Ideal Gas Part I

Eugenia Etkina

Renaming and links

Please rename yourself

First name, High School or College, country

Eugenia University USA

Link to the folder with materials for today:

https://drive.google.com/drive/folders/12mFMRirfsF_ekGtZJi1dTcTMd-hm4kA8

Have you ever seen what happens to wet clothes left to dry on a cold (below 0 C) winter day?

Homework This was ALG/OALG activity 12.1.1

What did you observe when you put a streak of rubbing alcohol on a piece of paper? Use only simple words to describe what you saw.

1) On a sheet of printing paper I make a streak in west to east direction with a paper towel wet of alcohol

2) I observe at the beginning the whole wet streak

3) With the time the east part of the streak starts to dry and drying proceeds with time in the direction from east to west

The paper wrinkles up

4) Before complete drying of the paper only the extreme west part of the streak remains wet.

5) Dried from the outside of the streak to the inside; looked as it did before when completely dried

6) It was wet at the beginning then it disappeared

Let's break down your observations into two parts and focus on part 1 first

1. Gradual process
2. Disappearance

1. What do you need to assume about the internal composition of alcohol to explain that the alcohol disappeared **gradually** rather than **all at once**?
2. What is a mechanism that is responsible for the disappearance?

First part of the model

Liquid consists of small parts (things, thingies, particles)

Team 1 What are possible mechanisms that can explain HOW little parts disappeared? (ALG/OALG 12.1.2)

- Pieces are still in the paper but spread out so the paper looks more dry
- The pieces might have fallen out of the paper (pulled down by Earth)
- Pieces fly out of the paper

Team 2 What are possible mechanisms that can explain HOW little parts disappeared? (ALG/OALG 12.1.2)

When they get to the top they get excited and jump off into the air

The disappear from the outside in

They bump into each other so they collide and move off.

They are absorbed by the paper

Team 3 What are possible mechanisms that can explain HOW little parts disappeared? (ALG/OALG 12.1.2)

Something in the air is pulling them off the paper

They don’t want to stay on the paper EE: This is not a mechanism

More attracted to the air

Moving all the time and will move into the air little by little

They were destroyed by the paper

They are a part of the paper now (they dry)

Team 4 What are possible mechanisms that can explain HOW little parts disappeared? (ALG/OALG 12.1.2)

“The alcohol goes away because of the outer temperature makes the particles go into the air”. EE: this is not a mechanism and we do not use use the term evaporate

Testing experiment:changing heat underneath: put on a freezer pack. normal vs hot plate/ Measure the mass.

Also: testing that it goes into the air: waving it around/not waving; putting a baggie around the paper; smelling the odor

Mechanisms

Still in the paper, but we cannot see them

Left because they move

Air is responsible

Team 1 Testing experiments and predictions based on each explanation

Experiment	Prediction based on Explanation 1 (still in paper)	Prediction based on Explanation 2 (left because they move)	Prediction based on Explanation 3 (left due to air)
Measure the mass of the paper before pouring alcohol, after pouring alcohol, and after the alcohol disappears	The paper should still weigh more after the alcohol “disappears”	The paper have the same mass as before the alcohol was poured on it *Assume: the mass is taken after all the alcohol completely disappears*	The paper have the same mass as before the alcohol was poured on it *Assume: the mass is taken after all the alcohol completely disappears*
Put the alcohol paper in a vacuum			The alcohol will not disappear

Team 2 Testing experiments and predictions based on each explanation

Experiment	Prediction based on Explanation 1	Prediction based on Explanation 2	Prediction based on Explanation 3	Prediction based on Explanation 4
Use a vacuum chamber		The paper will remain wet	The paper will remain wet (if the process of taking the air out is fast)	
Use a balance to measure the mass	The reading will be higher	The reading will be the same as before	The reading will be the same as before	

Team 3 Testing experiments and predictions based on each explanation

Experiment	Prediction based on Explanation 1	Prediction based on Explanation 2	Prediction based on Explanation 3	Prediction based on Explanation 4
Place the paper in a vacuum	Paper dries	Paper dries	Paper doesn’t dry	
Use a scale to measure the mass before and after	Mass doesn’t change	Mass does change, it goes down	Mass does change, it goes down	
Change the temperature of				

