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

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)

Ideal Gas part II and Thermodynamics

Eugenia Etkina
March 16 2024

Please rename yourself

First name

High school of College/University

Country

Eugenia, University, USA

Continuations of Ideal Gas workshop Part I

The link to the folder with the documents: E&AP Workshop Gases February 2024

OALG Chapter 12 (GASES) OALGChapter 12 Final.docx

OALG Chapter 15 (1st law of Thermodynamics) OALGChapter 15 Final.docx

All together 12.4.5

The following two mathematical representations are fairly similar: $PV = \frac{1}{3}Nm\overline{v^2}$ and $PV = Nk_B T$. How do these representations differ in terms of what they describe and the possibility of measuring the quantities that they relate?

Team 1 OALG 12.5.1. AOL Chapter 12 Final.docx

When the volume 10ml P = 98.31kPa

V=20 ml P= 52.80KPa

V=30ml P=34.79 Kpa

V=40ml P = 26.4 Kpa

When the volume was doubled, the pressure was half (inversely proportional)

When Temperature increases, the P increases   (Directly proportional)

Team 1 OALG 12.5.1 do not forget to use V in m^3 and T in K. OALGChapter 12 Final.docx

Part a) compare the prediction to the outcome at

https://www.youtube.com/watch?v=vmpTGvvmc0o

Part b) compare the prediction to the outcome at

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

Part c) compare the prediction to the outcome at

https://www.youtube.com/watch?v=rXGvIn8JIHs

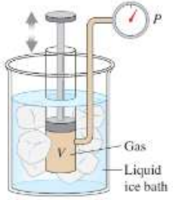
Team 2 OALG 12.5.1.[OALGChapter 12 Final.docx]

If we graph volume against pressure, we should see an inversely proportional relationship?

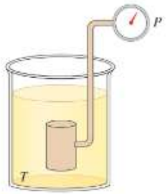
OALG 12.5.1 Test an idea

How can you use the mathematical representation $PV = Nk_BT$ to make quantitative predictions about the following processes occurring to a fixed mass of an ideal gas? The initial conditions of the gas P_1, V_1, T_1 are known and you need to show how P_2, V_2, T_2 are related to their initial conditions

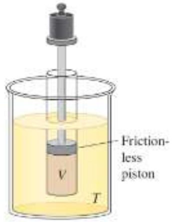
a. The gas is inside a container with a movable piston. The container is placed in a bath of constant temperature T_1. We push the piston slowly so that the temperature of the gas is always the same as the bath. Both the pressure and the volume change (see the figure on the right).



b. The gas is inside a container with a fixed volume V_1. The container is placed in different-temperature baths. Both the pressure and the temperature change (see the upper figure on the right).



c. The gas is inside a container with a movable frictionless piston. The frictionless piston in the gas container can move freely up and down, keeping the pressure P_1 constant. The pressure inside the container is the sum of the constant atmospheric pressure and the pressure exerted by the object on top of the piston. Both the gas volume and the temperature change (see the lower figure on the right).



d. Write down your predictions for the processes in parts **a.-c.** and compare them to the predictions and experimental outcomes described in Testing Experiment Table 12.5 in the textbook. What are the similarities in your predictions? What are the differences?

a. **Prediction**: When volume is doubled, pressure should halve; when volume is halved, pressure should double EE: Good, but make it more general and mathematical

   Outcome: (after video is watched)

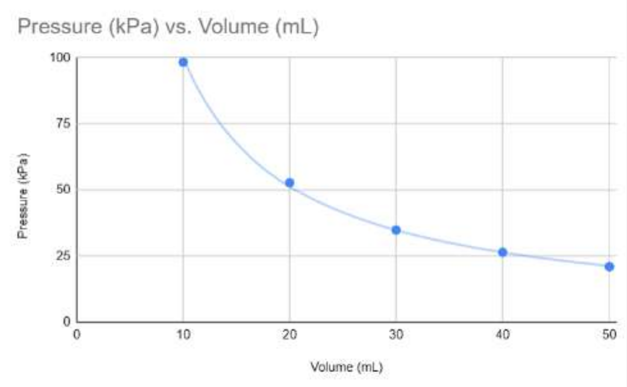
b. **Prediction**: As the temperature increases, the pressure increases; as the temperature decreases, the pressure decreases.

   Outcome: (after video is watched)

c. **Prediction**: As the temperature increases, the volume increases; as the temperature decreases, the volume decreases

   Outcome: (after video is watched)

Team 2 OALG 12.5.1 do not forget to use V in m^3 and T in K.OALGChapter 12 Final.docx



Part a) compare the prediction to the outcome at

https://www.youtube.com/watch?v=vmpTGvvmc0o

Part b) compare the prediction to the outcome at

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

Part c) compare the prediction to the outcome at

https://www.youtube.com/watch?v=rXGvln8JlHs

Team 3 OALG 12.5.1.[OALGChapter 12 Final.docx]

a) Change V (push the piston down) and measure p. Plot V vs 1/p and prediction is a straight line graph going through the origin. Also observe quantitatively if volume doubles, what happens to the pressure etc.
b) Change temperature (by heating) and the pressure will increase. If temperature (in K) doubles, pressure doubles (though this can't happen within the temp range). Plot p vs T (K) and expect straight line through origin
c) Increase the temperature (heating) and plot V vs T(K) - prediction straight line through origin.

EE: Can you write the relationships mathematically?

Team 3 OALG 12.5.1 do not forget to use V in m^3 and T in K.[OALGChapter 12 Final.docx]

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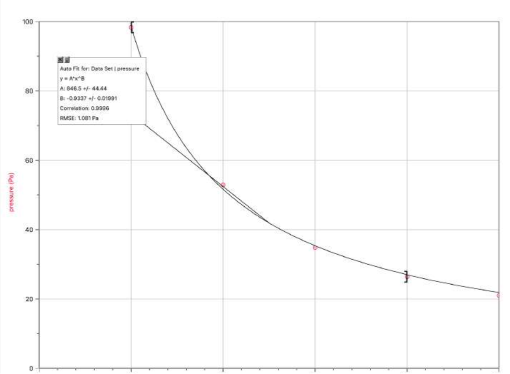
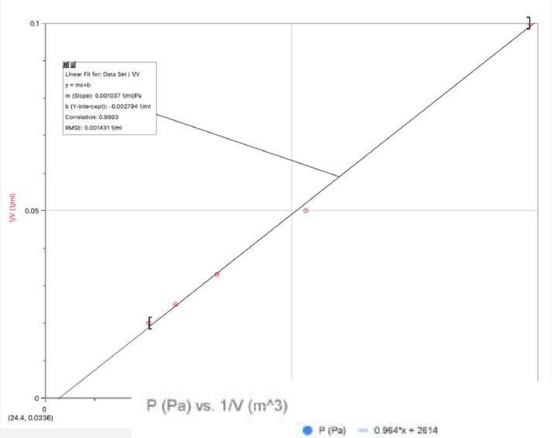
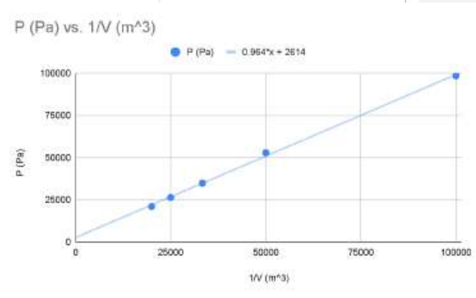


