Early E. C.:	/ 1
Total HW Points Unit 2.A:	/ 22
Total Lab Points Unit 2.A:	/ 18
Unit 2.A Apps.:	/ 5
Late, Incomplete, No Work, No Units Fee?	Y / N

Unit 2 – Kinetic Theory, Heat, and Thermodynamics:

2.A.1 Problems – Temperature and Heat

Sections 10.1 – 10.2 of your book.

Possible 2.A.1 Pts.:	5
Late, Incomplete, No work, No Units Fee:	-1 -2 -3
Final Score:	/ 5

Convert the following to Celsius and Kelvin temperatures:

1. 80.0 ^{o} F

2. 0.0 ^{o}F

3. 355 K

4. During open heart surgery, it is common to cool the patient's body down to slow blood processes and gain an extra margin of safety. A drop of 8.5 ^{o}C is typical in these types of operations. If a patient's normal body temperature is 98.2 ^{o}F, what is her final temperature in both Celsius and Kelvin?

5. There is one temperature at which the Celsius and Fahrenheit scales have the same reading. Determine what this is mathematically.

Possible 2.A.2 Pts.:	6
Late, Incomplete, No work, No Units Fee: -1 -2 -3	
Final Score:	**/ 6**

2.A.2 Problems – Gas Laws

Section 10.3 of your book.

1. Gas in a 1.2 L piston triples in pressure at constant temperature. By what factor does the volume change?

2. Gas inside a frictionless piston is heated from 25 °C to 400 °C. What's the new volume, if the original volume was 2.54 L?

3. 401 moles of gas are stored at 131 kPa in a 450 L tank. What is the temperature of the gas in Kelvins and degrees Celsius?

4. How many moles are in: 245.0 grams of water?

5. A cubic meter of carbon dioxide gas at room temperature (300.0 K) and atmospheric pressure (101 kPa) is compressed into a volume of 0.10 m^3 and held at a temperature of 260 K. What is the pressure of the compressed CO_2?

6. A steel belted radial automobile tire is inflated to a gauge pressure of 30.0 psi (lb/in^2) when the temperature is 61 ^oF. Later in the day, the temperature rises to 100 ^oF. Assuming the volume of the tire remains constant, what is the tire's pressure at the elevated temperature? Hint: remember that the ideal gas law uses absolute pressure.

Possible 2.A.3 Pts.:	6
Late, Incomplete, No work, No Units Fee: -1 -2 -3	
Final Score:	/ 6

2.A.3 Problems – Thermal Expansion
Section 10.4 of your book.

A steel beam 10.000 m long is installed in a structure at exactly 20.000 ^{o}C. What is the beam's length when the temperature reaches the following two temperatures:

1. -25 ^{o}C

2. 45 ^{o}C

3. A gold wedding ring has an inner diameter of 2.4 cm at 20.0 ^{o}C. If the ring is dropped into boiling water (100.0 °C), what will be the change in the inner diameter of the ring?

4. What temperature change would cause a 0.200% increase in volume of a quantity of water that was initially at 20.0 ^{o}C?

A copper block has an internal spherical cavity with a 10.00 cm diameter. The block is heated in an oven from 20.0 ^{o}C to 500.0 K. Use this to answer 5 and 6.

5. Does the cavity get larger or smaller? Explain.

6. What is the change in the cavity's volume?

Possible 2.A.4 Pts.:	5
Late, Incomplete, No work, No Units Fee: - 1 - 2 - 3	
Final Score:	/ 5

2.A.4 Problems – Kinetic Theory of Gases
Section 10.5 of your book.

1. The average kinetic energy per molecule of a monatomic gas is 1.0 E -21 J, what is the Celsius temperature of the gas?

2. 2.8 moles of a monatomic gas cools from 150 °C down to 120 °C, what is its internal energy change?

3. Natural gas is odorless; to alert people to gas leaks, the gas company inserts an additive that has a distinctive scent. When there is a gas leak, the additive reaches your nose before the gas does. What can you conclude about the masses of the additive molecules and gas molecules?

4. What is the rms speed of the molecules in low-density oxygen gas at 0 ^{o}C? The mass of an oxygen molecule, O_2, is 5.31 E -26 kg.

5. If 1.0 mol of a monatomic gas has a total internal energy of 5.0 E 3 J at a certain temperature, what is the total internal energy of 1.0 mol of a diatomic gas at the same temperature?