Team 4 Testing experiments and predictions based on each explanation

- Still in the paper, but we cannot see them
- Left because they move (they left on their own)
- Air is responsible (takes them away)

Experiment	Prediction based on Explanation 1	Prediction based on Explanation 2	Prediction based on Explanation 3	Prediction based on Explanation 4
Put on a balance, measure the mass before and after	Mass stays the same	Mass decreases	Mass decreases	
Put paper in a vacuum	Streak disappears	Streak disappears	Streak does not disappear	
Put dye in	Stay on paper	Colour would	Colour would	

Testing experiments and their outcomes

https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-12-1-3a

https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-12-1-3b

https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-12-1-3c

Outcomes of the experiments and judgment OALG 12.1.3

What can we say about the mechanisms?

The particles are not anymore in the paper

The dye moves because the particles in the alcohol are pushing them around.

The particles in the alcohol are always moving. It did not matter if there was air or not. The mass of the paper changed so it didn’t stay in the paper.

The dye particles are always moving in the alcohol

The particles of alcohol do not stay in the paper

The particles do not stay in the paper

OALG 12.1.4 Explain

The only explanation for drying alcohol that could not be rejected by testing experiments was the explanation that alcohol consists of tiny particles that move randomly. How do you need to modify this explanation to account for the fact that not all of the particles leave instantly?

Team 1 OALG 12.1.5

Represent and reason

Imagine that you have eyes that can see the particles of air in the room. Draw a picture representing the behavior of several particles as they move through the room. Think of their possible collisions and how the collisions will affect the directions of their motion and the magnitudes of their speeds.

Team 2 OALG 12.1.5

Represent and reason

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Team 3 OALG 12.1.5

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Team 4 OALG 12.1.5

Represent and reason

Imagine that you have eyes that can see the particles of air in the room. Draw a picture representing the behavior of several particles as they move through the room. Think of their possible collisions and how the collisions will affect the directions of their motion and the magnitudes of their speeds.

Same speeds or different speeds?

https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-15-7-4

Return to the need to know

How do frozen clothes dry?

Read, watch but do not do the calculation here

OALG 12.1.6 Observe and analyze

In this experiment https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-12-1-6 we used a pipette to put 4 drops of oil mixed with benzene on the surface of water. As the drops spread, benzene evaporates and only oil remains in the droplets.

a. Use the data that you can collect from the video to estimate the size of one molecule of oil. Note that the numbers on the ruler show centimeters.

b. State what assumptions you made to make your estimate.

c. Compare your estimate with the known values for the size of oil molecules.

All together OALG 12.2.1 and 12.2.2

Blow up a balloon and carefully observe how its shape changes during the process. Use the idea of moving particles to explain why it expands when you blow air into it. Explain why the balloon does not expand any more when you stop blowing. Describe an experiment you can perform to test your explanation(s).

In the experiment in the video [https://mediaplayer.pearsoncmg.com/assets/_frames.true/secs-egv2e-testing-the-model-of-moving-gas-particles-pushing-on-the-surface], a partially inflated (and tied) balloon will be placed in the bell-jar and the air will be removed by the vacuum pump. Use each of the ideas you came up with in Activity 12.2.1 to make predictions about what the balloon will do when the air is pumped out of the bell-jar (state one prediction for each idea being tested). Write down your predicted outcome(s). Then watch the experiment. Which of your predictions was consistent with the experimental outcome? What is your judgment on each of the ideas you were testing?

Model of a system - ideal gas

Model of an object - point like object (neglect size) - when can we use it?

Model of a process - free fall (neglect forces other than the gravitational force) - when can we use it?

Model of a system (ideal gas - neglecting the size of particles and interactions at a distance, assuming that Newton's laws work for the particles) - when can we use it?