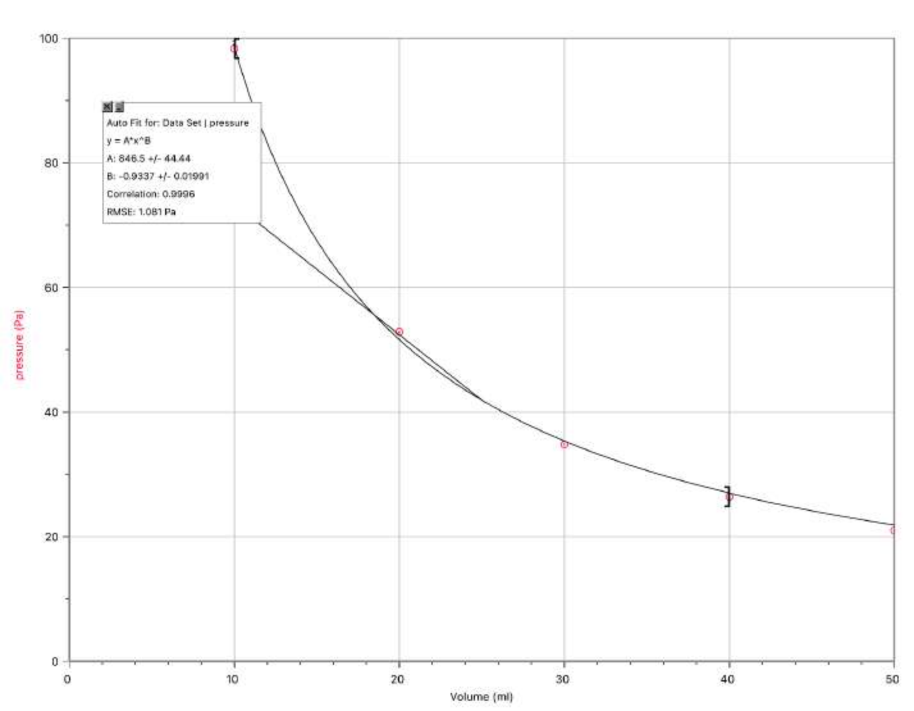


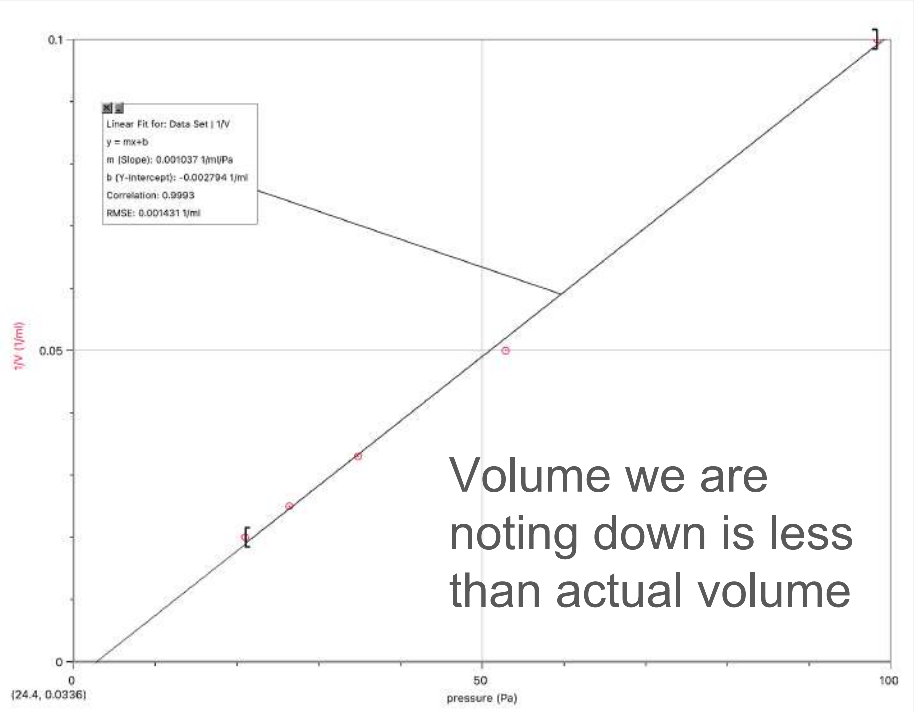


Team 3 OALG 12.5.1 do not forget to use V in m^3 and T in K.[OALGChapter 12 Final.docx]

Part a) compare the prediction to the outcome at

https://www.youtube.com/watch?v=vmpTGvvmc0o doesn't go through zero because of "dead volume"





Volume we are noting down is less than actual volume

Team 4 OALG 12.5.1.OALGChapter 12 Final.docx

a. Increase pressure the volume will decrease

Exp Volume increases pressure decreases EE: HOW? Your predictions are too vague V_i 30 P_i 29 V 20 P 52 - these are outcomes, not predictions, right?

a. Temperature increases pressure will increase HOW?

Exp. Temperature increase pressure increase. Temp decrease pressuring decrease.

a. As the gas volume increases the temperature will increase HOW?

Fixed number of particles V_i =20 ml 52

Team 4 OALG 12.5.1 do not forget to use V in m^3 and T in K.OALGChapter 12 Final.docx

Part a) compare the prediction to the outcome at

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Part c) compare the prediction to the outcome at

https://www.youtube.com/watch?v=rXGvln8JlHs

Reading exercise (not for the workshop)

OALG 12.6.2

All together OALG 12.7.1 OALGChapter 12 Final.docx

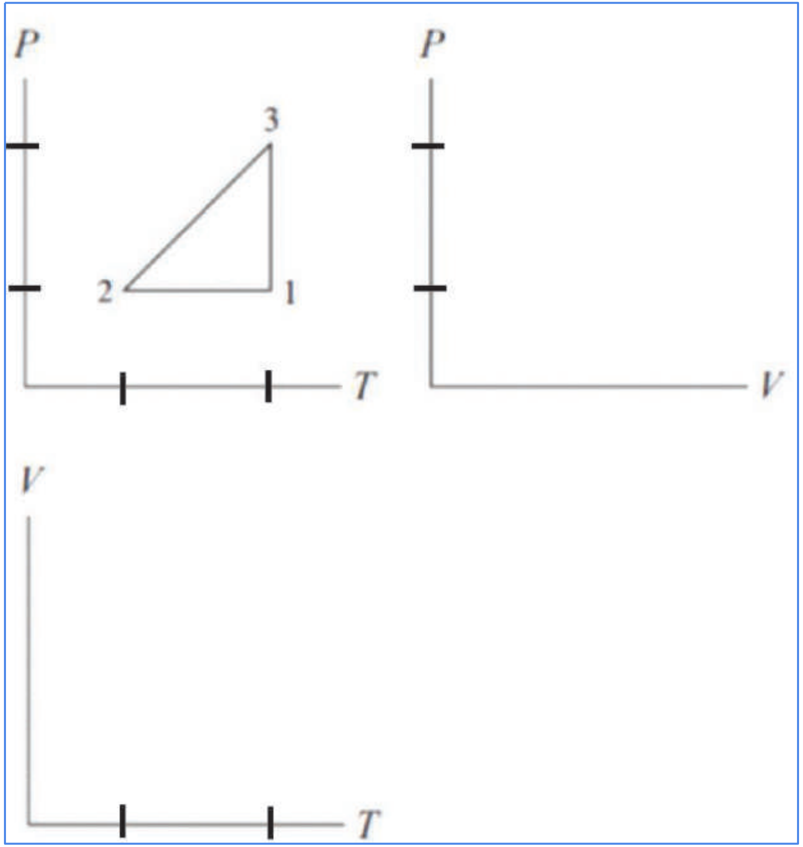
OALG 12.7.1 Represent and reason

The *P*-versus-*T* graph in part **b**. describes a cyclic process comprised of three hypothetical processes. The mass of the gas is constant.

