Particle Behavior in States of Matter
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

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

Heat

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

Temperature
Which has more Heat? Higher Temperature?
Measuring Temperature

How do we measure Temperature?

- Kelvin scale
  - 373 K
  - 100 degree intervals
  - Water boils

- Celsius scale
  - 100°C
  - 100 degree intervals
  - Normal body temperature

- Fahrenheit scale
  - 212°F
  - 180 degree intervals
  - Water freezes

Heat is a form of energy produced by molecular motion. Temperature is a measurement of energy and is NOT a form of energy.
Can there be a temperature lower than 0°C? **YES**
The Kelvin Scale

373 K : (100°C) BP of H₂O

273 K : (0°C) FP/MP of H₂O

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 =
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
Intermolecular Forces (IMFs)

**IMFs** - attraction between particles
As heat is **removed** from a gas,

- **Particle Attraction** increases.
- **Particle Speed** and **Average Kinetic Energy** decrease.

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

- **Particle Attraction** decreases.
- **Average Kinetic Energy** increases.
- **Particle Speed** increases.
Viscosity

Resistance to Flow

Decreasing Heat (Increase IMF)
Which of the following has the strongest forces of attraction?

1. CO₂(s)  (3) CO₂(g)
2. CO₂(l)  (4) CO₂(aq)
Behavior of Gases

Topic 3

Crush Orange

12 FL OZ (355 mL)
Kinetic Molecular Theory (KMT)

Moving Molecules!!

- *Random, continuous motion*
- Volume is *negligible*
- NO attractive forces
- Elastic collisions

IDEAL GASES

High Temperature
Large Volume
Low Pressure

*very small* particles
Pressure

PSI - pounds per square inch

- Gas molecules hitting the walls of a container... that’s Pressure!

Elastic Collisions

No energy is lost after the collision.
Real Gases

Have Mass

Have Attractive Forces

Ideal Gases act like real gases at high temperature and pressure!
Temperature Increases

(a) Low pressure  (b) High pressure
Pressure, Volume, and Temperature

Your turn…

As temperature increases, what will happen to the pressure?

As temperature increases, what will happen to the volume?
Gas Relationships

Pressure / Volume

Volume / Temperature

Pressure / Temperature

Inverse

Direct

Direct
Combined Gas Law

Table $T$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$P = \text{pressure}$

$V = \text{volume}$

$T = \text{temperature (K)}$
Combined Gas Law

\[
\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}
\]

\(P = \text{pressure}\)

\(V = \text{volume}\)

\(T = \text{temperature (K)}\)
Example Problems

ESA Format

\[ \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \]

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

Equation:
Substitute (with units):
Answer (with units):
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?

\[
\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}
\]
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?

\[ \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \]
Which of the following can be compressed under pressure?
(1) I₂(s)  (2) I₂(l)
(3) I₂(g)  (4) I₂(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