Watch the following videos and apply what we learned about particles to explain them

Observe and explain:

https://www.youtube.com/watch?v=pUVWSpXF_e8

Use the explanation you developed to predict when a balloon filled with air is placed in a container filled with CO_2 gas. Then watch the video

https://www.youtube.com/watch?v=CqzeqQ4k4LE

New physical quantity

Pressure: perpendicular component of a force / the area

Team 1 OALG 12.3.1 OALGChapter 12 Final.docx

OALG 12.3.1 Represent and reason

Imagine that a particle moves horizontally until it hits a vertical wall. Assume that it is an elastic collision (after the collision, the speed of the molecule is the same as before the collision, but in the opposite direction) and the motion of the particle obeys Newton's laws. Answer the following questions to analyze the motion of a single particle:

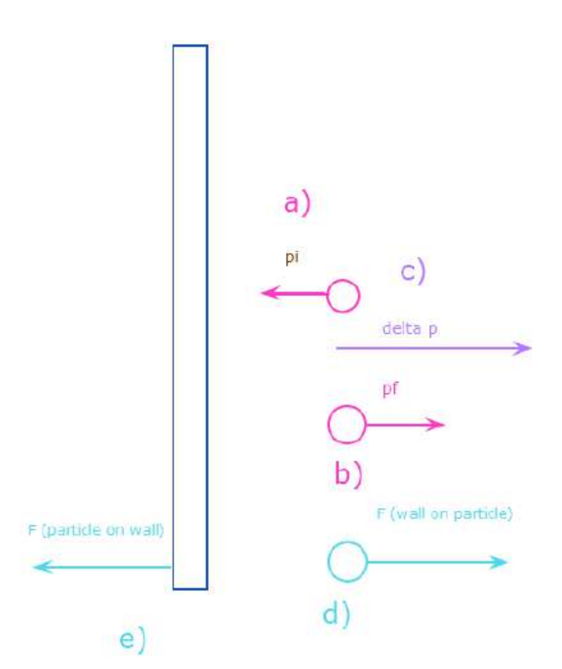
a. Draw an arrow representing the momentum of the particle before the collision.

b. Draw an arrow representing the momentum of the particle after the collision.

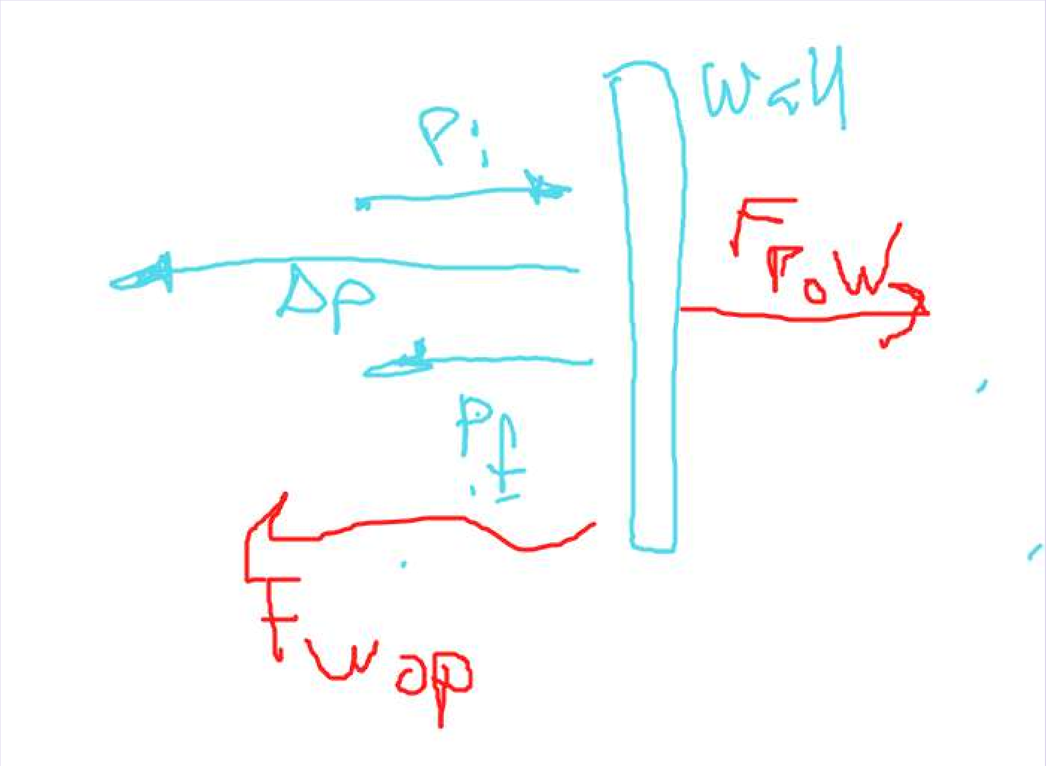
c. Draw a momentum change arrow.

