

Representation of Behavior of Gases through Action Models

Lesson's Curriculum Standard/Element

SC5. Obtain, evaluate, and communicate information about the Kinetic Molecular Theory to model atomic and molecular motion in chemical and physical processes.

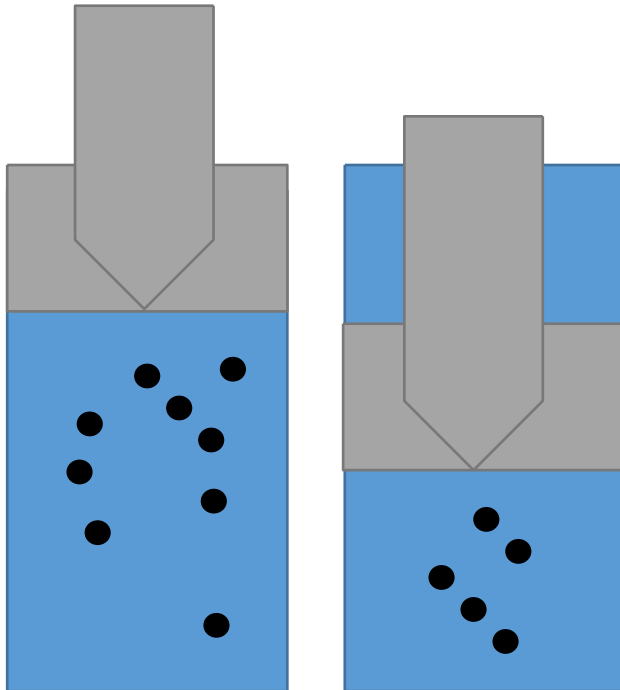
SC5c. Develop and use models to *quantitatively, conceptually, and graphically represent* the relationships between pressure, volume, temperature, and number of moles of a gas.

Lesson's Learning Objectives

1. To distinguish between Conceptual, Quantitative, and Graphical representations
2. To enumerate the postulates of Molecular Kinetic Theory
3. To use syringe as an action model (by Guided Practice) to construct conceptual, quantitative, and graphical representations of the Pressure-Volume relationship of an ideal gas
4. To use balloon and water at different temperature as an action model (Collaborative Practice) to construct conceptual, quantitative, and graphical representations of Volume-Temperature relationship of an ideal gas.
5. To use Popping of Popcorn at different temperatures as an action model (Collaborative Practice) to construct conceptual, quantitative, and graphical representations of the Pressure-Temperature relationship of an idea gas
6. To correlate the outcome of action models with the Standardized gas laws, namely, Boyle's Law, Charles' Law, and Gay-Lussac's Law (Independent Practice).
7. To derive the Combined Gas Law form Boyle's Law, Charles' Law, and Gay-Lussac's Law (Independent Practice)
8. To analyze molar content in different scenarios of gaseous temperature, pressure, and volume and evaluate the correctness of the Avogadro's Law

Bell-Ringer

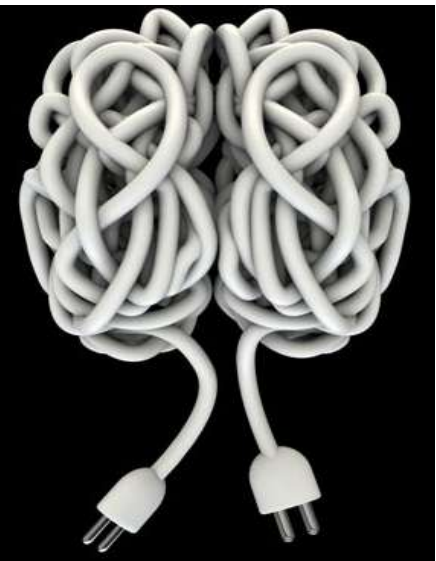
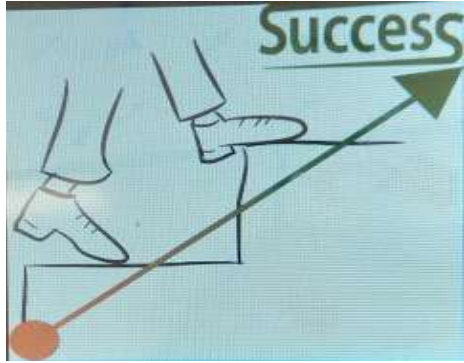
1. Find the error in the following diagram



2. Which of the following gases will have molecules that move the fastest?

1. H_2
2. O_2
3. Cl_2
4. CO_2

How would you call these representations as?



