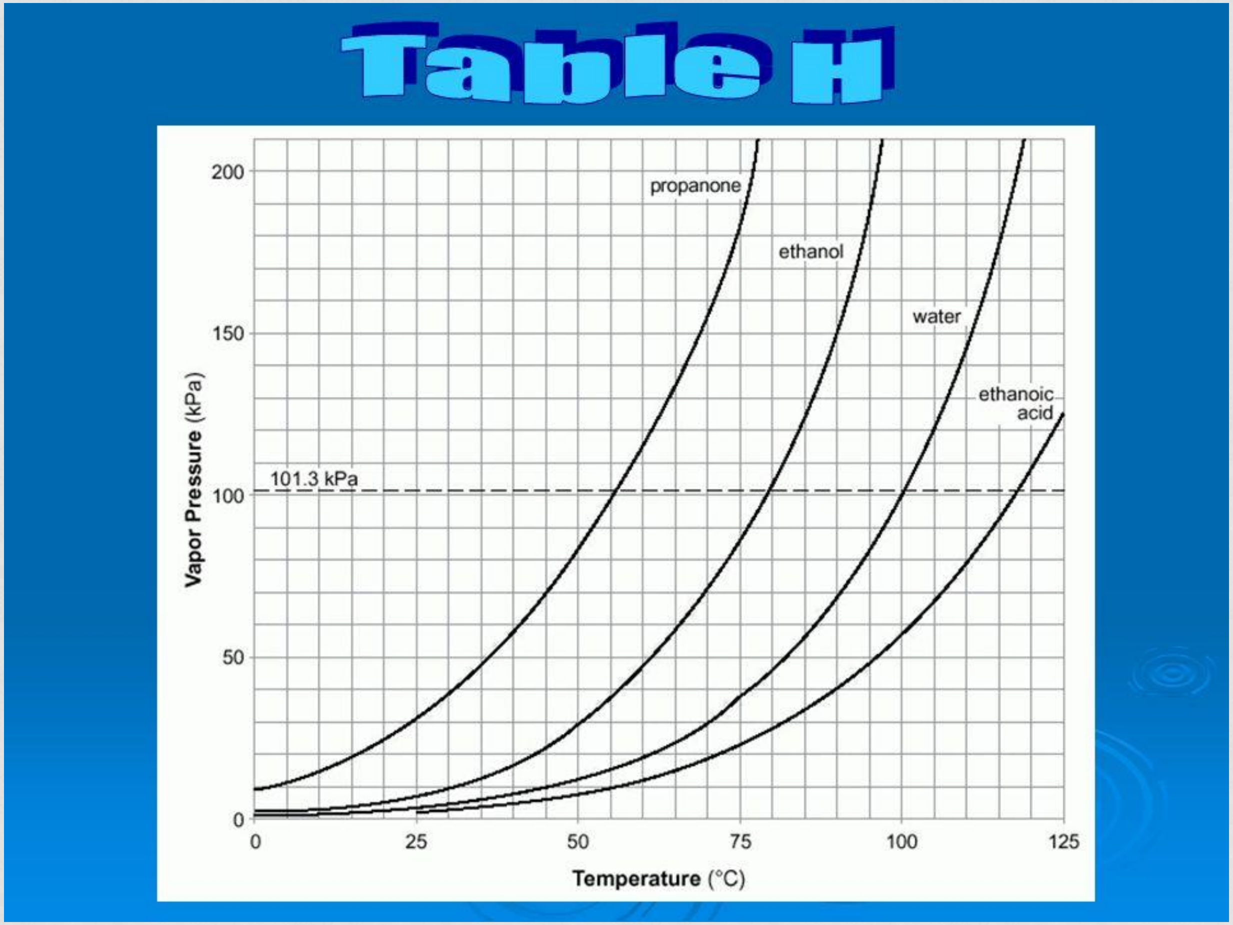


Table H
200
150
100
50
0
Vapor Pressure (kPa)
101.3 kPa
propanone
ethanol
water
ethanoic
acid
0
25
50
75
100
125
Temperature (°C)

HEAT OF FUSION VS. HEAT OF VAPORIZATION

- **Heat of fusion**: The amount of heat needed to convert a unit mass of a substance from a solid to a liquid. LOOK FOR MELTING!

$$Q = mH_f$$

- H_f of water= see reference tables
- Example: How many grams of ice at 0 C can be melted by the addition of 812 J of heat?