d. Draw an arrow representing the force exerted by the wall on the particle.

e. Draw an arrow representing the force exerted by the particle on the wall.



Team 2 OALG 12.3.1 OALGChapter 12 Final.docx



Team 3 OALG 12.3.1 OALGChapter 1

Imagine that a particle moves horizontally until it hits a vertical wall. Assume that it is an elastic collision (after the collision, the speed of the molecule is the same as before the collision, but in the opposite direction) and the motion of the particle obeys Newton's laws. Answer the following questions to analyze the motion of a single particle:

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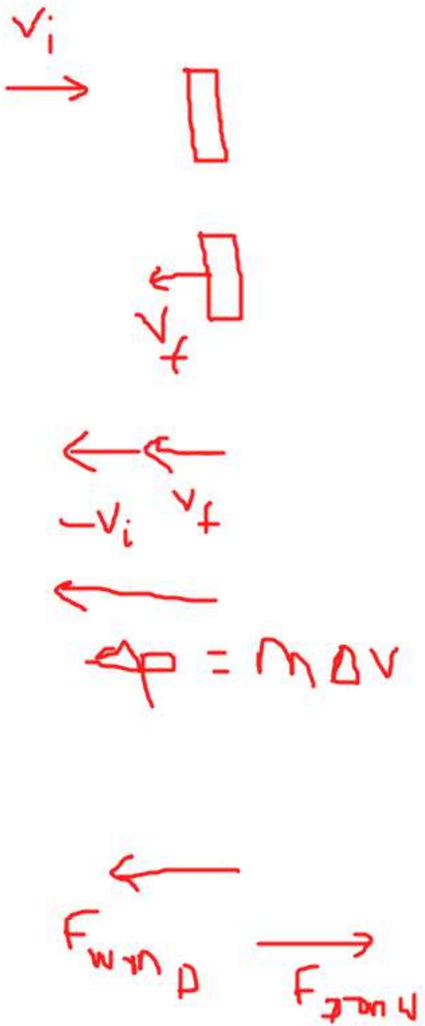

Team 4 OALG 12.3.1 [OALGChapter 12 Final.docx]

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c. Draw a momentum change arrow.
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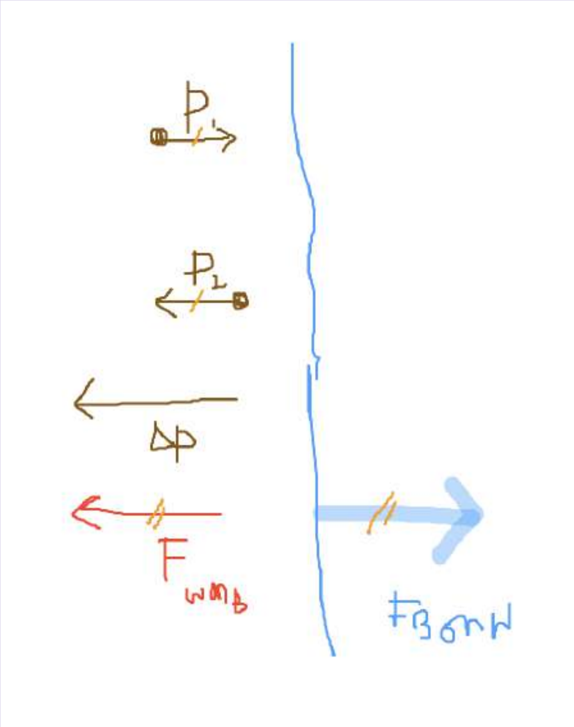
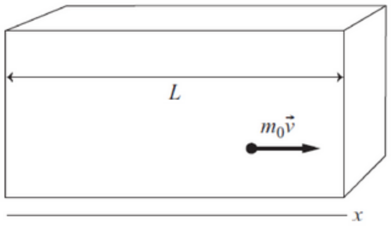
e. Draw an arrow representing the force exerted by the particle on the wall.