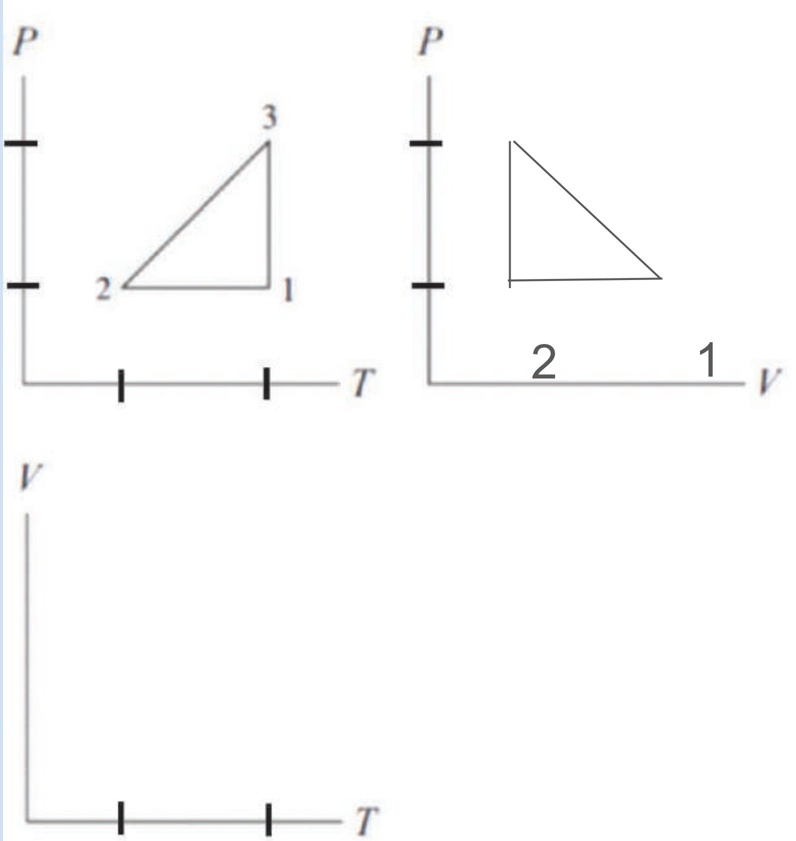
a. Describe the processes represented on the *P*-versus-*T* graph in part **b**. by completing the table that follows.

Process	Describe what happens to the pressure of the gas.	Describe what happens to the temperature of the gas.	Describe what happens to the volume of the gas.
$1 \rightarrow 2$	Remains constant	decreases	decreases
$2 \rightarrow 3$	increases	Increases	Remains constant (the line passes through the origin)
$3 \rightarrow 1$	decreases	constant	increases

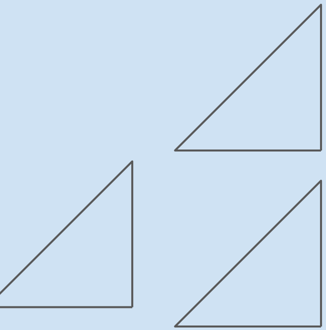
All together OALG 12.7.1 OALGChapter 12 Final.docx

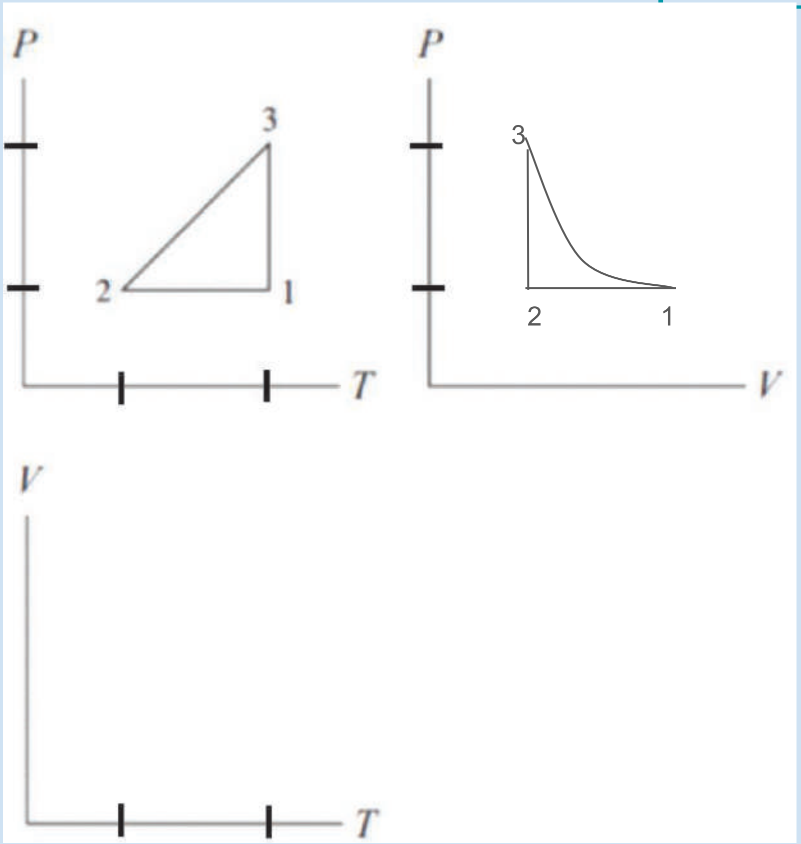


Team 1 OALG 12.7.2 OALGChapter 12 Final.docx



Team 2 OALG 12.7.2 OALGChapter 12 Final.docx





1→2

P same

T decrease

V decrease

2→3

P increases

T increases

V same?

