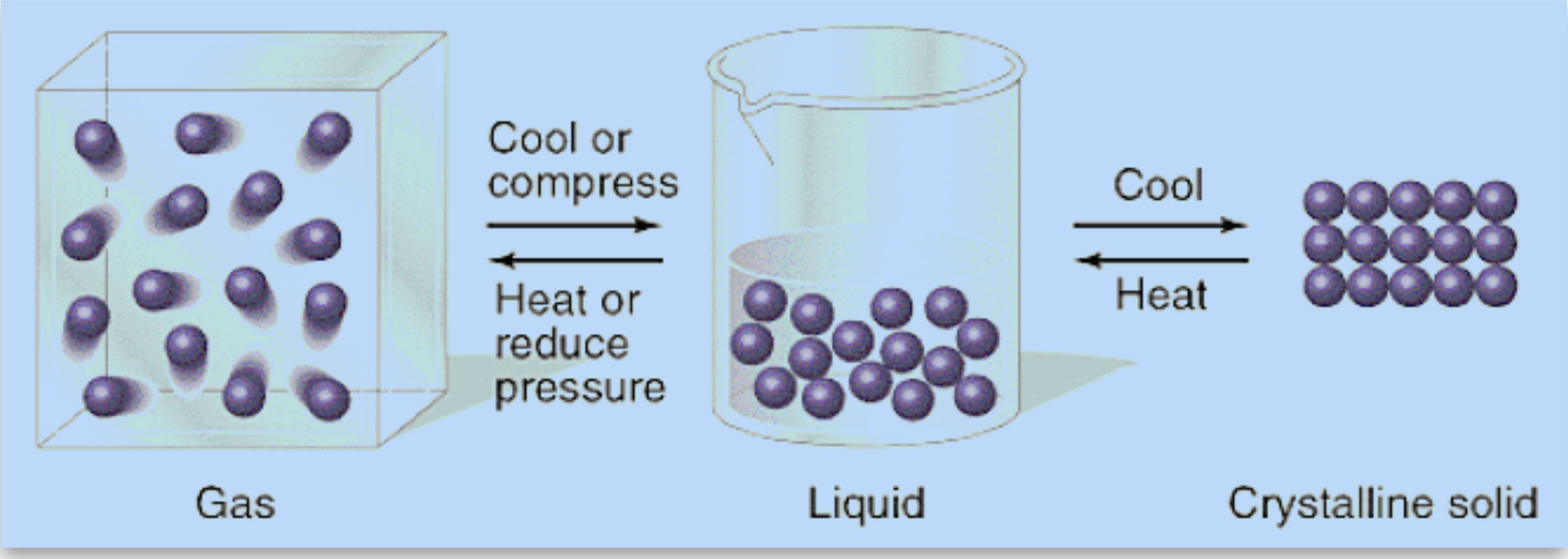
Particle Behavior in States of Matter

Unit 4

Particle Behavior

Topic 1



1. In which diagram do the particles move the fastest?
2. Which of these phases could be described as fluids? How do you know?
3. In terms of particles, which phase is compressible?

Phase Transitions

Heat

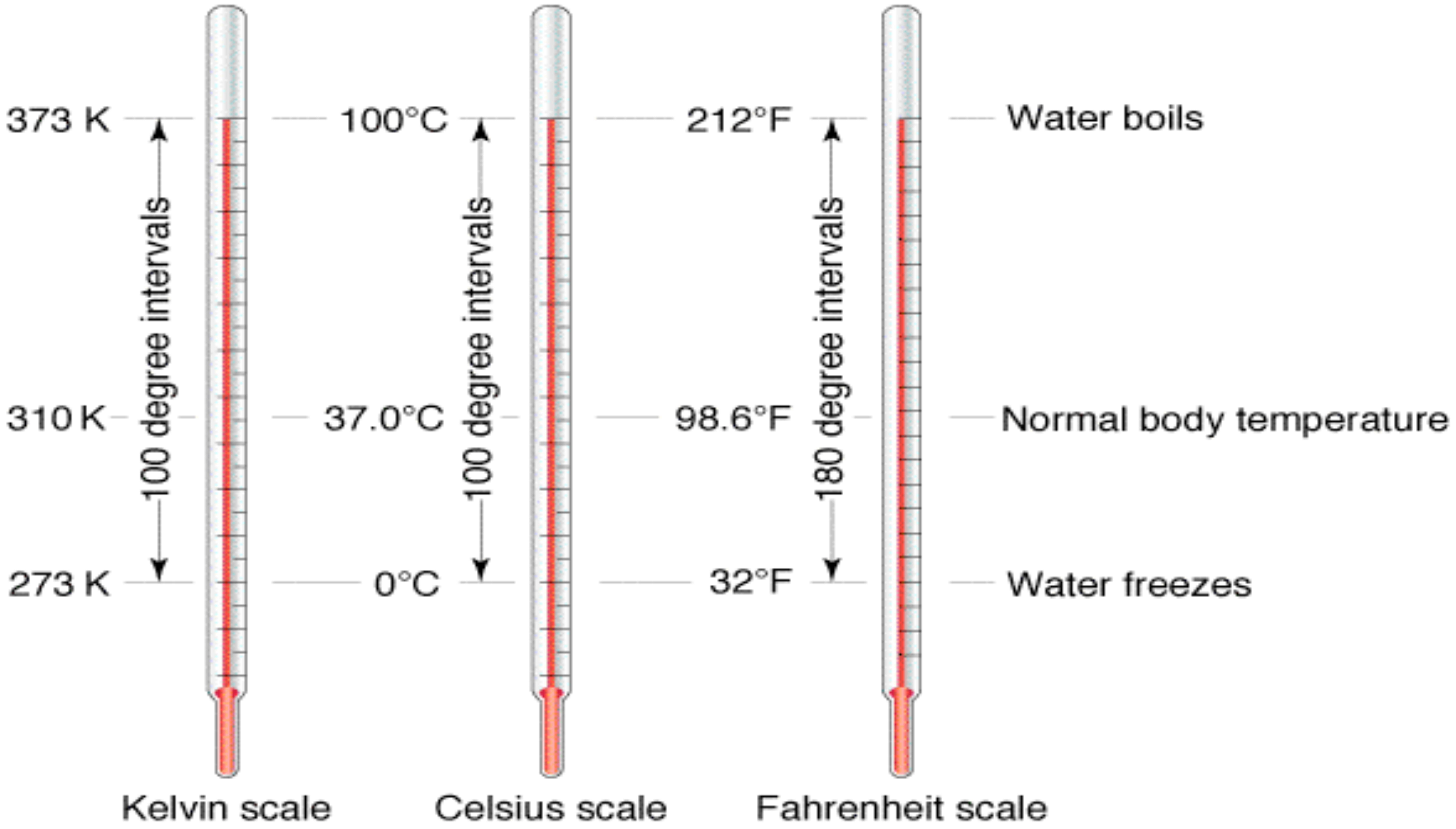
- <u>Energy</u> transferred between objects of different temperature.
- Heat flows from warm to cold.
- Produced by particle motion.
- Depends on sample size

Temperature

- Measure of *Average Kinetic Energy*.
- Random motion of particles.
- Can be measured *quantitatively*
- *NOT* dependent on sample size

Which has more Heat? Higher Temperature?

How do we measure Temperature?



Negative Energy?

Can there be a temperature lower than 0°C?