Team 1 OALG 12.3.2

OALG 12.3.2 Derive

Imagine that the gas inside a container has such low density that its particles almost never collide with each other; they collide only with the walls of the container. Assume a model of the gas as tiny moving billiard balls obeying Newton's laws. We wish to derive an expression for the pressure that the gas exerts on the walls of the container.



a. Start with one of the "balls" of mass m_0 traveling at speed v parallel to the x-axis at speed v_x. The ball bounces back and forth between the two walls of the container that are separated by distance L and that are perpendicular to the x-axis. Use your knowledge of the impulse–momentum principle to show that the impulse of the ball, as a result of one collision against one wall, has magnitude $2m_0v_x$.

b. Show that the time interval between impacts for the one ball against that same wall is $2L/v_x$.

c. Use the results from parts **a.** and **b.** to show that the average force that these collisions exert on the wall over the time of several passages of the ball (F_{avg}) is $m_0v_x^2/L$ and that the average pressure that N balls, or particles, will exert on a wall is $P = N(m_0v_x^2)/L^3$.

d. The v_x^2 in the expression for average pressure in part **c.** should more properly be designated as the average of the square of the x-components of the velocities $\overline{v_x^2}$. The N particles inside the container move at different speeds and in different directions. How is $\overline{v_x^2}$ related to the average of the square of the speeds $\overline{v^2}$? *Hint:* Assume that one-third of the particles move in each of the three directions (x, y, z).

e. Now consider the pressure that these particles exert on the walls of the container. Show that the pressure that they exert is equal to $P = \frac{1}{3}\frac{N}{V}\left(m_0\overline{v^2}\right)$.

f. Read and interrogate Section 12.3 in the textbook and compare your derivation to the one in the book.