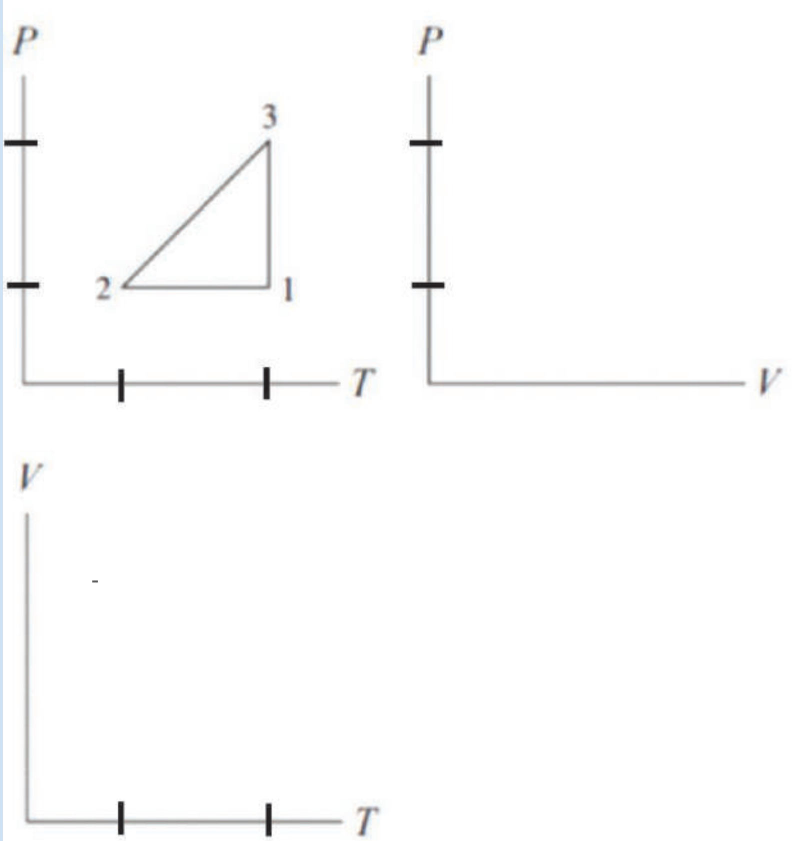
3→1

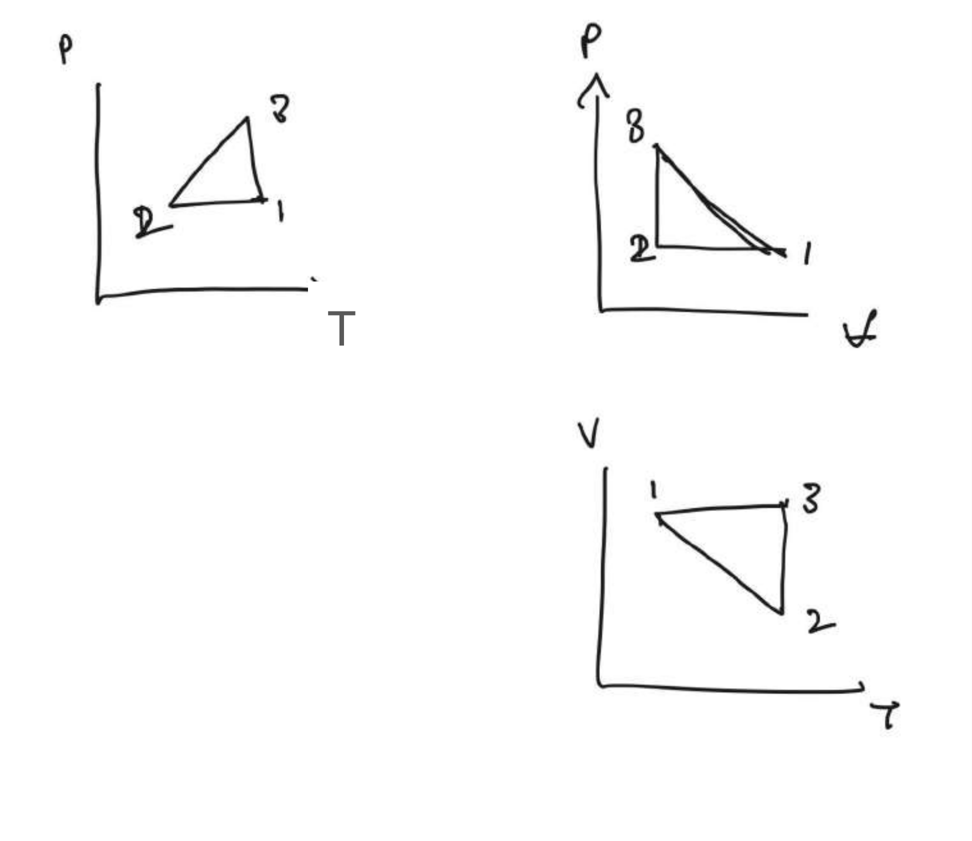
P decreases

T same

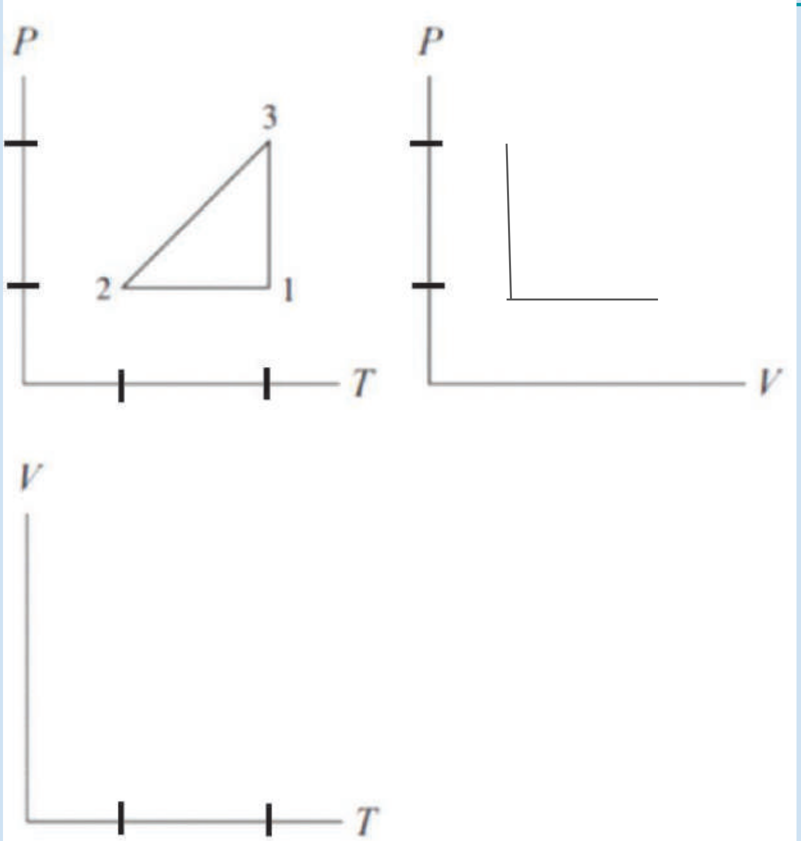
V increase

Team 3 OALG 12.7.2 [OALGChapter 12 Final.docx]

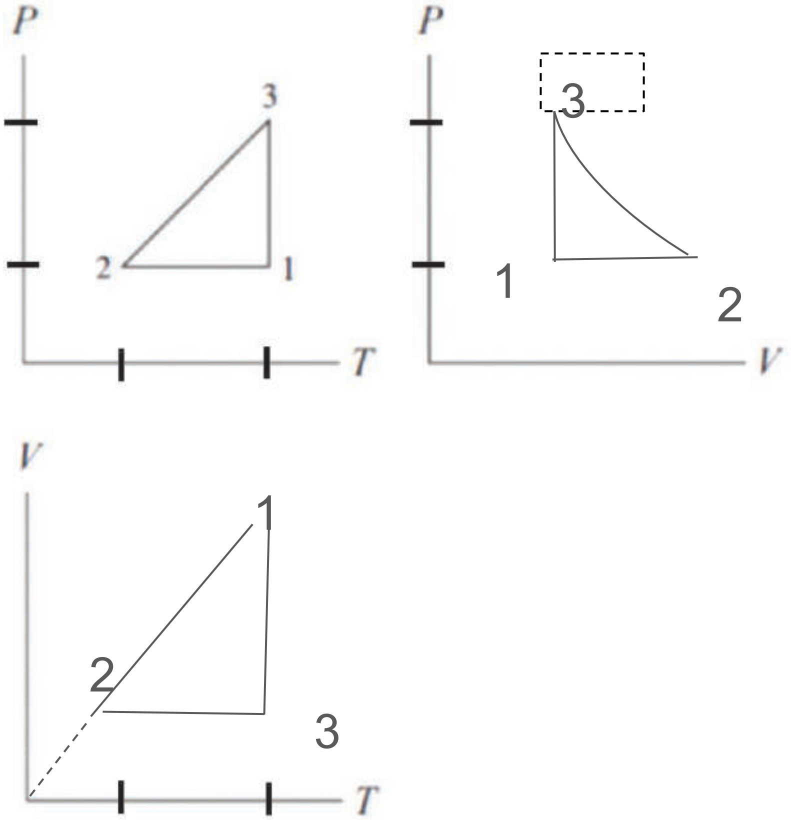




Team 4 OALG 12.7.2 OALGChapter 12 Final.docx



Solution



Summary in the table

[IGL activity table.docx]

Need to know

What happens to the energy of the gas when it expands?

https://youtu.be/lN5datUGEMU

Team 1

OALG 15.1.1 Derive

You have a container filled with a gas at known conditions (its molar mass, the number of moles, and the temperature).

a. In Chapter 12, you learned how the average kinetic energy of a particle of ideal gas is related to the temperature of the gas. Use this knowledge to derive an expression for the internal energy of the gas, assuming the gas is ideal. If you are having difficulties, read and interrogate sub-section “Thermal energy of ideal gas” in Section 15.1 in the textbook.

$U = N\,E_{Kin} = N\,3/2\,k_B T$

b. How will the internal energy of the same amount of gas change if you place it in a container with a larger volume while keeping the gas temperature the same? Explain.

U is the same if the temperature is the same

Team 2

OALG 15.1.1 Derive

You have a container filled with a gas at known conditions (its molar mass, the number of moles, and the temperature).

a. In Chapter 12, you learned how the average kinetic energy of a particle of ideal gas is related to the temperature of the gas. Use this knowledge to derive an expression for the internal energy of the gas, assuming the gas is ideal. If you are having difficulties, read and interrogate sub-section "Thermal energy of ideal gas" in Section 15.1 in the textbook.

b. How will the internal energy of the same amount of gas change if you place it in a container with a larger volume while keeping the gas temperature the same? Explain.