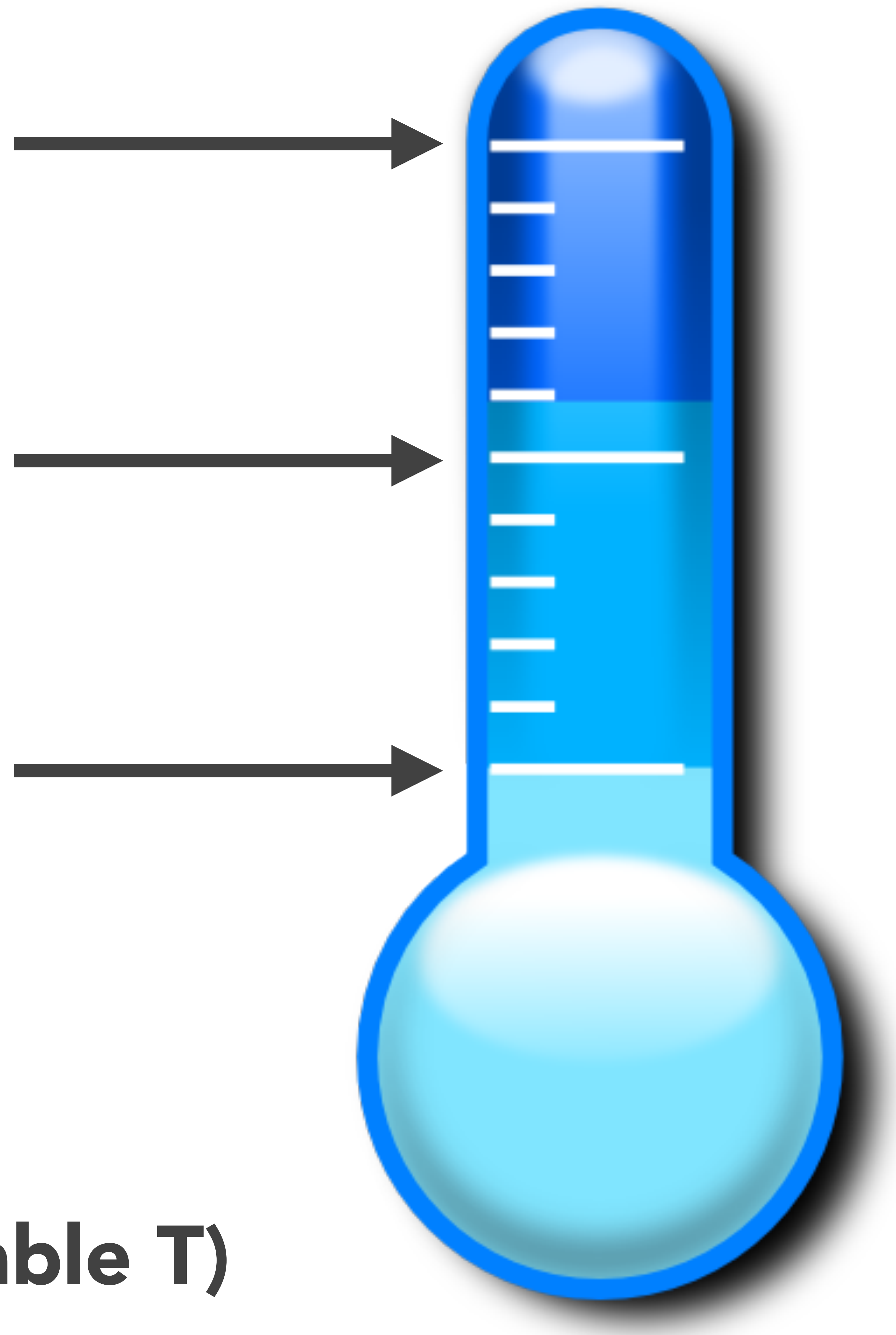
YES

The Kelvin Scale

373 K : (100˚C) BP of H_2O

273 K : (0˚C) FP/MP of H_2O

0 K : (-273˚C, Absolute Zero) no molecular movement



K = ˚C + 273 (Table T)

Temperature Conversions

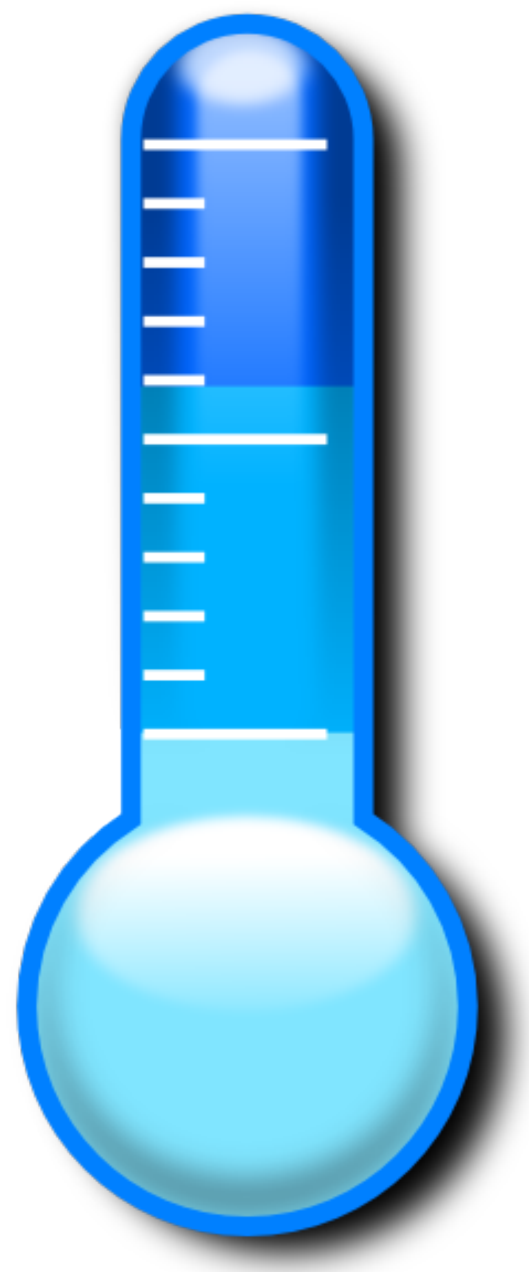
K = °C + 273 (*Table T*)

298 K to °C =

37°C to K =

-25°C to K =

245 K to °C =



Temperature Conversions

K = ˚C + 273 (Table T)

298 K to ˚C = 25˚C

37˚C to K = 310 K

-25˚C to K = 248 K

245 K to ˚C = -28˚C

Regents Practice

K = °C + 273 (Table T)

Which temperature represents absolute zero?

(1) 0 K (2) 0°C

(3)273 K (4) 273°C

At which temperature does a water sample have the highest average kinetic energy

(1) 0°C (2) 100°C

(3) 0 K (4) 100 K

Particle Attractions

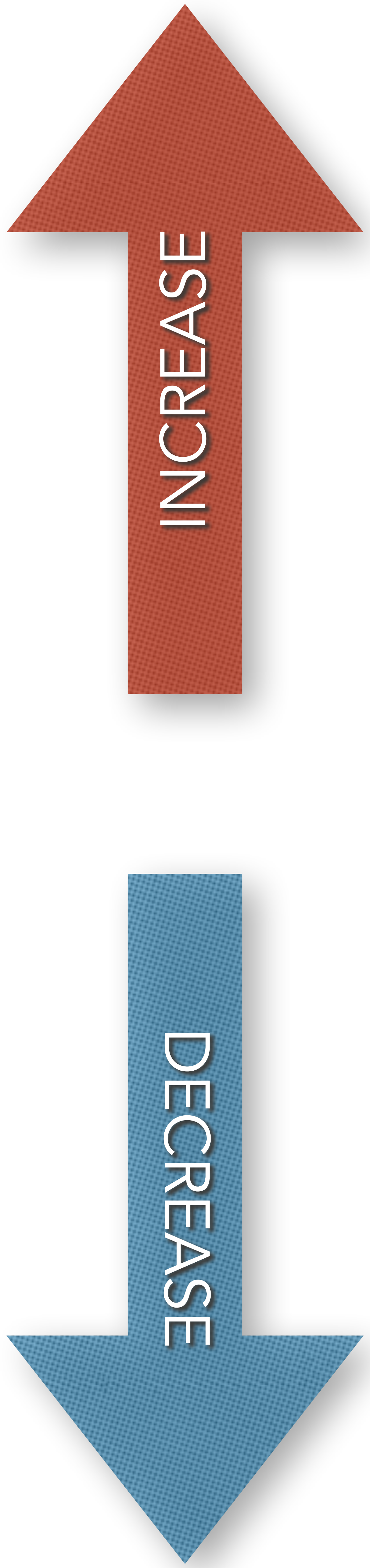
Topic 2

Stations #2, 8 and 9

Intermolecular Forces (IMFs)

IMFs - attraction ***<u>between</u>*** particles

Concepts to Consider



Particle Attraction

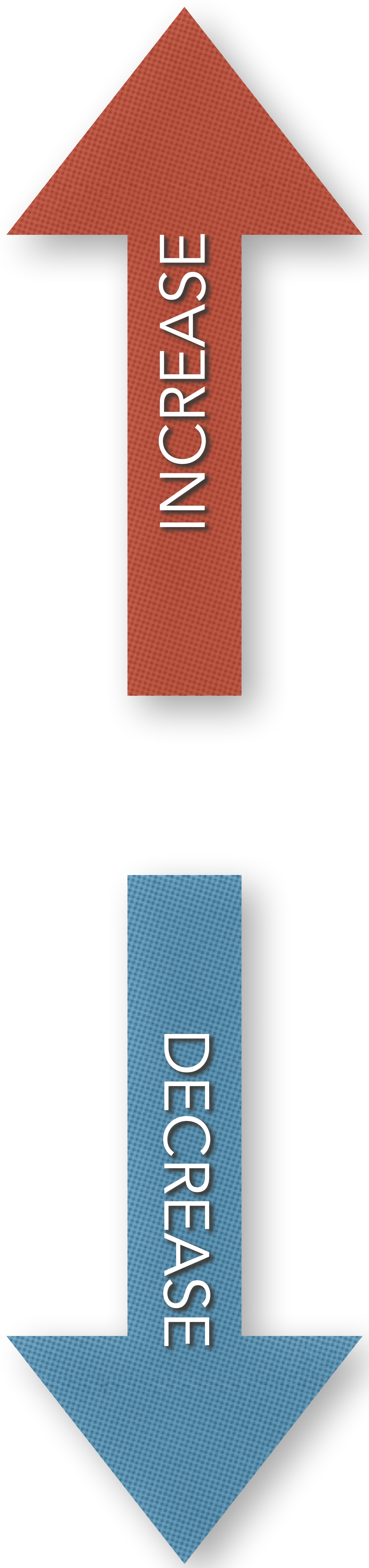
*As heat is **removed** from a gas*

Particle Speed

Average Kinetic Energy

Concepts to Consider

*As heat is **added** to a solid:*



Particle Speed

Average Kinetic Energy

Particle Attraction


Melting Point
IMFs
weaken

Boiling Point

Viscosity

Resistance to Flow

Decreasing Heat (Increase IMF)

Regents Practice

Which of the following has the strongest forces of attraction?