What would you call these representations each as?

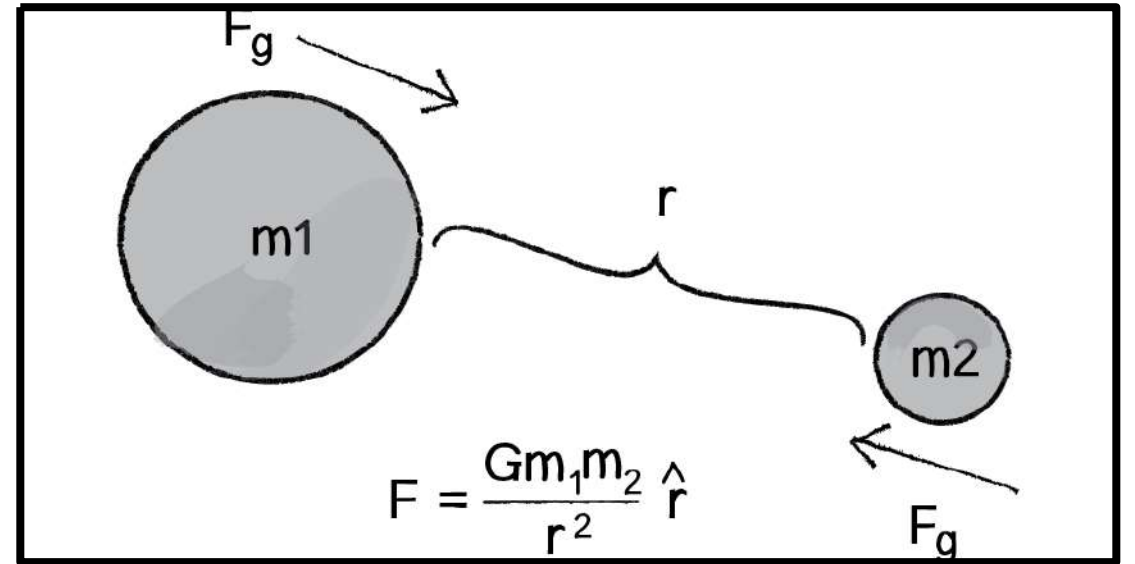
$x < 100$

$Y > 100$

$100 < x < 200$

$\Pi = 3.4$

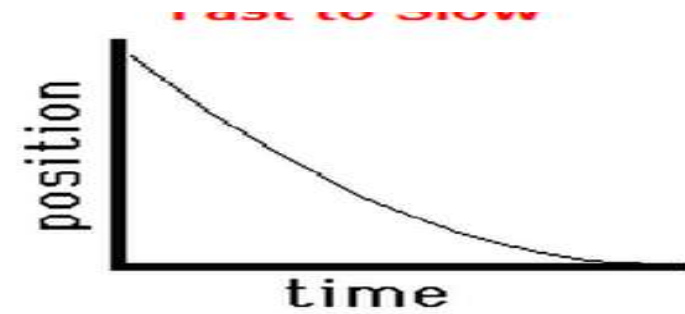
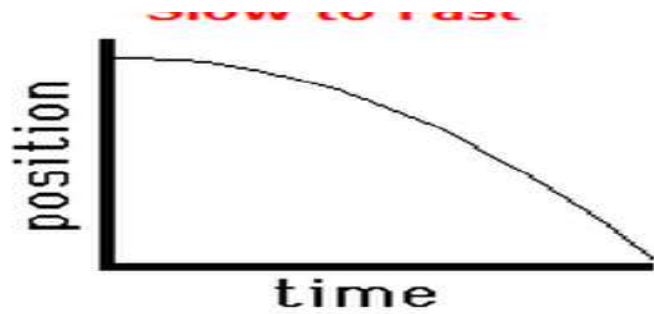