AP Physics 2	Unit 2.A.1 Lab - Boyle's Law
Reminder: Update Table of Contents	Correction Credit: Half

Lab Overview:

Your mission is to experimentally determine the constant of pressure times volume (Boyle's relation) for a closed cylinder. You will need to compare different constants for several different measurements.

Later, you will have a review session on Excel.

Boyle's Law Lab (2.A.1) Scoring Guide		
Table of Contents, Title/Date, Detailed Synopsis, Two Purposes		/ 2
Mission 1: Data Gathering	Cylinder Radius	/ 1
	Maximum Distance	/ 1
	Maximum Volume	/ 2
Mission 2: Excel Tutorial	Data Table Present	/ 2
	Graph Present	/ 2
	Well Labeled	/ 3
Analysis 1: Boyle's relation @ zero displacement		/ 1
Analysis 2: Average Boyle's relation		/ 1
Analysis 3: Smallest volume of gas.		/ 1
Question 1: Sources of error.		/ 2
Work Not Shown Fee:		-1 -2
Late Lab Fee:		-4
Total:		**/ 18**

Materials:

1 – Base Plate
2 – Base Attachment Brackets
2 – Threaded Rods
2 – Skew Connectors
2 – Short Rods
1 – Aluminum Syringe Assembly
1 – Ruler

Note: Gauge Pressure vs. Absolute Pressure

Here on Earth we're at the bottom of an ocean of air. The air above us presses down on us at an average of 1.0 atmosphere (1.0 Bar, 101 kPa, or 14.7 psi) of pressure at sea level. Often, when we measure the pressure of something (like a tire) using a gauge, we report what's seen on the gauge (called gauge pressure). In the US, this is often abbreviated to "psig:" pounds per square inch – gauge.

In this lab we need to account for atmospheric pressure. We will be adding atmospheric pressure to our gauge pressure to obtain our absolute pressure measurement.

Mission 1 – Data Gathering:

Use the construction equipment to make an experimental setup. There is one at the front of the room that you may use as a model.

Determine and record 1. cylinder radius (of cavity), accounting for wall thickness; 2. the maximum distance that the plunger can travel; and 3. the maximum volume of air that your cylinder can hold (at zero displacement). During the Excel graphing session later, you will have to add 2.2 cm^3 to your value – this is the volume of the neck of your apparatus.

Measure and record raw data of the gauge pressure of your system (in **Bars**) for up to nine different 1.0 cm displacements of the plunger, including a displacement of 0 of the plunger. When your displacement maxes out the pressure gauge, take no further data. Note: The air inside the cylinders needs a couple seconds to cool off after compression. Compile data in useable table in you Lab Notebook which you can transcribe into Excel later.

<u>Mission 2: Graph & Microsoft Excel Tutorial</u>

Open up a new file in Microsoft Excel. Enter all the following items, and build borders around all cells as shown. I will be walking students through this part, as well as the programming needed to enter formulas and produce graphs. At the end of the Resource section there is a quick guide to Excel.

Boyle's Law Lab Data Set - Enter the following data into Excel during the graphing tutorial.						
Displace-ment (cm)	Measured Pressure (bars)	Absolute Pressure (Bars)	Absolute Pressure (Pa)	Total Volume (cm^3)	Total Volume (m^3)	Boyle's Relation = P•V (N•m or J)
0.00						
1.00						
2.00						
3.00						
4.00						
5.00						
6.00						
7.00						
8.00						
Conversion Factors, Corrections, Etc.						
	Atmospheric Correction (Bars)	Conversion: Bars to Pa	Cylinder Radius (cm)	Maximum Displacement (cm)	Neck Volume (cm^3)	Conversion: cm^3 to m^3
Factors:	1.01	100000			2.2	0.000001

Print this data table on the same sheet as your graph (if possible) (4 points).

Make a well-labeled, titled graph of displacement vs. Boyle's Relation with your data points. Be sure to label the axes correctly, with respect to independent vs. dependent variables (4 points).

<u>Analysis</u>. Answer these completely in you Lab Notebooks, showing your work for full credit.

1. What was your Boyle's relation at no displacement?

2. What is the average Boyle's relation for your first six measurements?

3. What was the maximum displacement of your system? In other words, what was the smallest volume of gas that you obtained (without maxing out the system)?

Question. Rephrase and answer in complete sentences for full credit (1 - 3: 1 Point Each).