(1) $CO_{2(s)}$ (3) $CO_{2(g)}$

(2) $CO_{2(l)}$ (4) $CO_{2(aq)}$

Behavior of Gases

Topic 3

Stations # 5 and 7

Pressure

PSI - pounds per square inch

- *Gas molecules hitting the walls of a container… that's Pressure!*

<u>Elastic Collisions</u>

No energy is lost after the collision.

Kinetic Molecular Theory (KMT)

Ideal vs Real Gases

<u>IDEAL GASES</u>

- *Random, continuous* motion
- Volume is <u>*negligible*</u> (no volume)
- <u>NO</u> attractive forces
- Elastic collisions

<u>REAL GASES</u>

- *Have mass*
- *Have attractive forces*

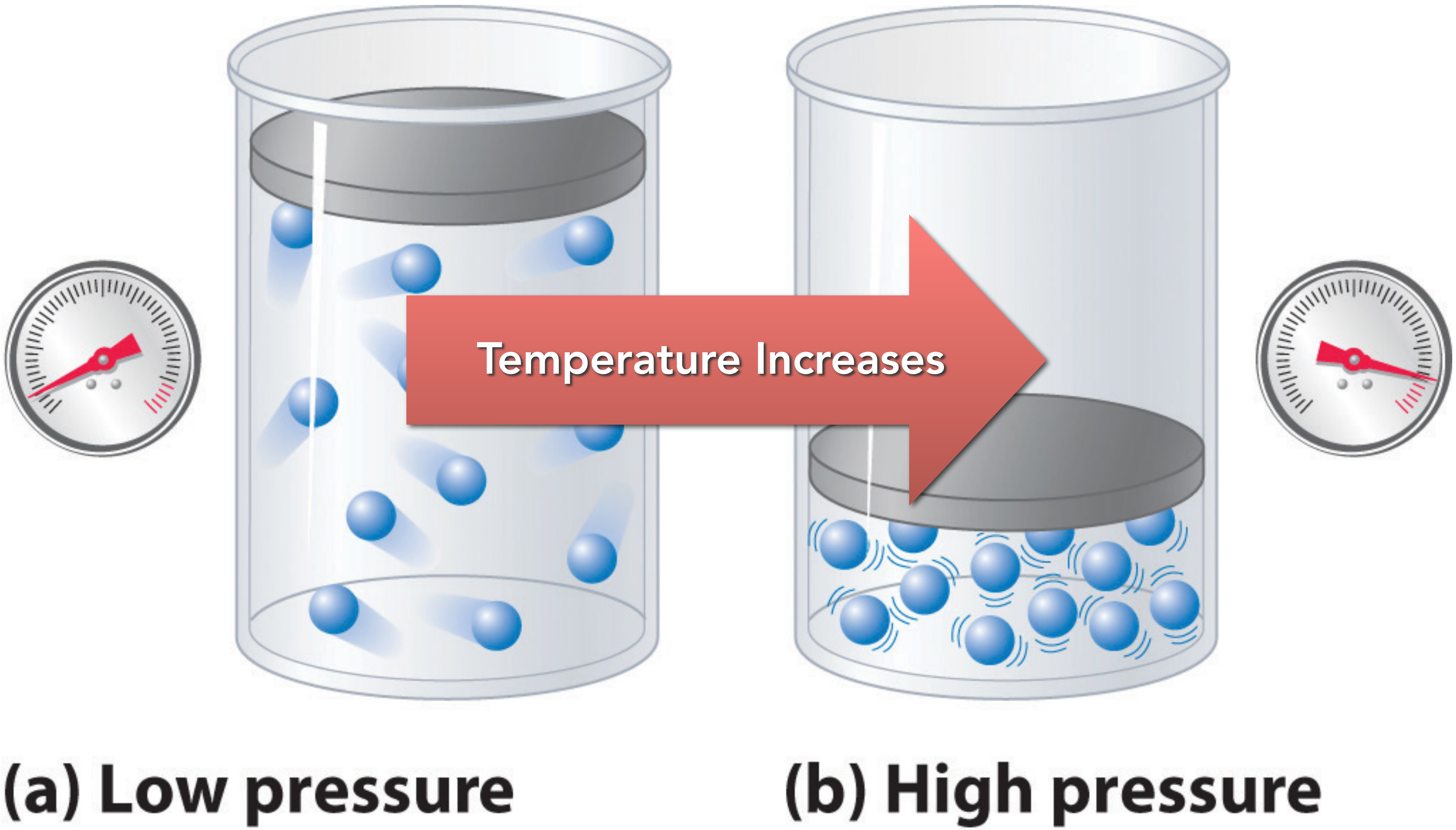
<u>Real Gases **behave** like Ideal Gases when</u>

High Temperature

Large Volume

Low Pressure

Pressure, Volume, and Temperature



Pressure, Volume, and Temperature

Your turn…

As temperature increases, what will happen to the pressure?

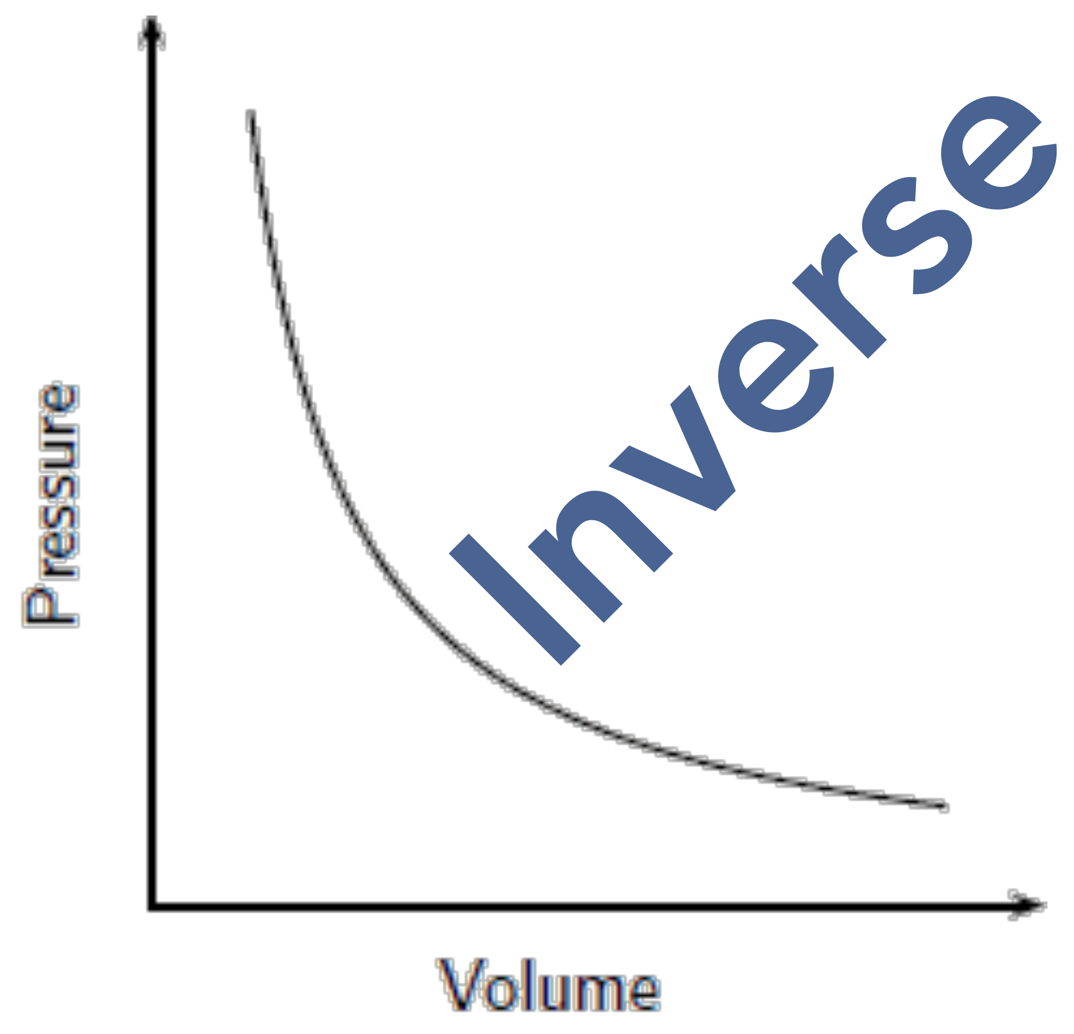
Increases

As temperature increases, what will happen to the volume?