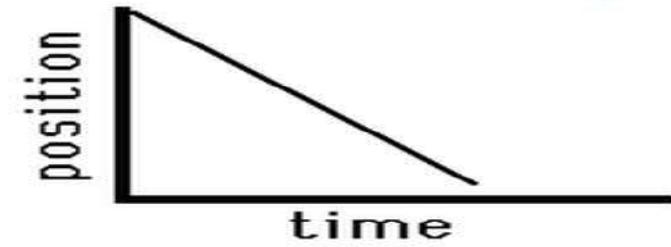
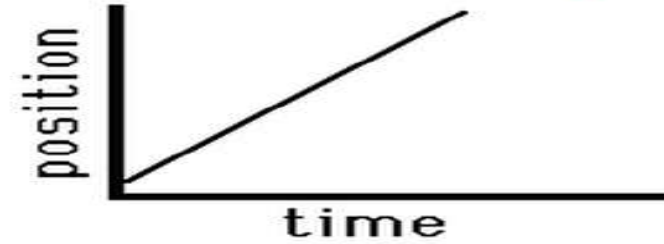
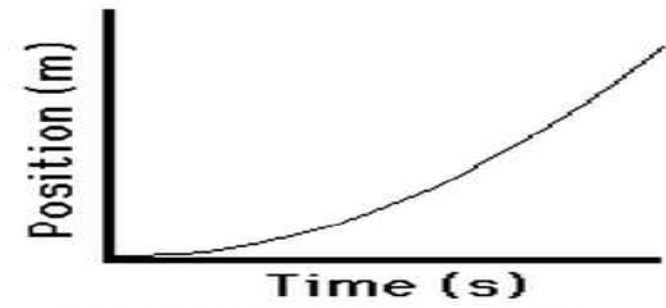
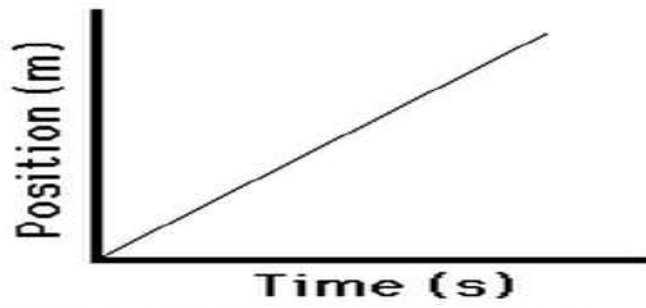
$E = mc^2$



Road Symbols are:

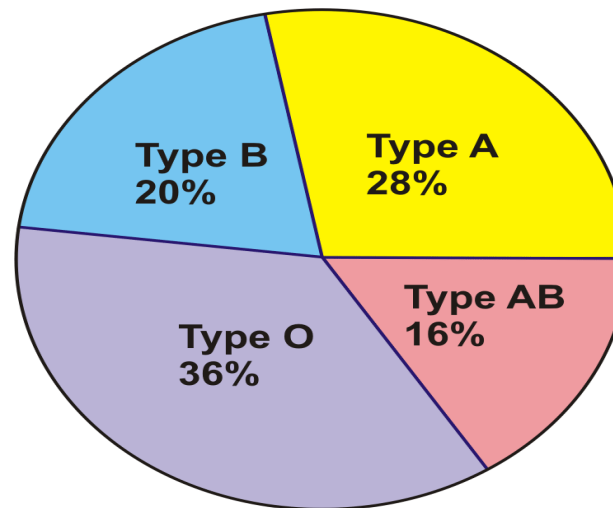
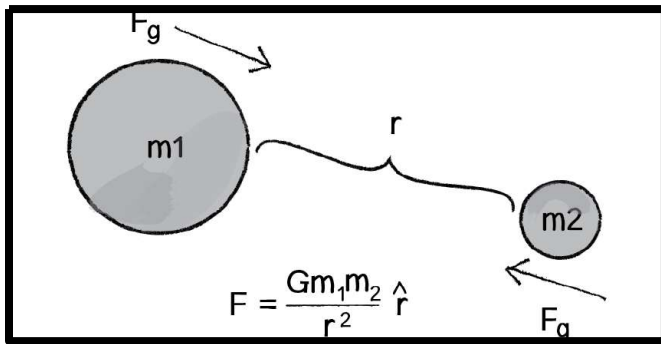
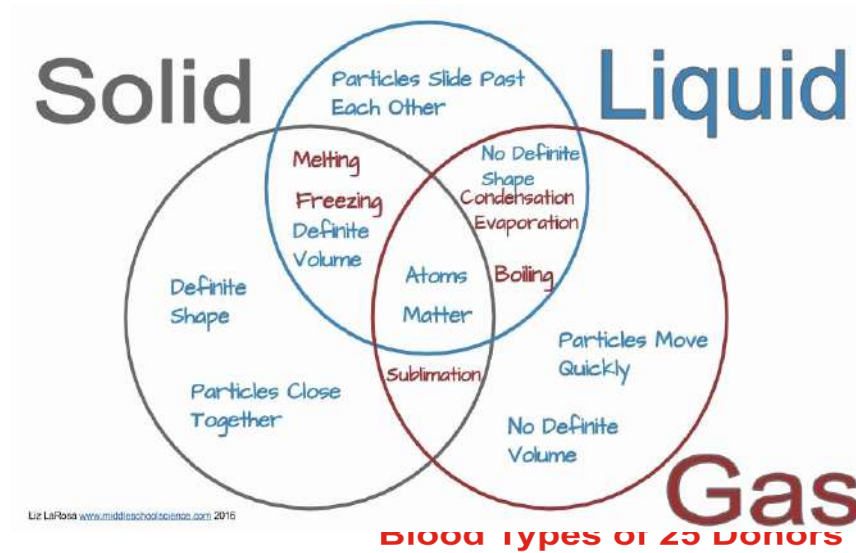
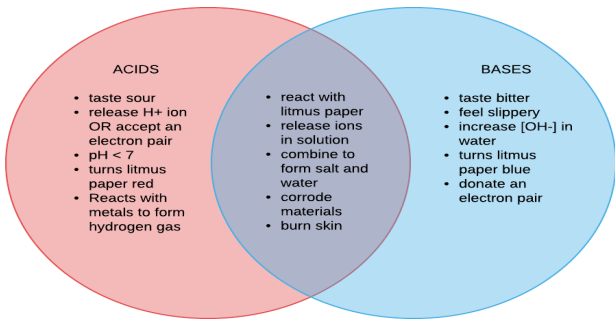
- (1) Purely conceptual;
- (2) Mostly conceptual but quantitative as well;
- (3) Purely quantitative





What would you call these representations each as?

What would you call these representations each as?



EXTREME CITY SPORTS INFOGRAPHICS



SKATEBOARDING

AVERAGE
557
people

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EXTREME CITY SPORT GRAPH



MORE THAN
8900
ACCIDENTS

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MAP INFOGRAPHICS



ROLLERBLADING



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CYCLING

AVERAGE
44%
bicycles

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PARKOUR



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EXTREME CITY SPORTS ICONS SET



What would you call this representation as?





Kinetic Molecular Theory

Postulates of the Kinetic Molecular Theory of Gases

- 1. Gases consist of tiny particles (atoms or molecules)**
- 2. These particles are so small, compared with the distances between them, that the volume (size) of the individual particles can be assumed to be negligible (zero).**
- 3. The particles are in constant random motion, colliding with the walls of the container. These collisions with the walls cause the pressure exerted by the gas.**
- 4. The particles are assumed not to attract or to repel each other.**
- 5. The average kinetic energy of the gas particles is directly proportional to the Kelvin temperature of the gas**

James Clerk Maxwell: Scottish Scientist, Mathematical Physics: Interesting Personality

Source: Wikipedia

As a great lover of Scottish poetry, Maxwell memorized poems and wrote his own. The best known is *Rigid Body Sings*, closely based on "Comin' Through the Rye" by Robert Burns, which he apparently used to sing while accompanying himself on a guitar. It has the opening lines

Gin a body meet a body
Flyin' through the air.
Gin a body hit a body,
Will it fly? And where?