3/2 PV=kinetic energy of N particles EE: How do you know? PV=⅓ NmV^2
PV=Nk_bT
⅓ NmV^2 = Nk_bT
⅓ mV^2 = k_bT

Team 3

OALG 15.1.1 Derive

You have a container filled with a gas at known conditions (its molar mass, the number of moles, and the temperature).

a. In Chapter 12, you learned how the average kinetic energy of a particle of ideal gas is related to the temperature of the gas. Use this knowledge to derive an expression for the internal energy of the gas, assuming the gas is ideal. If you are having difficulties, read and interrogate sub-section "Thermal energy of ideal gas" in Section 15.1 in the textbook.

One particle: E_{Kav}= 3/2 k_BT and U=N$E_{K\ av}$ since U is total E_k So U= 3/2 N K_BT or U= 3/2 nRT

b. How will the internal energy of the same amount of gas change if you place it in a container with a larger volume while keeping the gas temperature the same? Explain.

It wouldn't. If the temperature remains constant the internal energy stays the same.The pressure would change

Team 4

OALG 15.1.1 Derive

You have a container filled with a gas at known conditions (its molar mass, the number of moles, and the temperature).

a. In Chapter 12, you learned how the average kinetic energy of a particle of ideal gas is related to the temperature of the gas. Use this knowledge to derive an expression for the internal energy of the gas, assuming the gas is ideal. If you are having difficulties, read and interrogate sub-section "Thermal energy of ideal gas" in Section 15.1 in the textbook.

$U_t = 3/2nRT$ EE: Why? Where did it come from? $3/2K_BT=K_{avg}$

b. How will the internal energy of the same amount of gas change if you place it in a container with a larger volume while keeping the gas temperature the same? Explain.

The thermal energy only depends on the number of moles and the temperature and the pressure should not have any effect.

Team 1

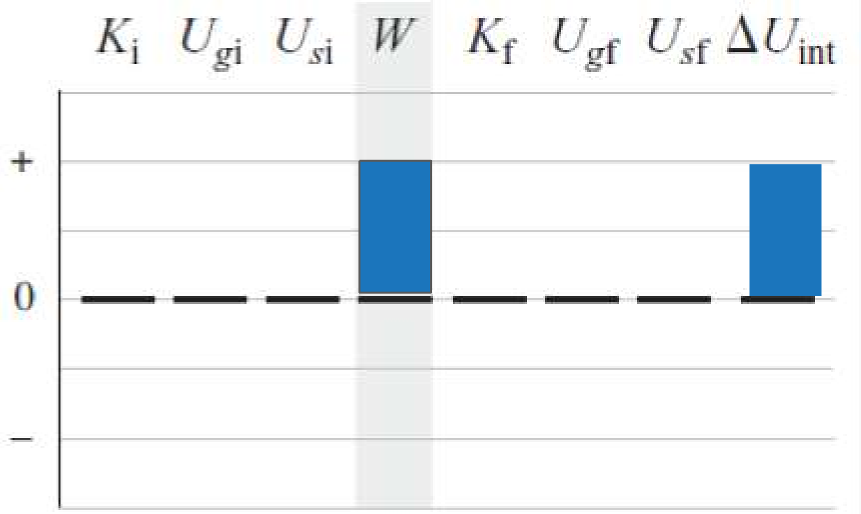
OALG 15.1.2 Observe and explain

In the following video, you see a syringe and a piston that fits snugly into it. At the end of the piston is a small hook to which a small piece of cotton is tied. The experimenter is holding the syringe vertically and suddenly presses down forcefully on the piston. The high-speed video (recorded at 1200 frames per second) shows what happens: [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-15-1-2]. Answer the questions below:

a. What happens to the temperature of the air in the syringe during the experiment? How do you know?

b. What happens to the pressure of the air in the syringe during the experiment? How do you know?

c. Draw an energy bar chart for the experiment. Choose the air in the syringe as a system. The initial state is before the piston is pushed in and the final is just before the cotton ball starts to burn.


K_i U_{gi} U_{si} W K_f U_{gf} U_{sf} ΔU_{int}
+
0
−

Team 2

OALG 15.1.2 Observe and explain

In the following video, you see a syringe and a piston that fits snugly into it. At the end of the piston is a small hook to which a small piece of cotton is tied. The experimenter is holding the syringe vertically and suddenly presses down forcefully on the piston. The high-speed video (recorded at 1200 frames per second) shows what happens: [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-15-1-2]. Answer the questions below:

a. What happens to the temperature of the air in the syringe during the experiment? How do you know?

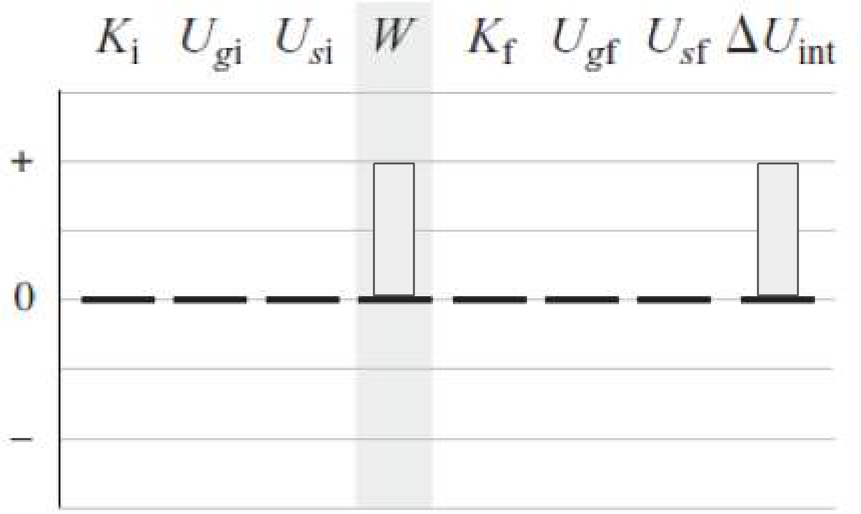
The temperature increases because the cotton catches on fire

b. What happens to the pressure of the air in the syringe during the experiment? How do you know?

The volume decreases and the temperature increases, so the pressure must increase since pressure is inversely proportional to volume and directly proportional to temperature

c. Draw an energy bar chart for the experiment. Choose the air in the syringe as a system. The initial state is before the piston is pushed in and the final is just before the cotton ball starts to burn.

System: air in the syringe



Team 3

OALG 15.1.2 Observe and explain

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a. What happens to the temperature of the air in the syringe during the experiment? How do you know?

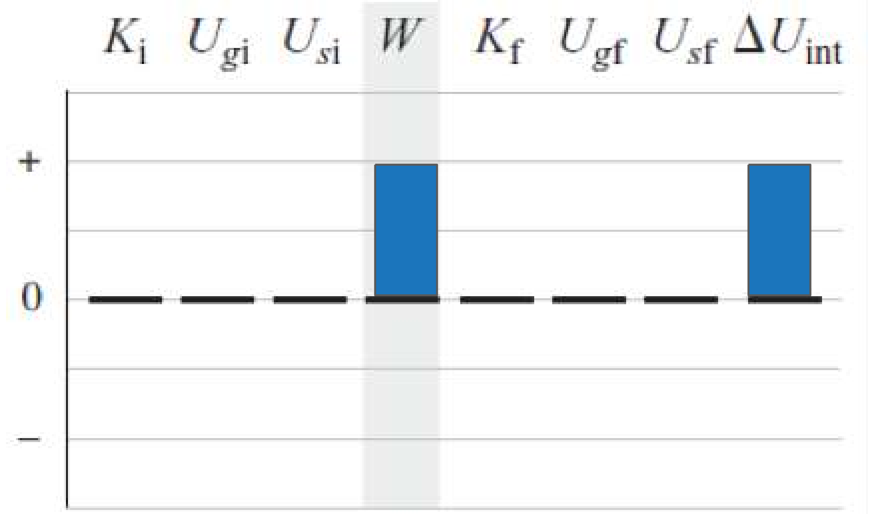
It increases. We know because we can see that a glow.

b. What happens to the pressure of the air in the syringe during the experiment? How do you know?