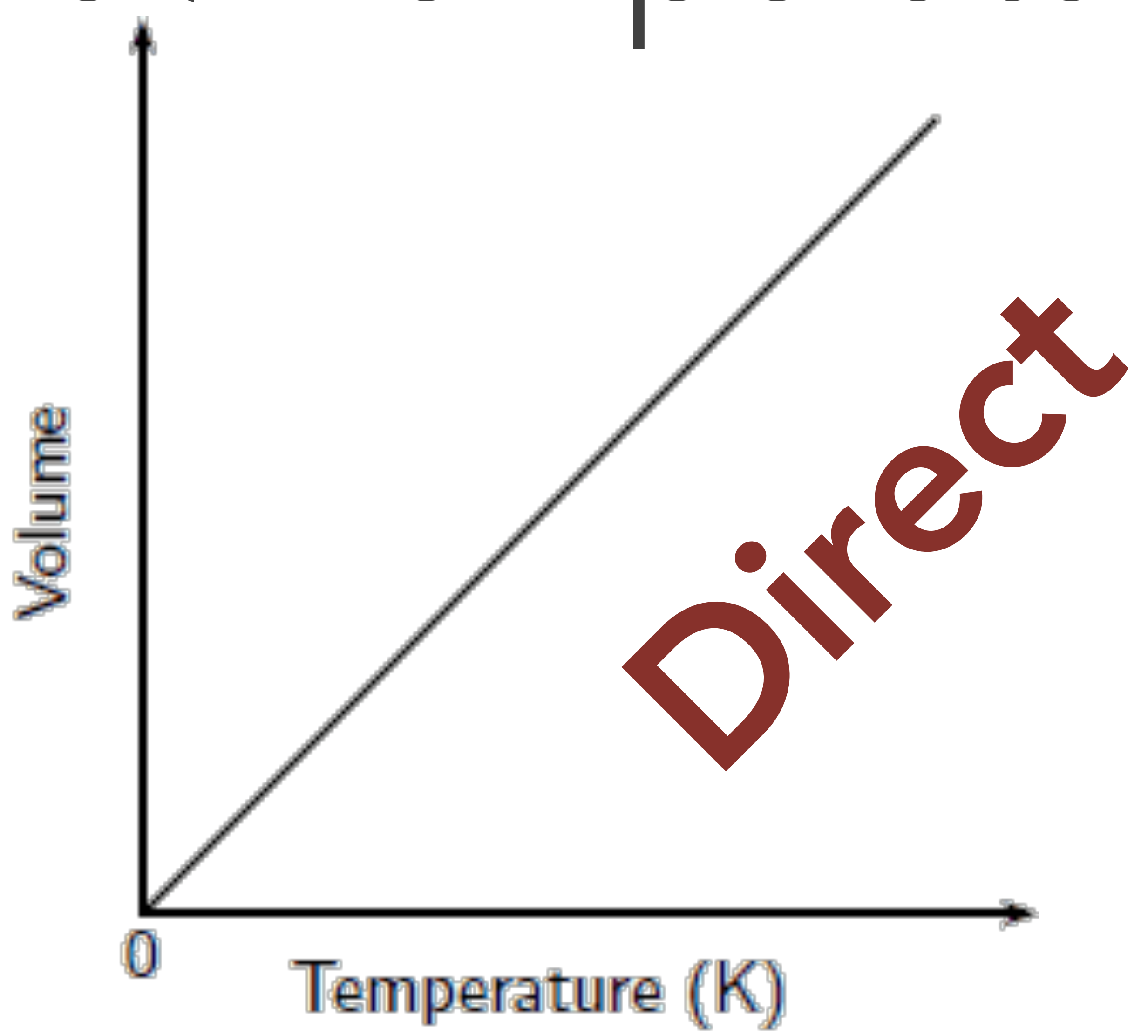
Increases

Gas Relationships

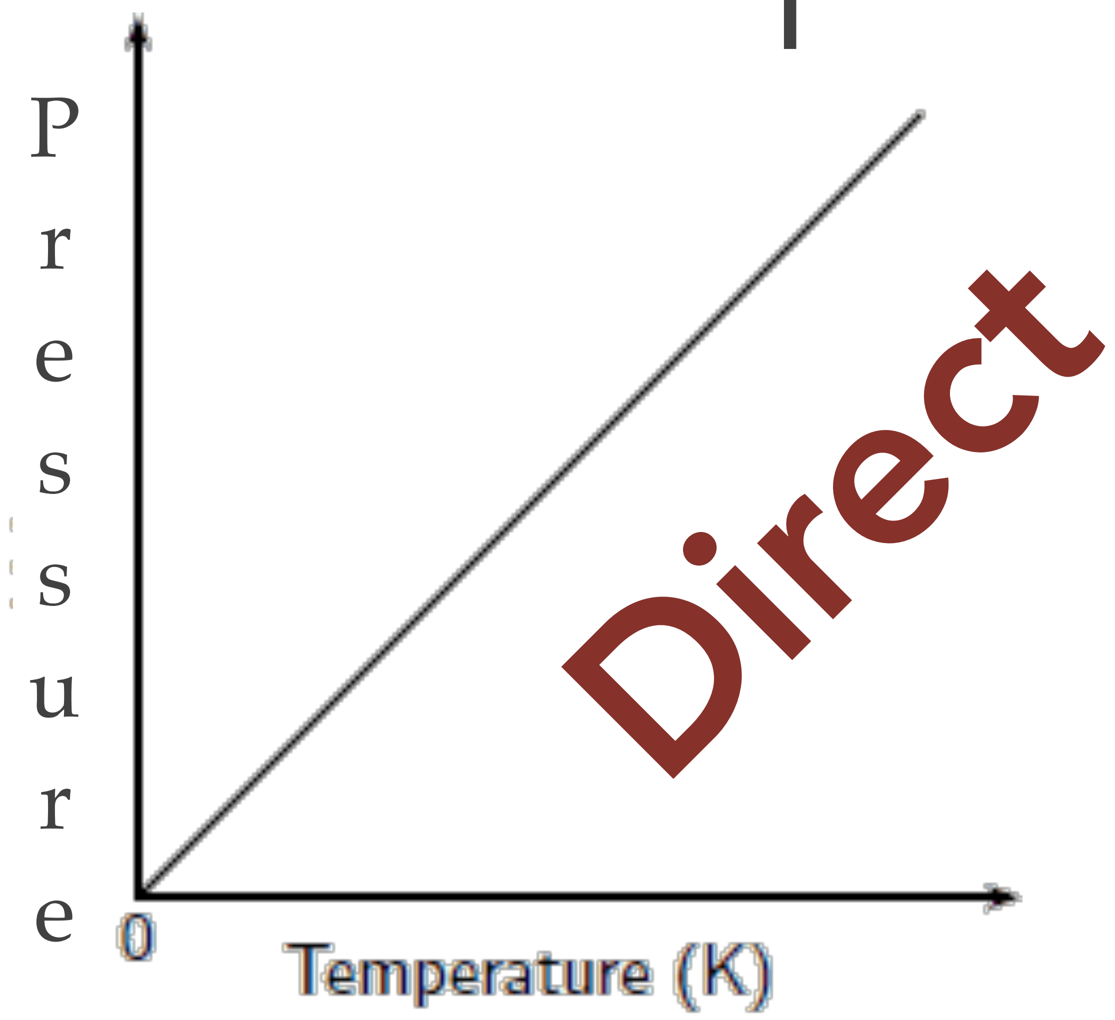
Pressure / Volume



Volume / Temperature



Pressure / Temperature



Combined Gas Law

Table T

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

P = pressure

V = volume

T = temperature (K)

Combined Gas Law

Table T

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

P = pressure

V = volume

T = temperature **(K)**

Example Problems

ESA Format

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Equation:

Substitute (with units):

Answer (with units):

A balloon at STP is compressed from 3 L to 2 L. The temperature is constant. What is the pressure?

Example Problems

ESA Format

Driving your car down the road, the temperature of your tires increase from 26°C to 38°C. While at constant volume, the pressure at 38°C is 350 kPa. What was the original pressure?

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Example Problems

ESA Format

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

As a balloon rises to the upper part of the atmosphere, the temperature, pressure, and volume change. The temperature at the surface is 25°C and in the upper atmosphere the temperature is -15°C. The pressure decreases from 1 atm to 0.45 atm. If the original volume is 2.75 L, what is the final volume?

Regents Practice

Which of the following can be compressed under pressure?

(1) $I_{2(s)}$ (2) $I_{2(l)}$

(3) $I_{2(g)}$ (4) $I_{2(aq)}$

A 100 milliliter sample of a gas is enclosed in cylinder under a pressure of 101.3 kPa. What volume would the gas sample occupy at a pressure of 202.6 kPa, temperature remaining constant?