A collection of his poems was published by his friend Lewis Campbell in 1882.

Descriptions of Maxwell remark upon his remarkable intellectual qualities being matched by social awkwardness.

Maxwell was an evangelical Presbyterian and in his later years became an Elder of the Church of Scotland. Maxwell's religious beliefs and related activities have been the focus of a number of papers.

The extent to which Maxwell "ploughed up" his Christian beliefs and put them to the intellectual test, can be judged only incompletely from his writings. But there is plenty of evidence, especially from his undergraduate days, that he did deeply examine his faith. Certainly, his knowledge of the Bible was remarkable, so his confidence in the Scriptures was not based on ignorance.

Maxwell was fascinated by geometry at an early age, rediscovering the regular polyhedra before he received any formal instruction. Despite winning the school's scripture biography prize in his second year, his academic work remained unnoticed until, at the age of 13, he won the school's mathematical medal and first prize for both English and poetry

Maxwell's interests ranged far beyond the school syllabus. He wrote his first scientific paper at the age of 14. In it, he described a mechanical means of drawing mathematical curves with a piece of twine, and the properties of ellipses, Cartesian ovals, and related curves with more than two foci.

Along with most physicists of the time, Maxwell had a strong interest in psychology

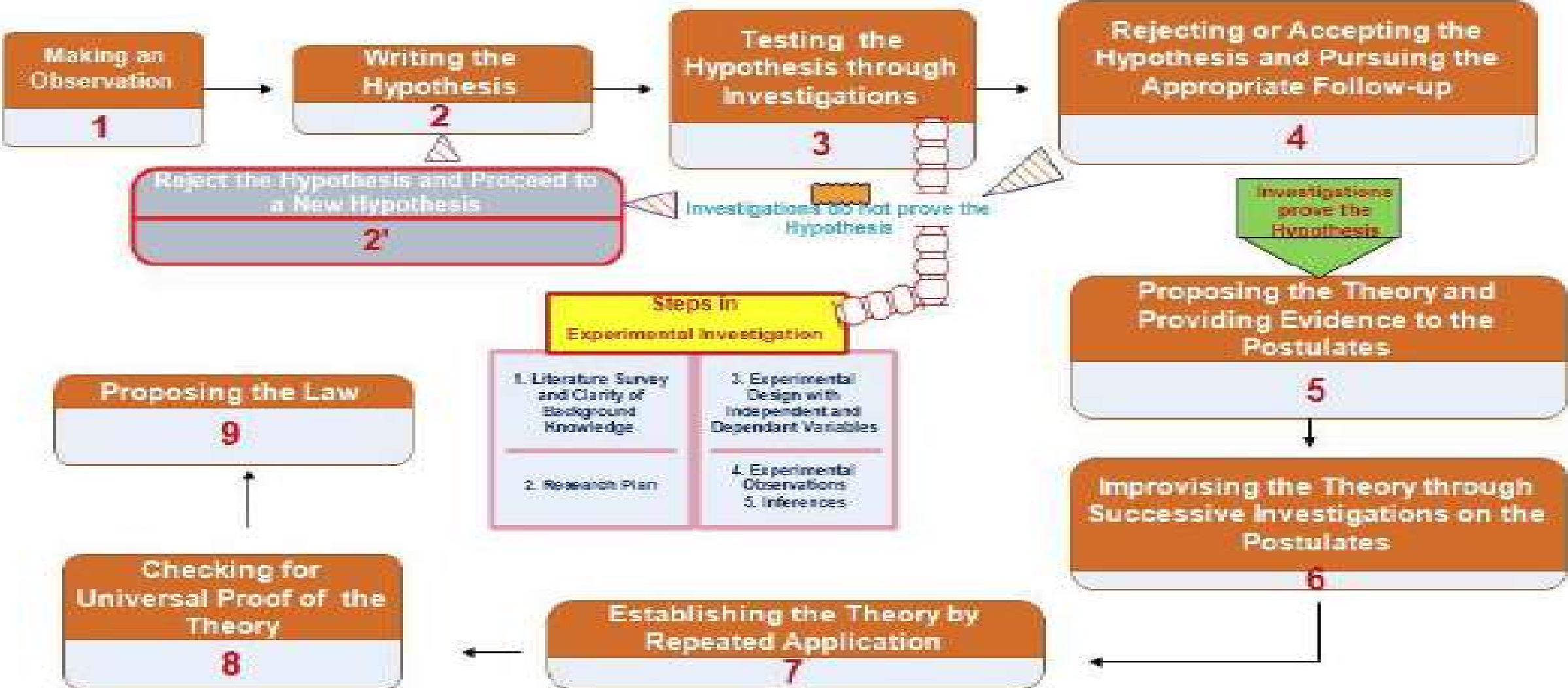
Behavior of Gases is governed by GAS LAWS