It increases. The experimenter pushes down the piston forcefully.

The piston recoils so the pressure at the very end decreases.

c. Draw an energy bar chart for the experiment. Choose the air in the syringe as a system. The initial state is before the piston is pushed in and the final is just before the cotton ball starts to burn.



K_i
U_{gi}
U_{si}
W
K_f
U_{gf}
U_{sf}
ΔU_{int}
+
0
−

Team 4

OALG 15.1.2 Observe and explain

In the following video, you see a syringe and a piston that fits snugly into it. At the end of the piston is a small hook to which a small piece of cotton is tied. The experimenter is holding the syringe vertically and suddenly presses down forcefully on the piston. The high-speed video (recorded at 1200 frames per second) shows what happens: [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-15-1-2]. Answer the questions below:

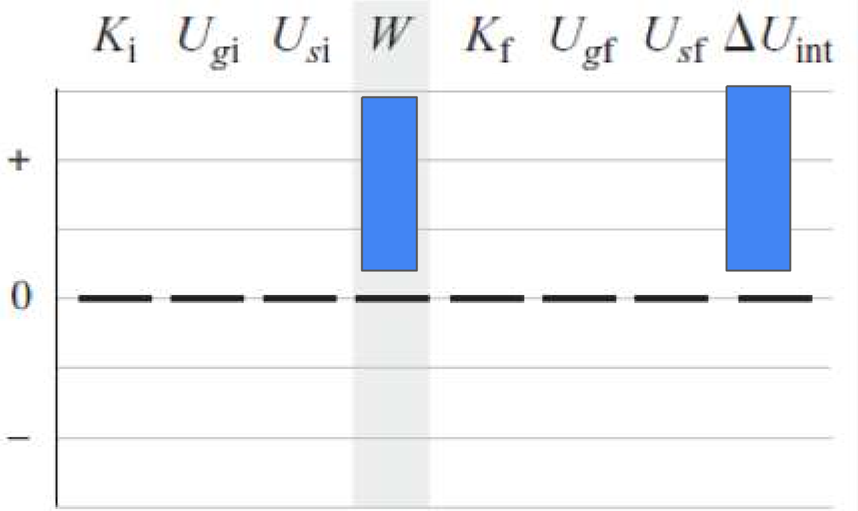
a. What happens to the temperature of the air in the syringe during the experiment? How do you know?

Increases. We can see the spark and light. As the pressure increases the temperature should also increase.

b. What happens to the pressure of the air in the syringe during the experiment? How do you know?

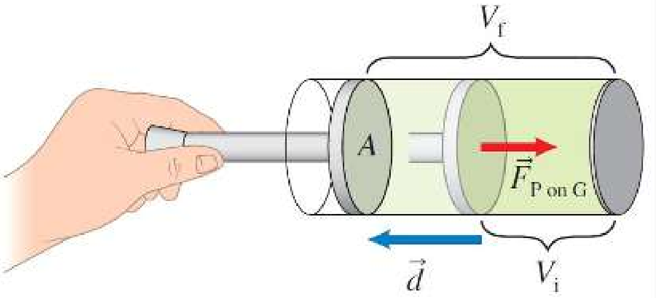
The pressure increases because the volume decreases.

c. Draw an energy bar chart for the experiment. Choose the air in the syringe as a system. The initial state is before the piston is pushed in and the final is just before the cotton ball starts to burn.



K_i
U_{gi}
U_{si}
W
K_f
U_{gf}
U_{sf}
ΔU_{int}
+
0
−

All together



OALG 15.1.3 Derive

In the previous activity, you learned that if you do work on a gas, you can increase its internal energy tremendously. But how do we calculate this work quantitatively?

Imagine that you have a gas (the system) at high pressure in a cylinder with a movable piston as shown in the figure below.

You hold the piston and allow it to move slowly outward to the left (if you were not holding it, the gas would push it out instantly). The gas pushes to the left on the piston and the piston in turn pushes toward the right on the gas, exerting a force on the gas The gas expands slowly. What is the work done by the force that the piston exerts on the gas? Assume that the piston moves outward a distance allowing the gas to expand from its initial volume to its final volume with the final volume being just slightly larger than the initial.

To derive the expression for the work, answer the following questions:

a. Recall the definition of work and when this definition is applicable.

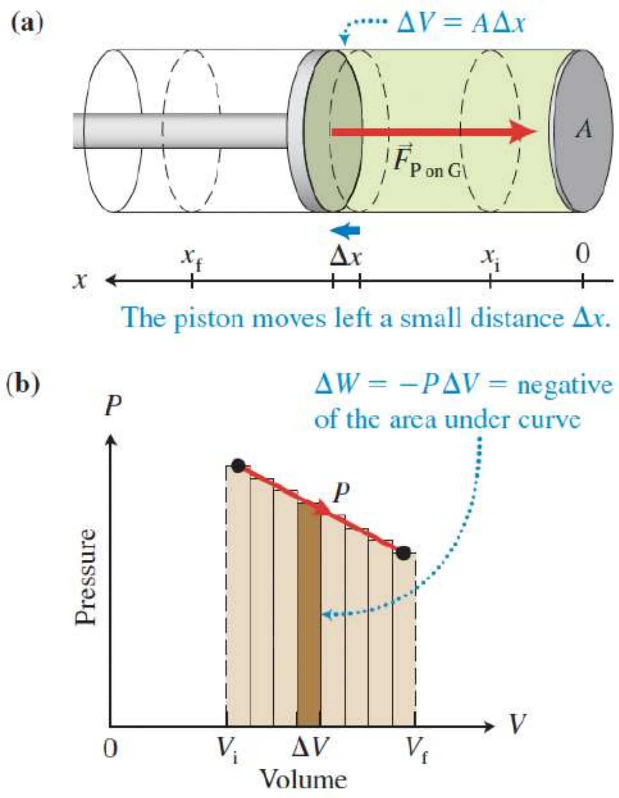
b. Does the force that the piston exerts on the gas do work on the gas? Is the work positive or negative?

c. How can you represent this work mathematically?

d. Revise the expression you wrote in part **c**. to use pressure and volumes instead of force and distance. If you are having difficulties, consult the derivation in sub-section “Work done on a gas” in Section 15.1 in the textbook.

e. Represent this work on a graph of pressure versus volume.

FIGURE 15.2 Determine the work done on a changing volume of gas.



Team 1

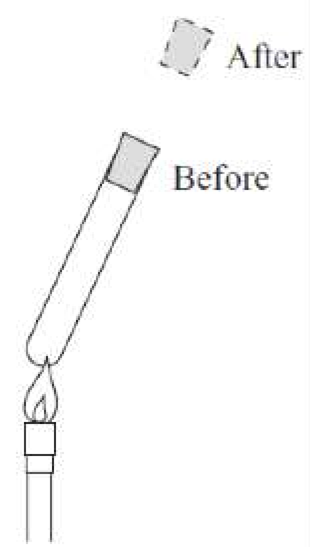
OALG 15.2.1 Observe and explain

Watch the video https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-15-2-1. Answer the following questions:

a. Construct a microscopic explanation for how the hot gas pushes out the stopper. Remember what you learned about molecules of gas, their motion, and the pressure that they exert.

b. Choose the gas inside the test tube, the stopper, and Earth (not the flame) as the system, and use the concepts of work and energy to explain the experiment. If you need a new physical quantity or quantities for your explanation, define them qualitatively.

d. Draw an energy bar chart to explain the experiment using this new physical quantity. The system is the gas and the cork. The initial state is before we started warming up the gas and the final state is when the cork is flying out.