(1) 50 mL (2) 100 mL (3) 200 mL (4) 380 mL

As the pressure on a given sample of a gas increases at constant temperature, the mass of the sample

(1) decreases

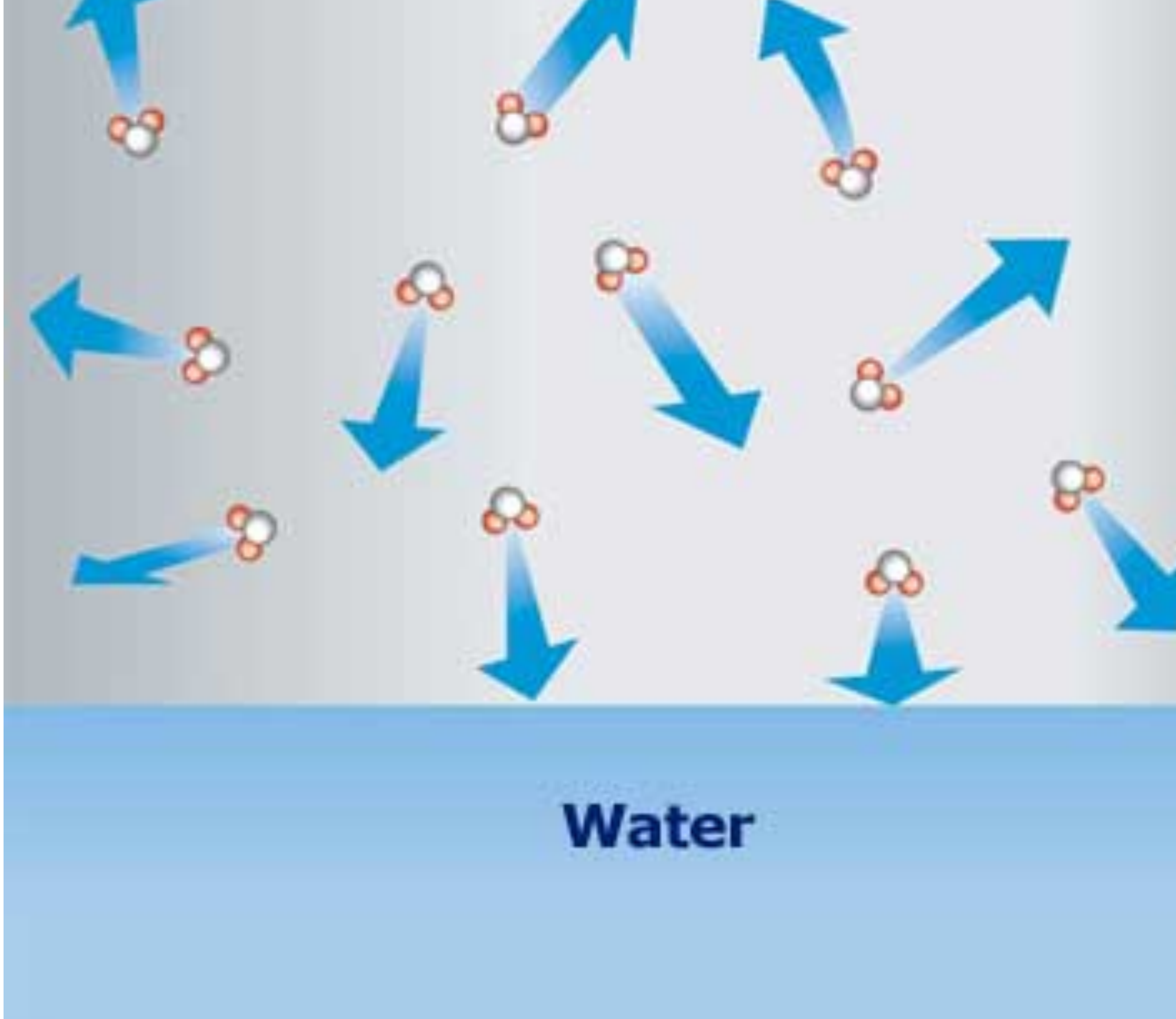
(2) increases

(3) remains the same

Vapor Pressure

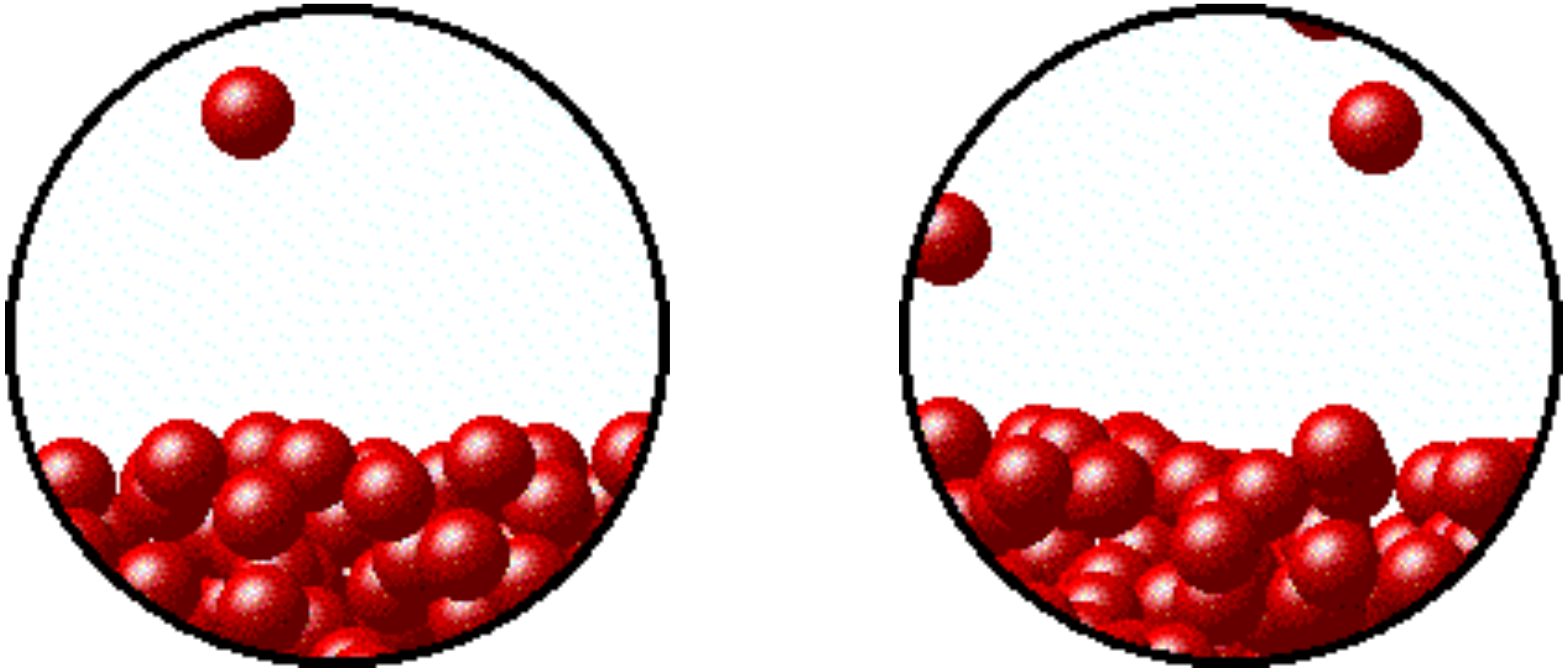
Topic 4

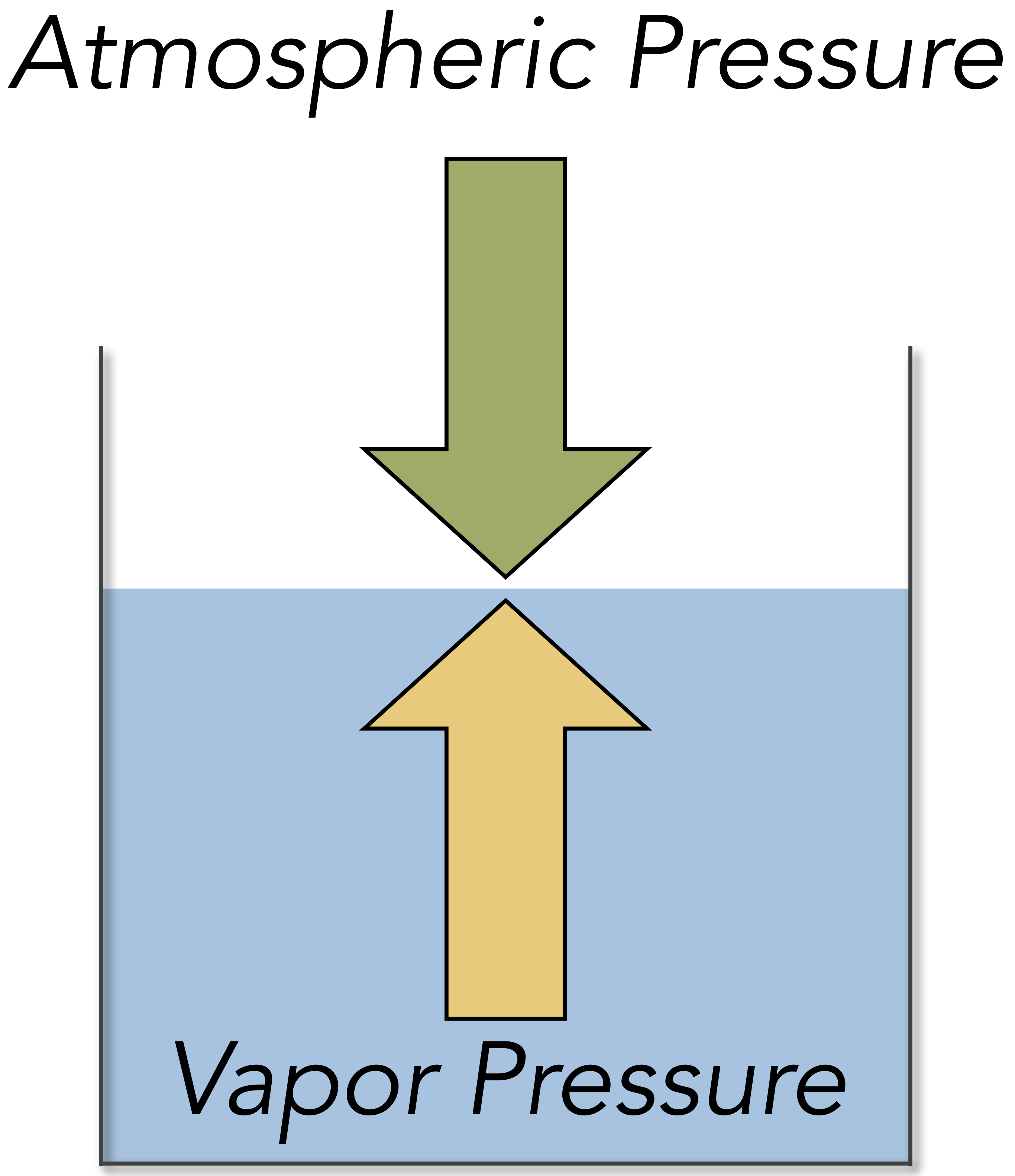
Station #8



Vapor Pressure *Table H*

Vapor pressure is a measure of the tendency of a material to change into the gaseous or vapor state, and it **increases** with temperature. (The