- Boyle's Law
- Charles' Law
- Gay-Lussac's Law
- Combined Gas Law
- Avogadro's Law

By using the models you develop, you will construct these gas laws and then verify the correctness of the laws proposed by you by comparison with the Standardized Laws proposed by the respective scientists.

Let us recall the Scientific Method: Observation is the foremost thing: So let us perform a relevant activity and make some useful observations.

The Scientific Method



**Developing certain action
models to explore the four
important properties of gases:
Volume, Pressure, Temperature,
and Number of Molecules**

I. Pressure and Volume: Guided Practice: Syringe as an Action Model

Syringe is made of the piston (inner – moving part) and the drum (outer stationary part)

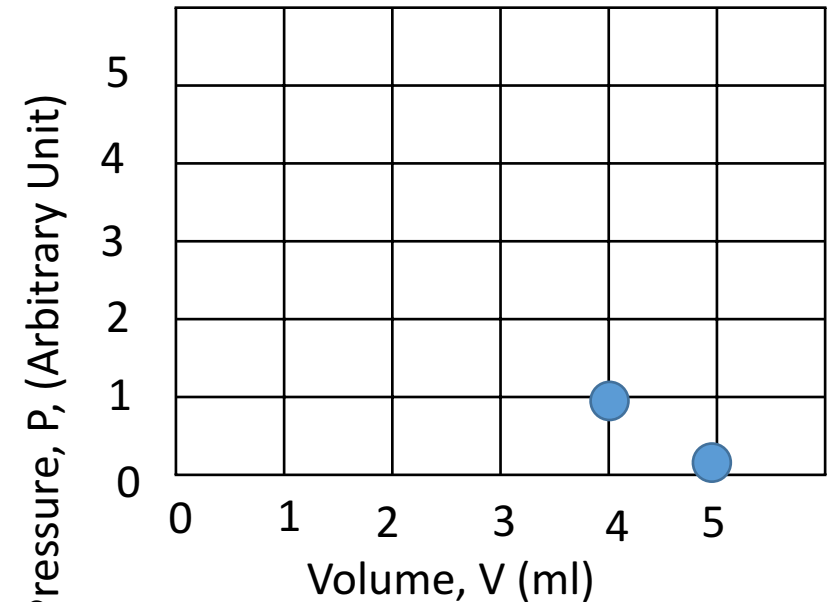
(1) Keep the piston at reading 5. This means volume is 5 ml and you have not applied any pressure yet. Record the Pressure (0) and Volume (5) in the Data Chart. Note volume is ml. For pressure, we are going to keep the unit as arbitrary unit as we do not exactly how many Pascals of pressure it is (Pascal is the unit of Pressure)

(2) Now move the piston inward at definitive intervals and note down the volume. You can move the piston in 1 ml installments or you can even choose smaller dimensions . For every installment of piston movement, note down the pressure and volume in the data chart.