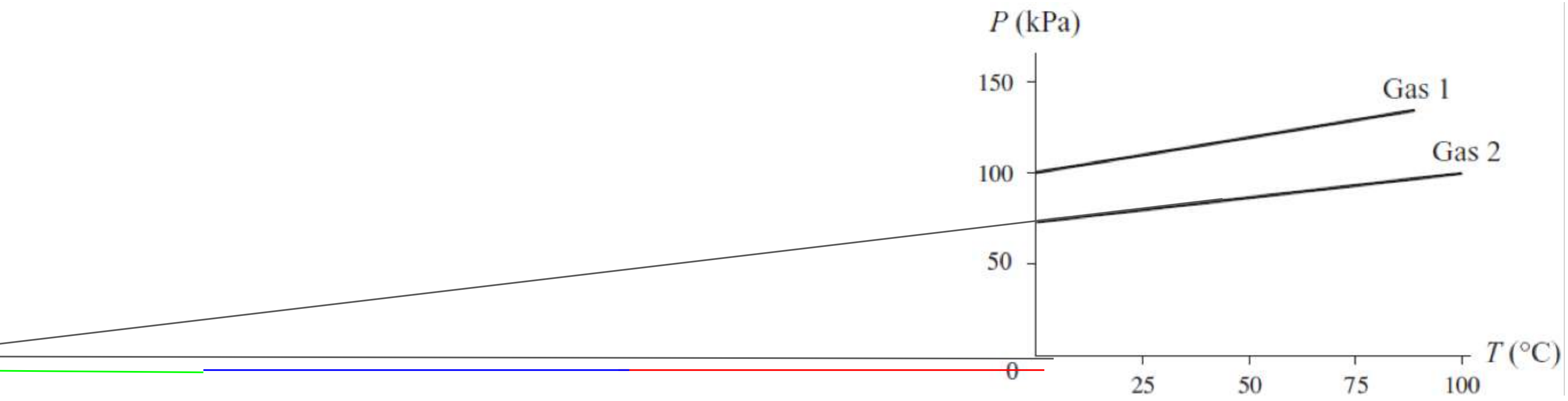
Team 2 OALG 12.3.2

Team 3 OALG 12.3.2

Team 4 OALG 12.3.2

All together 12.3.3 a and b

All together OALG 12.4.1



Team 1 OALG 12.4.3 and 12.4.4

OALG 12.4.4 Reason

The table below represents data collected when a constant-volume metal container with 1 mol of helium ($N = N_A = 6.02 \times 10^{23}$ molecules) is placed in baths of very different temperatures. If we assume that the ratio $\frac{PV}{N}$ is proportional to the absolute temperature of the gas (i.e., $\frac{PV}{N} = kT$), we can find the coefficient of proportionality, k. Solve for the proportionality constant k for the two sets of data.

Known physical quantities	$\frac{PV}{NT} = k$	Known physical quantities	$\frac{PV}{NT} = k$
$P = 1.01 \times 10^5$ N/m^2	$k =$	$P = 1.38 \times 10^5$ N/m^2	$k =$
$T = 273$ K (melting ice)		$T = 373$ K (boiling water)	
$V = 22.4 \times 10^{-3}$ m^3		$V = 22.4 \times 10^{-3}$ m^3	

k = PV/NT = 1.38x10^-23 N*m/mol*K for both temperatures

a) Yes, the value of k is independent of gas temperature because at two different temperatures the value is the same.

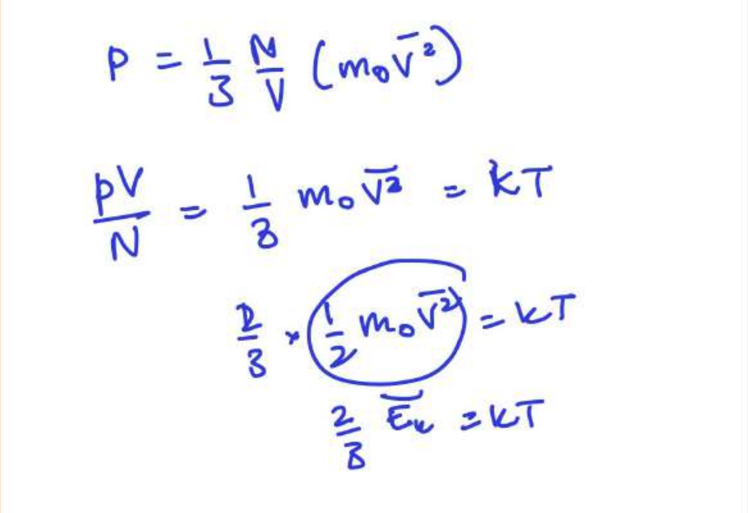
b)

Team 2 OALG 12.4.3 and 12.4.4

Team 3 OALG 12.4.3 and 12.4.4

Team 4 OALG 12.4.3 and 12.4.4

First: N.m/particle (change in energy = work)



Second activity:

$k=1,38\ 10^{-23}$ independent of temperature

$\frac{1}{3} m v^2 = kT$

What did you learn today?

I learned how to use some images to visualize microscopic phenomena in a macroscopic way

I learned that Energy is how we tie temperature to pressure and volume.

Learned use videos for students. I teach CP and do not have the book to show the students.

Thinking about having a physical mechanism rather than "fancy" vocabulary words to test (e.g. "evaporation" is not a mechanism; emphasizing difference between observational experiment and testable experiment,

Logical and experimental steps to be able to deduce Ideal gas law. A few key steps: Energy to temperature relationship, the concept of how momentum relates to particles. A few wows on how alcohol dries off, how C02 goes into a balloon, how a balloon will inflate when on vacuum

Speed more tangible to think about than energy

Create discrepancies but use concrete experiences to do this. Use simple words.

I learned that not all analogies can apply to all scenarios and it's really important to think of assumptions in them