temperature at which the vapor pressure at the surface of a liquid becomes equal to the pressure exerted by the surroundings is called the boiling point of the liquid.)





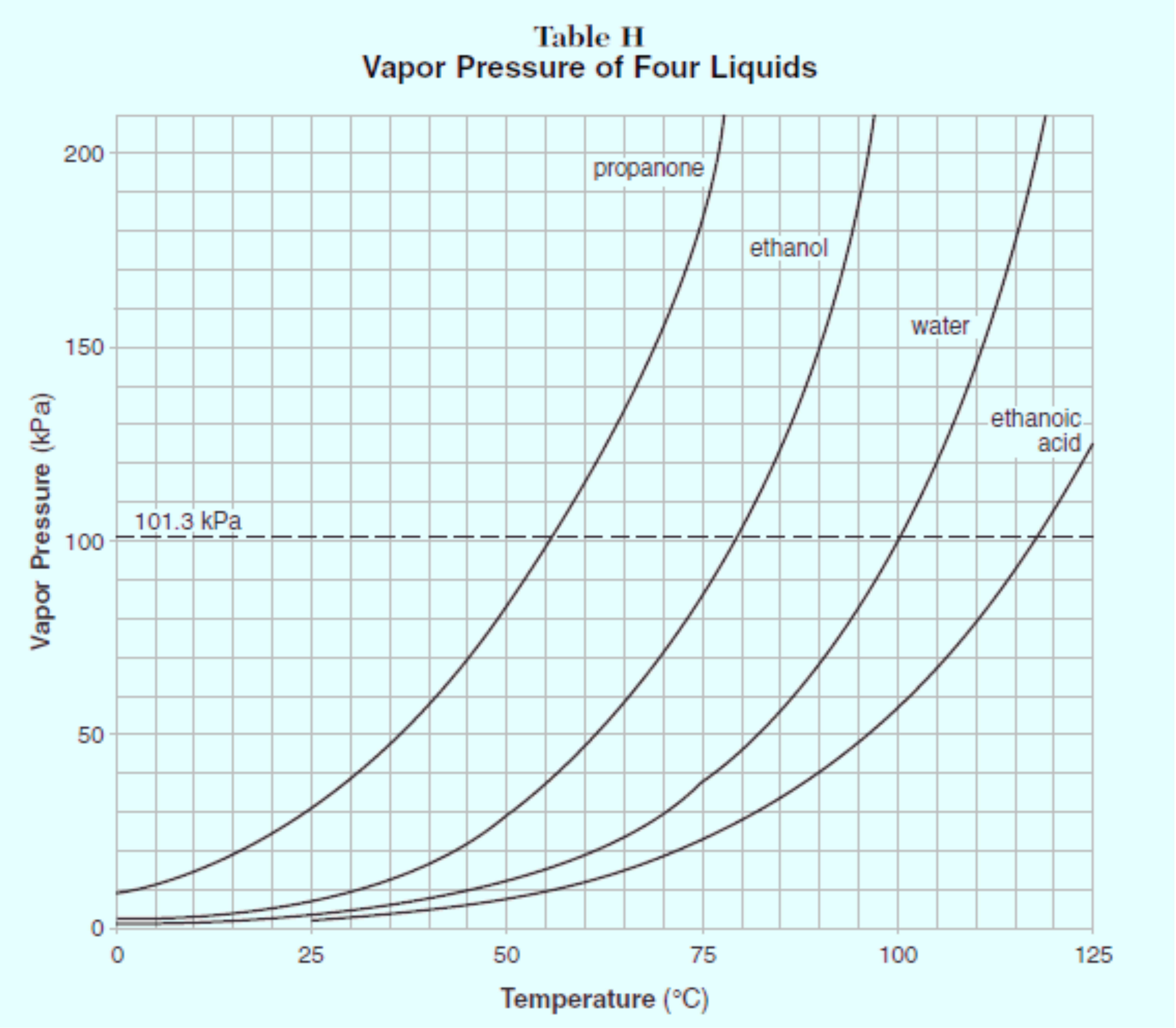
Vapor Pressure

Table H

H_2O VP @ BP?

Low Vapor Pressure = STRONG IMFs (ethanoic acid)

High Vapor Pressure = WEAK IMFs (propanone)



Regents Practice

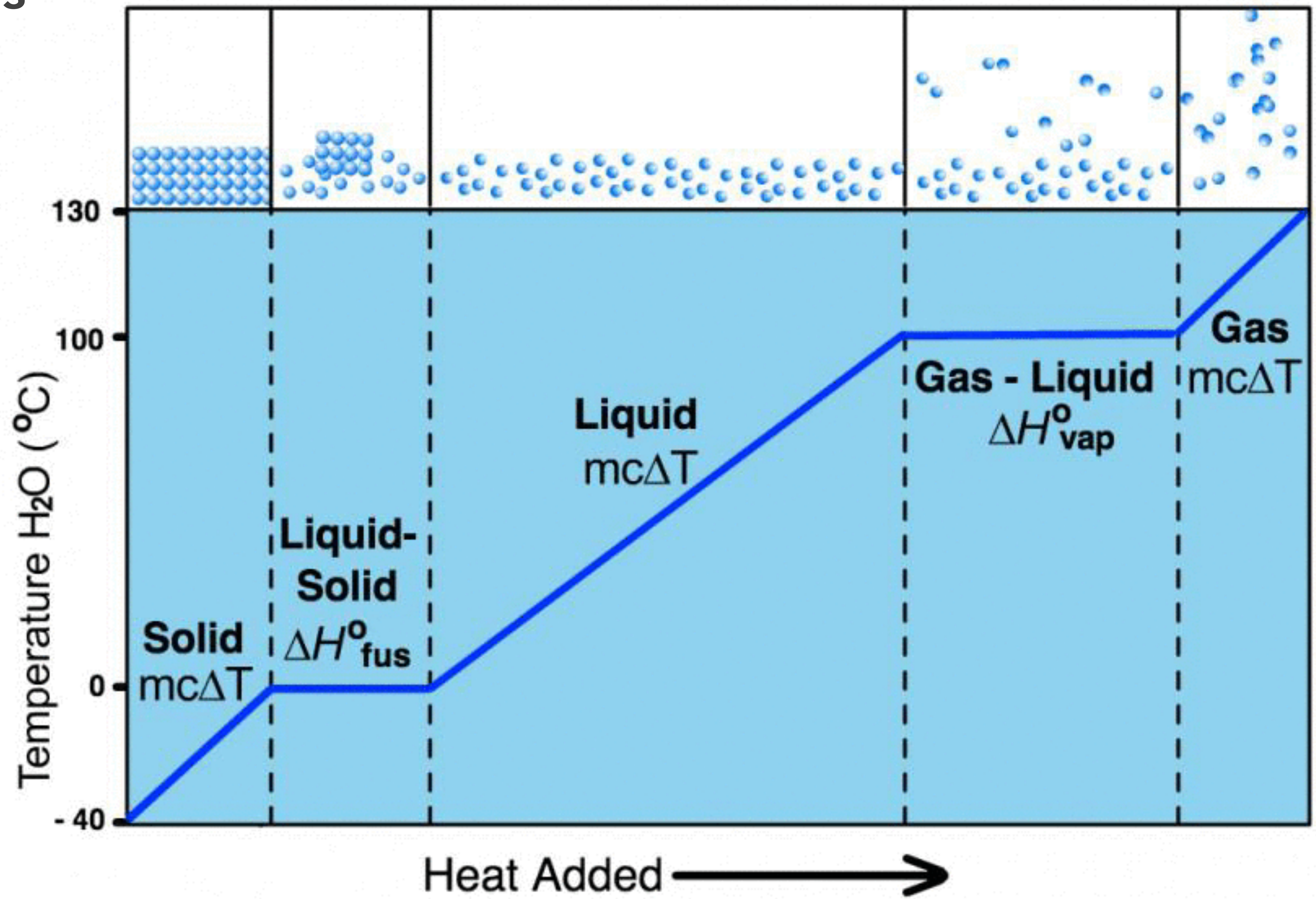
When the vapor pressure of a liquid in an open container equals the atmospheric pressure, the liquid will