SUBLIMATION/ SUBLIME

- **Sublimation:** The process by which a solid changes to a gas or vapor without passing through the liquid state.
- * Occurs when the vapor pressure of a solid exceeds the atmospheric pressure around room temperature

Example 1: Iodine (S) → Iodine vapor

Violet black   Purple

Example 2: Solid carbon dioxide (dry ice)

(solid at -78 C)

HEAT OF VAPORIZATION

- Heat of Vaporization: The amount of heat needed to convert a unit mass of a substance from a liquid to a gas. LOOK FOR BOILING !

Q=mHv

- H_v of water= see reference tables
- Example: How much heat is absorbed when 258.3 grams of water at 100 C and 101.3 kPa is converted to steam at 100 C?

SUBLIMATION/SUBLIME

- <u>**Sublimation:**</u> The process by which a solid changes to a gas or vapor without passing through the liquid state
- *occurs when the vapor pressure of a solid exceeds the atmospheric pressure around room temperature

- Example 1: Iodine (s) → Iodine (g)
  violet black Purple
- Example 2: Solid carbon dioxide (dry ice)
- (solid at -78C)

- <u>**Deposition:**</u> A substance that changes from a gas to a solid without passing through the liquid phase

DEPOSITION

- Gas directly to solid

TABLE I

Table I
Heats of Reaction at 101.3 kPa and 298 K

Reaction	ΔH (kJ)*
$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(\ell)$	–890.4
$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(\ell)$	–2219.2
$2C_8H_{18}(\ell) + 25O_2(g) \longrightarrow 16CO_2(g) + 18H_2O(\ell)$	–10943
$2CH_3OH(\ell) + 3O_2(g) \longrightarrow 2CO_2(g) + 4H_2O(\ell)$	–1452
$C_2H_5OH(\ell) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(\ell)$	–1367
$C_6H_{12}O_6(s) + 6O_2(g) \longrightarrow 6CO_2(g) + 6H_2O(\ell)$	–2804
$2CO(g) + O_2(g) \longrightarrow 2CO_2(g)$	–566.0
$C(s) + O_2(g) \longrightarrow CO_2(g)$	–393.5
$4Al(s) + 3O_2(g) \longrightarrow 2Al_2O_3(s)$	–3351
$N_2(g) + O_2(g) \longrightarrow 2NO(g)$	+182.6
$N_2(g) + 2O_2(g) \longrightarrow 2NO_2(g)$	+66.4
$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$	–483.6
$2H_2(g) + O_2(g) \longrightarrow 2H_2O(\ell)$	–571.6
$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$	–91.8
$2C(s) + 3H_2(g) \longrightarrow C_2H_6(g)$	–84.0
$2C(s) + 2H_2(g) \longrightarrow C_2H_4(g)$	+52.4
$2C(s) + H_2(g) \longrightarrow C_2H_2(g)$	+227.4
$H_2(g) + I_2(g) \longrightarrow 2HI(g)$	+53.0
$KNO_3(s) \xrightarrow{H_2O} K^+(aq) + NO_3^-(aq)$	+34.89
$NaOH(s) \xrightarrow{H_2O} Na^+(aq) + OH^-(aq)$	–44.51
$NH_4Cl(s) \xrightarrow{H_2O} NH_4^+(aq) + Cl^-(aq)$	+14.78
$NH_4NO_3(s) \xrightarrow{H_2O} NH_4^+(aq) + NO_3^-(aq)$	+25.69
$NaCl(s) \xrightarrow{H_2O} Na^+(aq) + Cl^-(aq)$	+3.88
$LiBr(s) \xrightarrow{H_2O} Li^+(aq) + Br^-(aq)$	–48.83
$H^+(aq) + OH^-(aq) \longrightarrow H_2O(\ell)$	–55.8

*The ΔH values are based on molar quantities represented in the equations. A minus sign indicates an exothermic reaction.

- - This table has various reactions. The large numbers (coefficients) are the "moles"
- You may have to adjust the H values for questions to compare heat quantities