(3) Then plot a graph for the dependence of volume on pressure.

Table 1. Pressure and volume data from syringe activity. Follow up to fill-in data

P, arbitrary unit	V, ml
0	5
1	4



Using balloon and hot water as an action model to explore the relationship between Volume and Temperature at Constant Pressure: Collaborative Practice

What type representation(s) have you now developed for the relationship between P and V?

Graphical
Conceptual
Quantitative

You are now given a craft stick, how would you like to represent P and V relationship on it?

Use Seesaw as a medium to develop a conceptual model for the relationship between P and V



What type of representation is this?

Comment on the graph's slope

How is P related V? Fill in the blanks

P is inversely proportional to V

Write a proportional relationship using the proportional symbol, \propto

$$P \propto \frac{1}{V}$$

We can convert the proportional relationship into a mathematical equation by introducing a proportionality constant

$$P = \frac{\text{Constant}}{V}$$

Analogy

$3 = 21/7$
Or
$3 \times 7 = 21$

Rewriting, we get (fill-in the blank)

$$\dots\dots\dots = \text{Constant}$$

Since we used the syringe in only one temperature, Temperature was a constant entity; therefore, we can write, At constant temperature,
 $PV = \text{Constant}$



II. Using Balloon and Water at different temperatures an action model to represent the relationship between volume and temperature: Collaborative Practice

Determine the diameter of the balloon at different temperatures. You are given hot water at three different temperatures and cold water. In addition, measure the diameter of the balloon at room temperature. The diameter of the balloon is an indirect measure of the volume of the balloon. Report this in cm

Remember to measure the temperature using thermometer. Remember to convert the temperature from degree Celsius to Kelvin by adding 273.

Fill in the data in the data chart and draw the graph.

Table 2. Volume and Temperature data from balloon activity.

T, K	Diameter, cm

Comment on the graph's slope

How is V related T? Fill in the blanks

V is ----- proportional to T

Write a proportional equation using the proportional symbol, \propto

Using Balloon and Hot Water as an action model to explore the relationship between Volume and Pressure at Constant Temperature.

What type representation(s) have you now developed for the relationship between P and V?

Graphical
Conceptual
Quantitative

You are now given a craft stick, how would you like to represent V and T relationship on it?

Use Seesaw as a medium to develop a conceptual model for the relationship between V and T



What type of representation is this?

Comment on the graph's slope

How is V related T? Fill in the blanks

V is proportional to T

Write a proportional relationship using the proportional symbol, \propto

We can convert the proportional relationship into a mathematical equation by introducing a proportionality constant

Rewriting, we get (fill-in the blank)

= Constant

Since we used the same balloon filled with a constant amount of air, the pressure was a constant entity; therefore, we can write, At constant Pressure,

= Constant



III. Using Popcorn Popping as an action at different temperatures as an action model to represent the relationship between Pressure and temperature:

Collaborative Practice

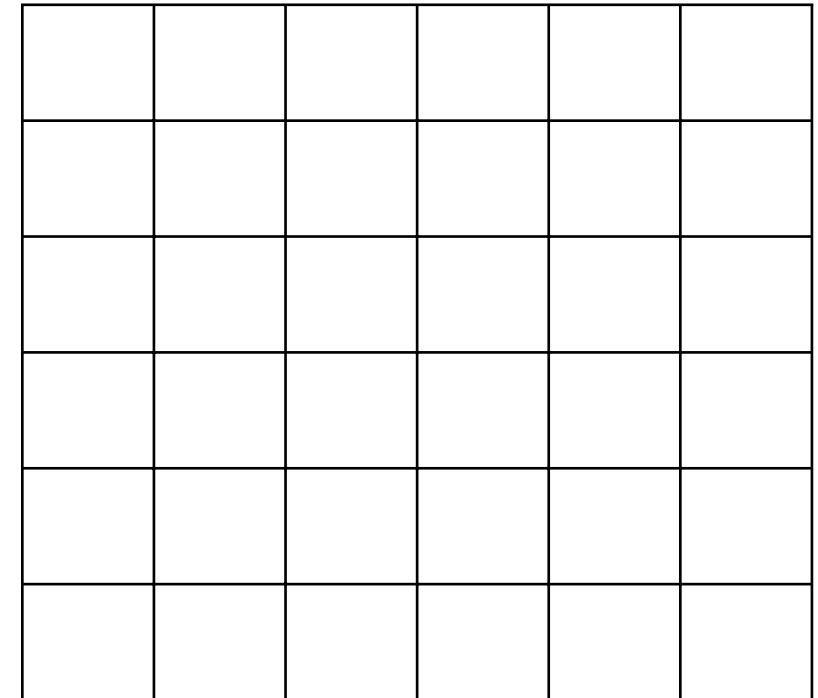
Determine the Width of the popcorn bag at four different temperatures. You control the temperature by controlling the time of heating in the Microwave oven. Record the temperature of the bag at the end of popping time in each case. The width of the bag is a measure of pressure, report this in cm.