(1) freeze (2) crystallize
(3) melt (4) boil

Phase Changes

Topic 5

Station #9



Things to Consider…

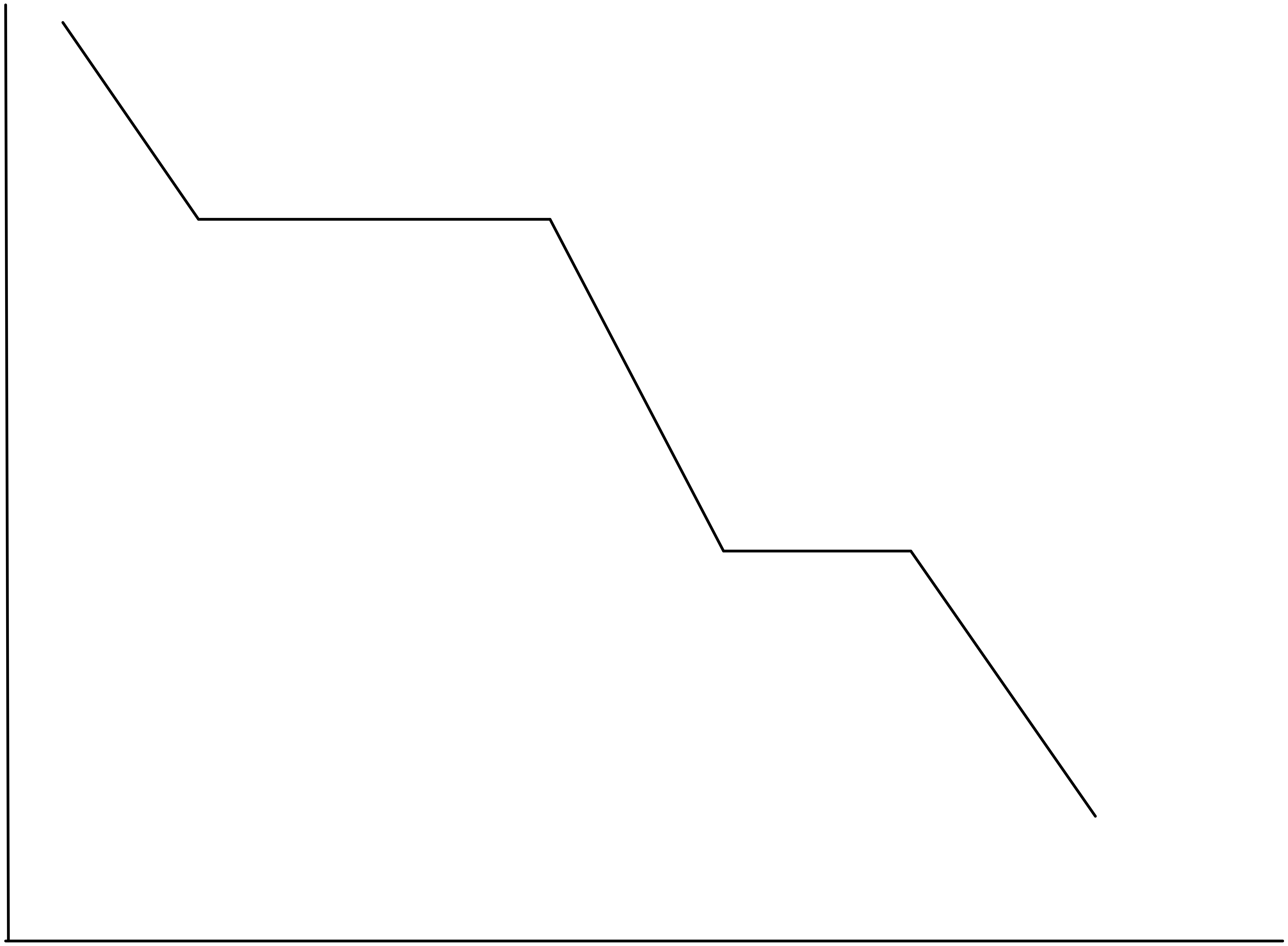
Horizontal (plateaus) = phase change

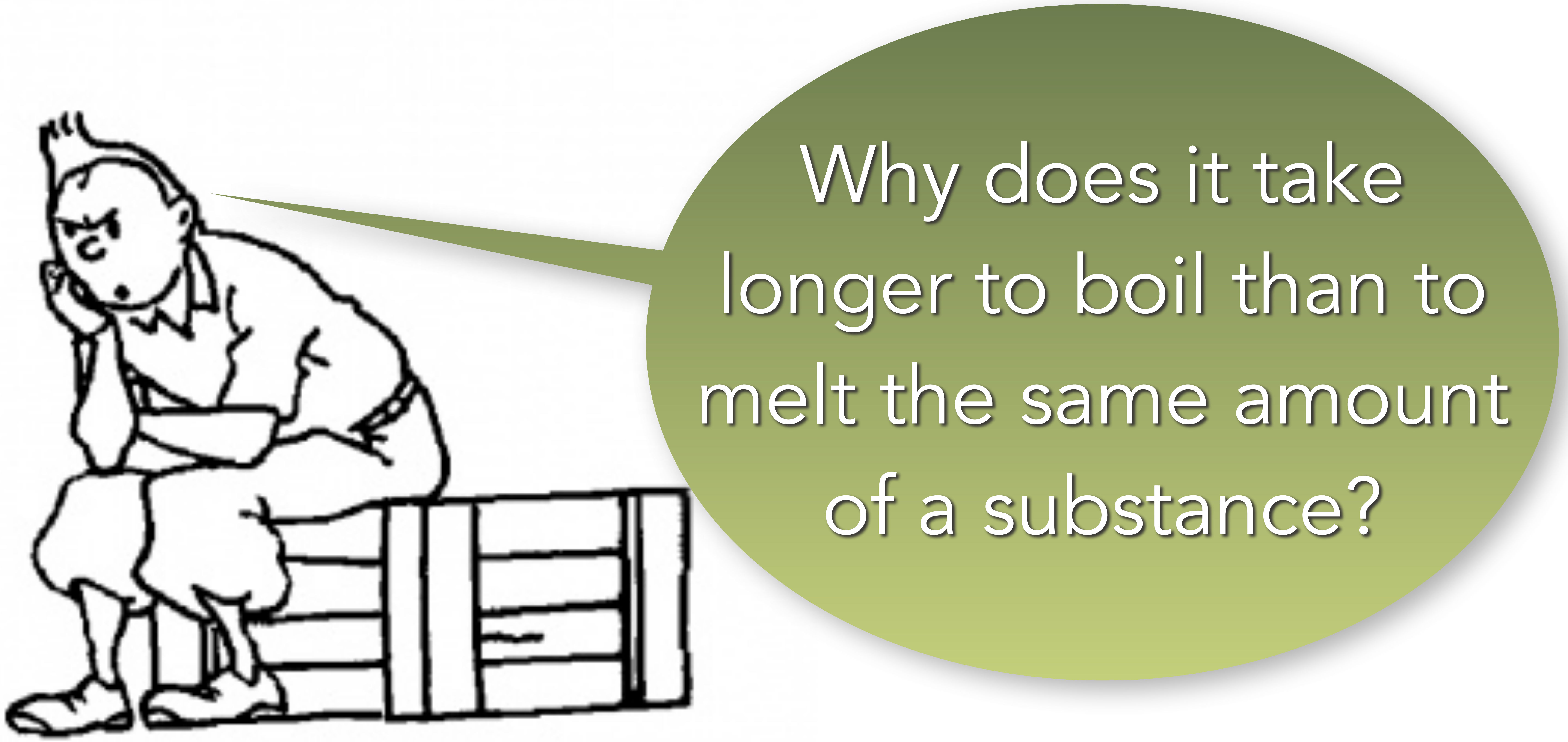
1. Melting (0˚C)
2. Boiling (100˚C)

Notice! Temperature remains constant during the phase changes!!