For the bar chart

Internal energy increases because the temperature increases causing the pressure to increase. Work is done by the gas PV, the Force … Pressure makes the cork to move

Team 2

OALG 15.2.1 Observe and explain

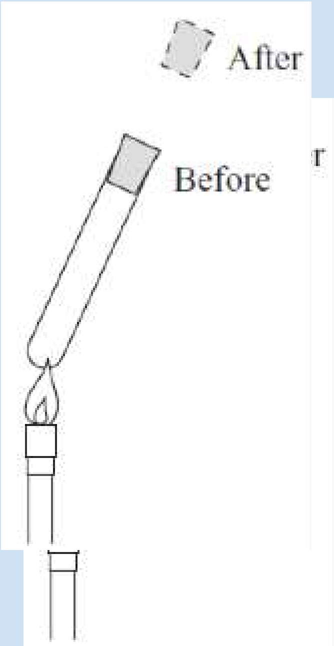
Watch the video https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-15-2-1. Answer the following questions:

a. Construct a microscopic explanation for how the hot gas pushes out the stopper. Remember what you learned about molecules of gas, their motion, and the pressure that they exert.

Gas becomes hotter, gas particles are moving faster, they are hitting more often and harder against the stopper and therefore the pressure that they exert on the stopper is greater.

b. Choose the gas inside the test tube, the stopper, and Earth (not the flame) as the system, and use the concepts of work and energy to explain the experiment. If you need a new physical quantity or quantities for your explanation, define them qualitatively.

d. Draw an energy bar chart to explain the experiment using this new physical quantity. The system is the gas and the cork. The initial state is before we started warming up the gas and the final state is when the cork is flying out.

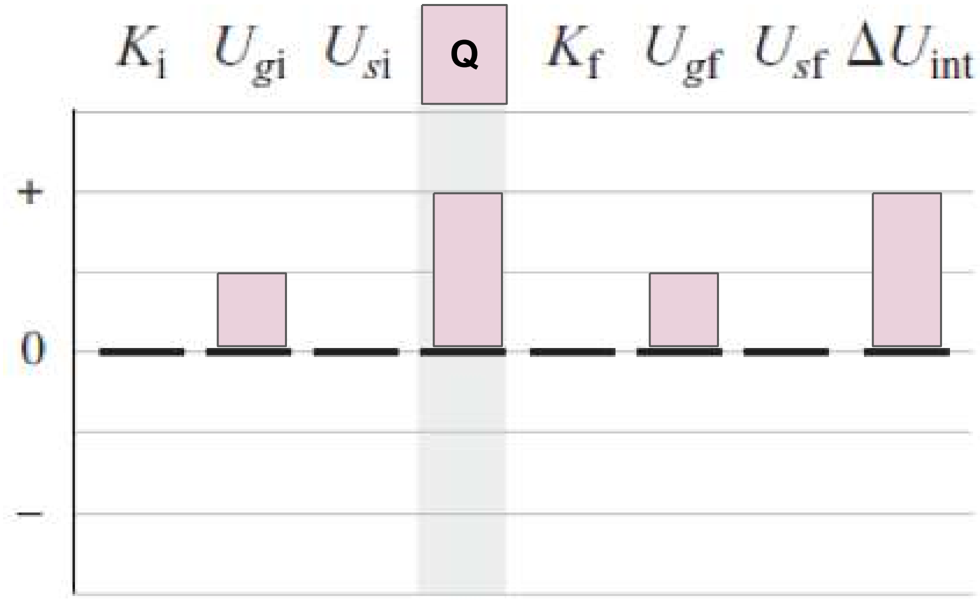


For the bar chart

System: gas inside the test tube, the stopper, and Earth (not the flame)

Initial: before the gas is heated

Final: after the gas is heated (right before stopper flies)



Team 3

OALG 15.2.1 Observe and explain

Watch the video https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-15-2-1. Answer the following questions:
a. Construct a microscopic explanation for how the hot gas pushes out the stopper. Remember what you learned about molecules of gas, their motion, and the pressure that they exert.

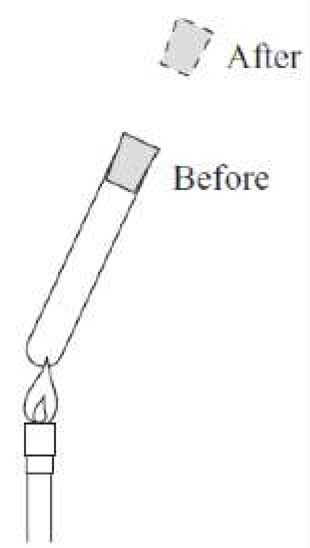
The molecules have a greater average velocity so the change in momentum when colliding with the stopper is larger

b. Choose the gas inside the test tube, the stopper, and Earth (not the flame) as the system, and use the concepts of work and energy to explain the experiment. If you need a new physical quantity or quantities for your explanation, define them qualitatively.

The internal energy of the gas increases.

d. Draw an energy bar chart to explain the experiment using this new physical quantity. The system is the gas and the cork. The initial state is before we started warming up the gas and the final state is when the cork is flying out.

Internal energy → kinetic energy



For the bar chart

Team 4

OALG 15.2.1 Observe and explain

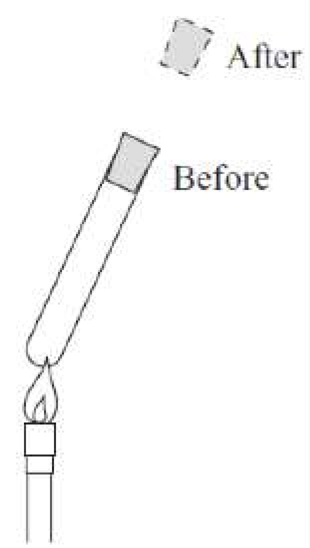
Watch the video https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-15-2-1. Answer the following questions:

a. Construct a microscopic explanation for how the hot gas pushes out the stopper. Remember what you learned about molecules of gas, their motion, and the pressure that they exert.