Remember to measure the temperature using thermometer. Remember to convert the temperature from degree Celsius to Kelvin by adding 273.

Fill in the data in the data chart and draw the graph.

Table 2. Volume and Temperature data from popcorn activity.

T, K	Width of the Bag, cm



Comment on the graph's slope

How is P related T? Fill in the blanks

P is ----- proportional to T

Write a proportional equation using the proportional symbol, \propto

III. Using Popcorn Popping as an action at different temperatures an action model to represent the relationship between Pressure and temperature: Collaborative Practice

What type representation(s) have you now developed for the relationship between P and V?

Graphical
Conceptual
Quantitative

You are now given a craft stick, how would you like to represent P and T relationship on it?

Use Seesaw as a medium to develop a conceptual model for the relationship between V and T



What type of representation is this?



Comment on the graph's slope

How is P related T? Fill in the blanks

P is proportional to T

Write a proportional relationship using the proportional symbol, \propto

We can convert the proportional relationship into a mathematical equation by introducing a proportionality constant

Rewriting, we get (fill-in the blank)

= Constant

Since we used the same bag of popcorn filled with a constant amount of popcorn, the volume was a constant entity; therefore, we can write, At constant volume,

= Constant

INDEPENDENT PRACTICE

The Gas Laws are stated below; use these statements to identify which of the action models you explored represents each of these laws.

Boyle's Law: The pressure of a given mass of an ideal gas is inversely proportional to its volume at a constant temperature.

Charles' Law: The volume of a given mass of an ideal gas is directly proportional to its absolute temperature at constant pressure.

Gay-Lussac's Law: The pressure of a given mass of an ideal gas is directly proportional to its absolute temperature at constant volume.

Combine the mathematical equations of Boyle's, Charles' and Gay-Lussac's to develop the Combined Gas Law

Boyle's Law: $PV = \text{Constant}$

Charles' Law: $V/T = \text{Constant}$

Gay-Lussac's Law: $P/T = \text{Constant}$

Clue:

Take the common entities (only one time) in the numerator from all gas laws as the numerator

Take the common entities (only one time) in the denominator from all gas laws as the denominator.

End-of Lesson Assessment

Avogadro's Law states that equal volume of all gases under the same conditions of temperature and pressure contain the same number of molecules.

Use this statement and the statements of Boyle's Law, Charles' Law, and Gay-Lussac's Law to answer the following questions

1. You are given four flasks of 2 li volume at 303 K, each contains a different gas at the same pressure: He, Ne, Ar, and Kr. Which flask has the highest number of molecules?
2. When a cylinder containing 2 moles of a gas at 3 liters was compressed to 1 liter. What is the number of moles in the compressed gas?
3. Four gas cylinders filled with the same volume of the same gas are at different temperatures: 300 K, 330 K, 400 K, and 450 K, which cylinder has the highest pressure in it?
4. V/T is a constant is the mathematical representation of which gas law?
5. What is the mathematical representation of the combined gas law?
6. Identify the gas law represented by the graph on the right?