Cooling Curves

Fill this in!




Why does it take longer to boil than to melt the same amount of a substance?

Regents Practice

Which term represents the change of a substance from the solid phase to the liquid phase?

(1) condensation (2) vaporization

(3) evaporation (4) fusion

Which change of phase is exothermic?

(1) gas to liquid

(2) solid to liquid

(3) solid to gas

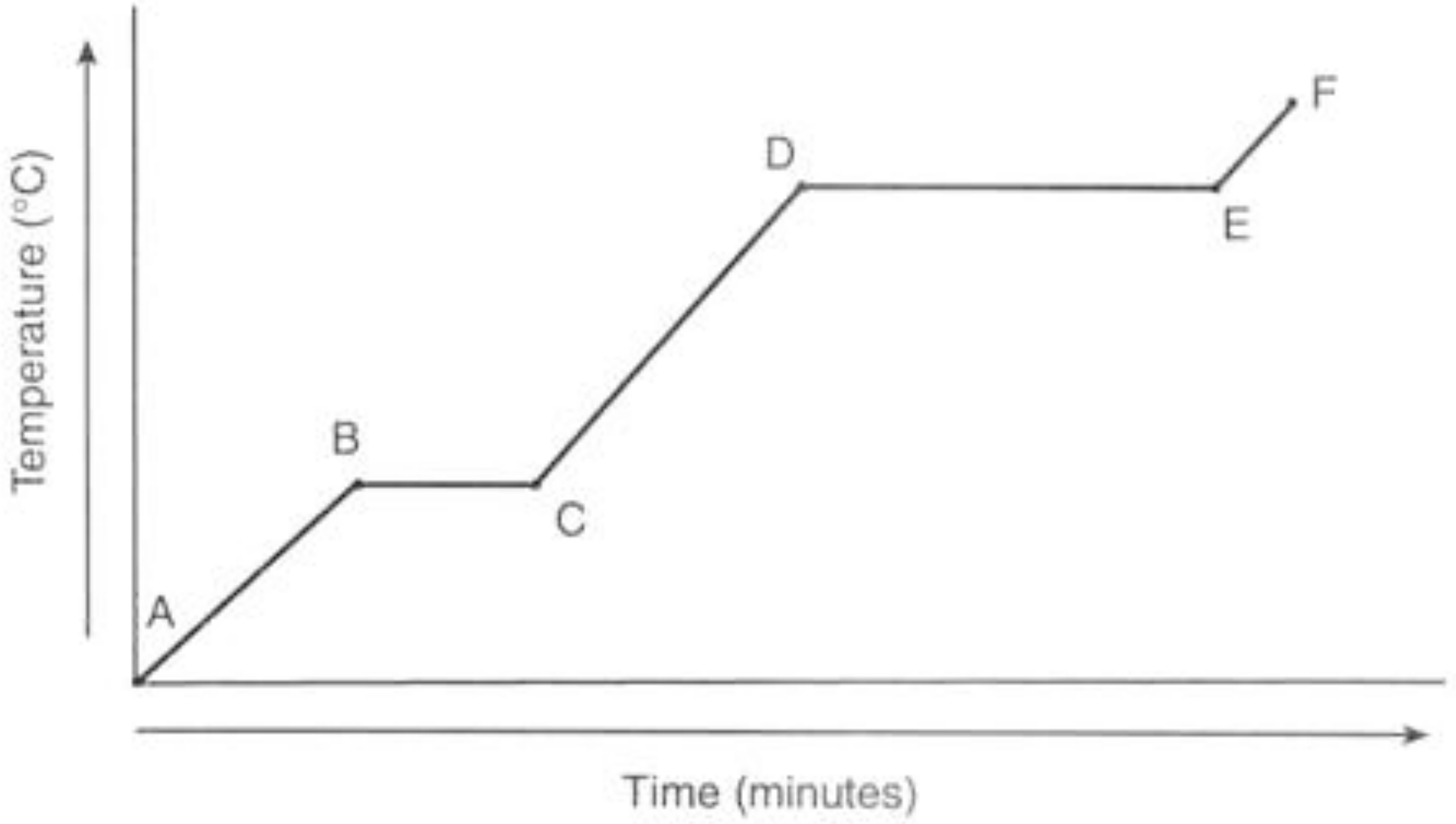
(4) liquid to gas

As ice melts at standard pressure, its temperature remains at 0°C until it has completely melted. Its potential energy

(1) decreases

(2) increases

(3) remains the same



1. Identify the process that takes place during line segment DE of the heating curve.

2. Identify a line segment in which the average kinetic energy is increasing.

Topic 1 - Particle Behavior in States of Matter

ESSENTIALS: Know, Understand, and Be Able To…

- ❑ The three phases of matter (solids, liquids and gases) have different properties.
- ❑ Use a simple particle model to differentiate among properties of solids, liquids, and gases (organization of matter and how they fill their containers).
- ❑ Describe the differences in the types of particle motion (vibrating, rotating and sliding) for the 3 phases.
- ❑ Describe which phases are described as "fluids," and explain what it means to be a fluid at the particle level
- ❑ Describe which phase is compressible, and explain why from a particle perspective.
- ❑ Temperature **is not** a form of energy. Temperature **is not** the same thing as "heat."
- ❑ The temperature of a sample of matter **is** determined by the amount of movement its particles have. More particle motion = higher temperature.
- ❑ **Kinetic energy** is energy due to the **motion** of the particles in a material. The particles in a sample of matter have three possible ways of moving: **vibrating** in place, **rotating** (spinning), and **sliding** past one another.
- ❑ **Potential energy** is energy that is **"stored"** in a material, the amount of which is determined by the **structure** of the particles and/or their **positions** relative to each other.
- ❑ **Absolute zero** is the temperature at which all particle motion ceases (kinetic energy becomes zero); this is therefore the lowest possible temperature in the universe.
- ❑ Chemists primarily use the **Celsius and Kelvin temperature scales**.
- ❑ **Convert** temperatures in Celsius degrees (^oC) to Kelvin (K), and Kelvin to Celsius.

TEXT REFERENCES: p. 385-396

Topic 2 - Particle Attractions (IMFs)

<u>ESSENTIALS:</u> Know, Understand, and Be Able To…

- ❑ How particles are arranged (what phase they are in) is dependent on their energy and the effect this has on their attractions for each other.
- ❑ As particles gain energy, the attractions between them decrease.
- ❑ The strength of attractions between particles can be evaluated based on the property of viscosity.
- ❑ Viscosity is a property related to how easily a liquid pours, or flows.

<u>TEXT REFERENCES:</u> p. 385-396

Topic 3 - Kinetic Molecular Theory & Gases

<u>ESSENTIALS:</u> Know, Understand, and Be Able To…

- ❑ Kinetic molecular theory describes the relationships of pressure, volume, temperature, velocity, and frequency and force of collisions among gas molecules.
- ❑ Pressure is force per area.
- ❑ Convert units of pressure from atmospheres to mmHg to kiloPascals. Be familiar with others, including torr and lb/in^2 (aka "psi").
- ❑ Explain the source of atmospheric pressure, why it changes with elevation, and how it is measured (barometers).
- ❑ Explain the source/cause of P, V, and T for gases, using KMT (Kinetic Molecular Theory)
- ❑ Explain various phenomena from a KMT perspective (factors affecting rate of evaporation, effect of changes in P and T on gas volume, expansion of hot air balloons with increasing elevation in the atmosphere

<u>TEXT REFERENCES:</u> p. 413-429

Topic 4 - Vapor Pressure

ESSENTIALS: **Know, Understand, and Be Able To…**

- ❑ Explain the source of vapor pressure, what conditions must be met in order to measure it, and why it always increases with temperature.
- ❑ The strength of attractions between particles can be evaluated based on the property of vapor pressure.
- ❑ Use Table H in order to determine normal and reduced pressure boiling point temperatures and relative strengths of the particle attractions for the four liquids.

TEXT REFERENCES: p. 413-429

Topic 5 - Heating Curves

ESSENTIALS: **Know, Understand, and Be Able To…**

- ❑ The strength of attractions between particles can be evaluated based on properties such as melting and boiling points, heat of fusion and heat of vaporization, vapor pressure and viscosity.
- ❑ The structure and arrangement of particles and their interactions determines the physical state of a substance at a given temperature and pressure.
- ❑ Phase changes are physical changes.
- ❑ Phase changes can be either exothermic or endothermic.
- ❑ Explain phase change in terms of the changes in particle energy and attractions.
- ❑ Distinguish between endothermic and exothermic phase changes, by writing "heat energy" correctly into a phase change equation, or by using experimental data.
- ❑ The concepts of kinetic and potential energy can be used to explain physical processes that include: fusion (melting), solidification (freezing), vaporization (boiling, evaporation), condensation, sublimation and deposition.
- ❑ Interpret heating or cooling curves in order to determine melting/boiling points, energy absorption as KE or PE, particle movement, arrangement and interactions.

TEXT REFERENCES: p. 523, 385-396, 413-429