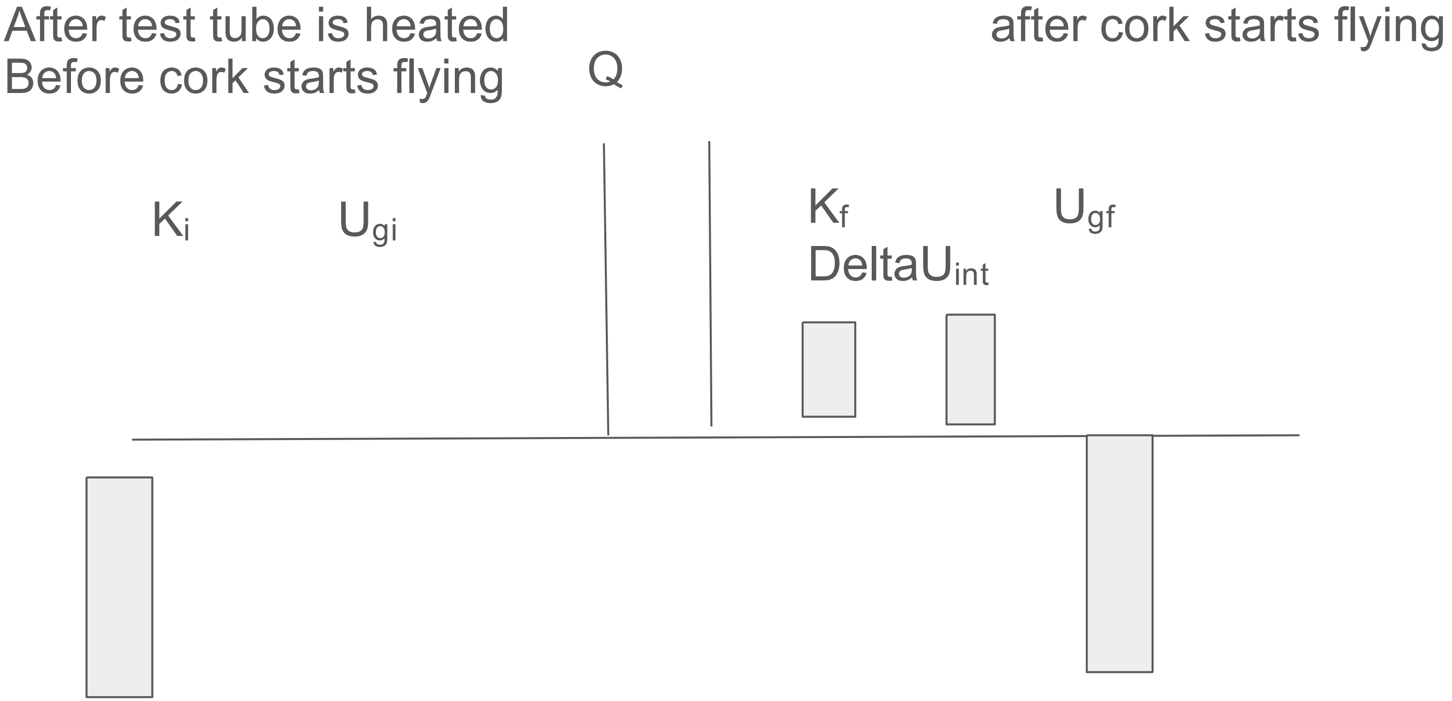
The heat

b. Choose the gas inside the test tube, the stopper, and Earth (not the flame) as the system, and use the concepts of work and energy to explain the experiment. If you need a new physical quantity or quantities for your explanation, define them qualitatively.

d. Draw an energy bar chart to explain the experiment using this new physical quantity. The system is the gas and the cork. The initial state is before we started warming up the gas and the final state is when the cork is flying out.



For the bar chart



Team 1

OALG 15.2.2 Observe and explain

Watch the video of a cup of cold water in an aluminum container being placed in a container with warm water [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-15-2-2]. The video is taken with a thermal camera and allows you to see the change of temperature of the water.

a. Describe what you observe (choose the initial state to be when the cup is outside the container and the final state when cup is inside and the temperature reaches some intermediate value).

b. Consider the water in the cup as the system and explain this observed process using your knowledge of molecules and their motion. Then use the generalized work–energy principle developed in Chapter 7 to explain what happened to the cold water. If you cannot explain this process with this principle, try to modify the principle (for example, introduce a new physical quantity) to account for your observations.

c. Repeat part **b.**, only this time consider the water in the container as the system.

d. Use your knowledge of molecules and their motion to explain the reasoning behind when two liquids of different temperatures mix together, the mixture will eventually reach some intermediate temperature (called the *equilibrium temperature*).

All together

OALG 15.2.3 Observe and explain

Equipment: two pieces of paper.

Vigorously rub two pieces of paper together, pressing the fingers of each hand firmly on the paper as you rub it. Consider one piece of paper as the system. Why did the thermal energy of that piece of paper increase?

$$E_i + Q + W = E_f$$

All together OALG 15.3.2 OALGChapter 15 Final.docx

Team 1 OALG 15.3.3 OALGChapter 15 Final.docx

Gas is the system.

Team 2 OALG 15.3.3 OALGChapter 15 Final.docx

Gas is the system.

Team 3 OALG 15.3.3 OALGChapter 15 Final.docx

Gas is the system.

Team 4 OALG 15.3.3 [OALGChapter 15 Final.docx]

Gas is the system.

Together OALG 15.3.4 [OALGChapter 15 Final.docx]

A note about temperature, thermal energy, and heating

We’ve learned that energy can only be transferred spontaneously through heating when the temperatures of
environment are different. This is different than saying that their thermal energies must be different. Imagine a s
temperature placed in a bathtub filled with water at room temperature. Although the water in the bathtub ha
energy than the spoon does, there is no energy transfer from the water to the spoon.

The spoon and bathtub example highlights the difference between three physical quantities: temperature, t
heating. Temperature is the physical quantity that quantifies the *average* random kinetic energy of the indiv
comprise the object. Temperature does not depend on the number of particles in the object. Thermal energy is
that quantifies the *total* random kinetic energy of all the particles. Adding more particles at the same temper
increases the system’s thermal energy. Heating is the physical quantity that quantifies the *process* through whi
thermal energy is transferred between the system and the environment when they are at different temperatures. I
the same temperatures but different thermal energies, there is no transfer of energy between them through heatin

All together OALG 15.4.1 OALGChapter 15 Final.docx

Return to the Need to Know

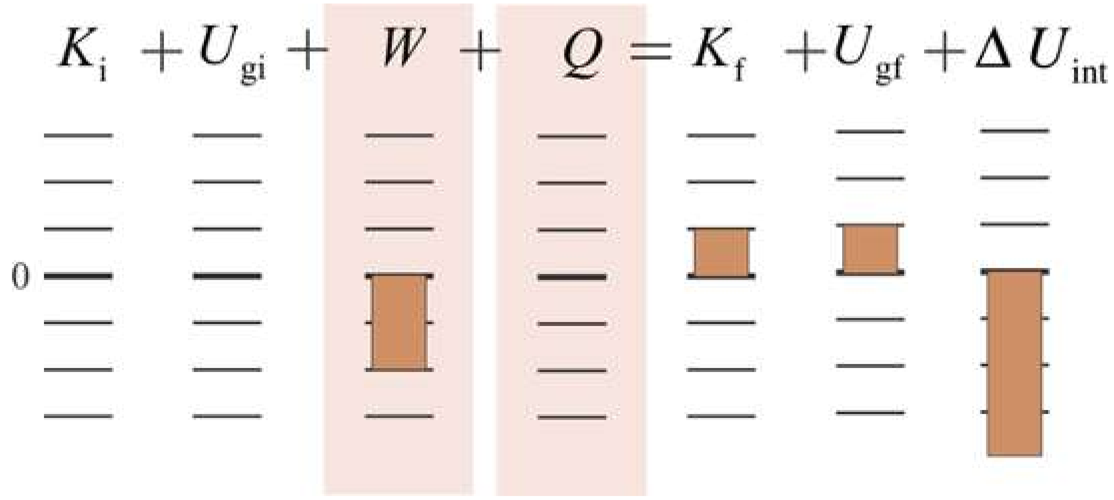
https://youtu.be/lN5datUGEMU

How do you explain the process using gas/water as the system?

Initial state is right before Finn opens the valve and the final state is after some water has shot from the container and has not yet reached the maximum height of several meters.

How do we represent this with a bar chart?

How can we test this explanation?



Initially the kinetic energy and the gravitational potential energy are zero. When Finn opens the valve, the air in the container starts expanding, pushing water out from the container. As a result, water starts moving out from the container ($K_f > 0$) and rising up in the air ($U_{gf} > 0$). At the same time the center of mass of water in the container moves down a little bit, but the corresponding decrease in U_{gf} is much smaller than the increase due to the water jet rising up. As the water is emerging from the container the ambient pressure (about 1 bar) is exerting a force on water that is directed opposite to the displacement of water, therefore doing negative work on the system (note, that if the ambient pressure was lower, the water would rush out from the nozzle at higher speed). As air molecules in the container are hitting the downward moving water surface, their average speed after the collision with water decreases (adiabatic expansion). As a result, the internal energy (and the temperature) of the gas decreases.

Return to the Need to Know

Testing experiment

https://youtu.be/Rw3mcK6PPho

What did you learn today?

I learned that Energy is always conserved, but is not always constant.

How to add “heating” to a bar chart

When a gas expands the environment does negative work because of the pressure of the environment (in vacuum a gas expands and it doesn’t change temperature).

Today really put together the 1st law of thermodynamics, heating is process, I liked the bar charts and the discovery method of putting together everything

When we graph the iso processes (PV, PT, VT) the shape of one of the paths on each graph looks similar to the directly proportional and inversely proportional graphs.

My ideas that were vague until now have become clearer.

Heating is a process not a thing and where it is on the bar chart.