1. What were the sources of error in your experiment? <u>Explain</u> this thoroughly (2 points).

AP Physics 2	Unit 2.A - Kinetic Theory				
Application Problems, AP Test Preparation Questions					
Presentation Points:	/ 5	Late Fee:	-2	Completion (Booklet Check)	/ 5

Your grade on this problem set will depend on the presentation you provide for your problem, and whether they are complete when you submit your Booklet at the end of the Unit.

1. It's 445 Kelvin. What's that in °C?

2. Explain what happens to a gas when it is warmed up in a rigid container.

3. Explain what happens to a gas when it is warmed up in a balloon.

4. 13 L of gas at 5.0 atm is compressed to 5.0 L (constant temperature). What is the final pressure?

5. 25 L of gas at 50 °C is heated to 150 °C and allowed to expand freely. What will the volume be?

6. A patient receiving breathing therapy purchases a filled oxygen (O_2) tank. The tank has a volume of 2.5 L, and is filled with pure oxygen to an absolute pressure of 100 atm at 20 °C. How many moles of oxygen are in the tank? What is the mass of oxygen in the tank?

7. What will the length of a 15.0000 m aluminum rail be if it is cooled from 450.0 °C to 255 °C?

8. What will the volume of 15.00 L of water at 15 °C be if it's temp. is increased to 75 °C?

9. What is the RMS speed of the following data set: 230 m/s, 280 m/s, 290 m/s, and 150 m/s?

10. An argon tank used for welding (volume = 25.0 L) at 25.0 °C contains 520 moles of gas. How much internal energy does the entire gas sample contain? How much energy per atom? Argon is monatomic.

Unit 2.A Practice AP Multiple Choice Questions

The following problems (multiple choice and free response) are designed to train you to take the AP Physics 1 test in the spring, and will be scored at the end of the Unit – based on completion and accuracy.

1. At constant temperature, an ideal gas is at a pressure of 30 cm of mercury (another unit of pressure: 1 cm Hg = 1300 Pa)and a volume of 5 L. If the pressure is increased to 65 cm of mercury, the new volume will be
   a. 10.8 L b. 2.3 L c. 0.43 L d. 1.7 L

2. At constant volume, an ideal gas is heated from 75 °C to 150 °C. The original pressure was 1.5 atm. After heating, the pressure will be
   a. doubled b. halved c. the same d. less than doubled

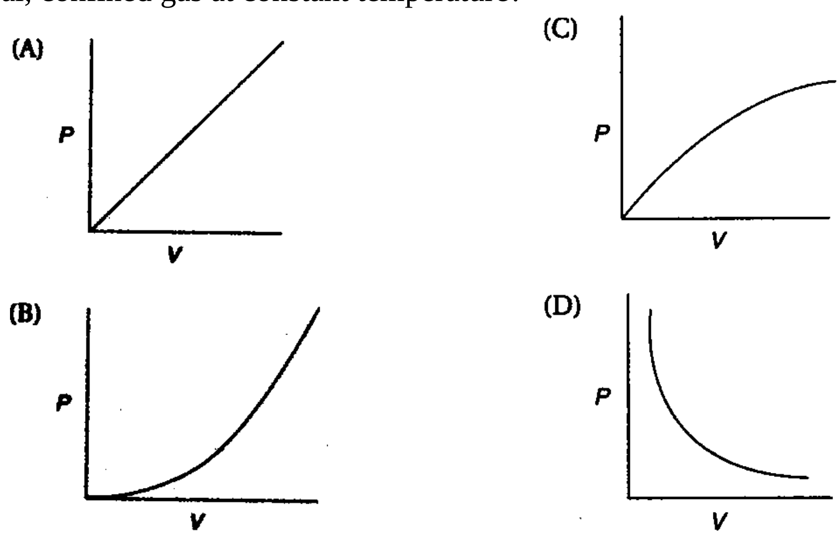
3. At constant pressure, 6 m^3 of an ideal gas at 75°C is cooled until its volume is halved. The new temperature of the gas will be
   a. 174 °C b. 447 °C c. -99°C d. 37.5 °C

4. As the temperature of an ideal gas increases, the average kinetic energy of its molecules
   a. increases, then decreases b. decreases c. remains the same d. increases

5. The product of pressure and volume is expressed in units of
   a. pascals b. kilograms/Newton c. watts d. Joules

6. Which of the following is equivalent to 1 Pa of gas pressure?
   a. 1 kg/s^2 b. 1 kg•m/s c. 1 $kg•m^2/s^2$ d. 1 $kg/m•s^2$

7. Which of the following graphs represents the relationship between pressure and volume for an ideal, confined gas at constant temperature?



Unit 2.A Example AP Question – Free Response

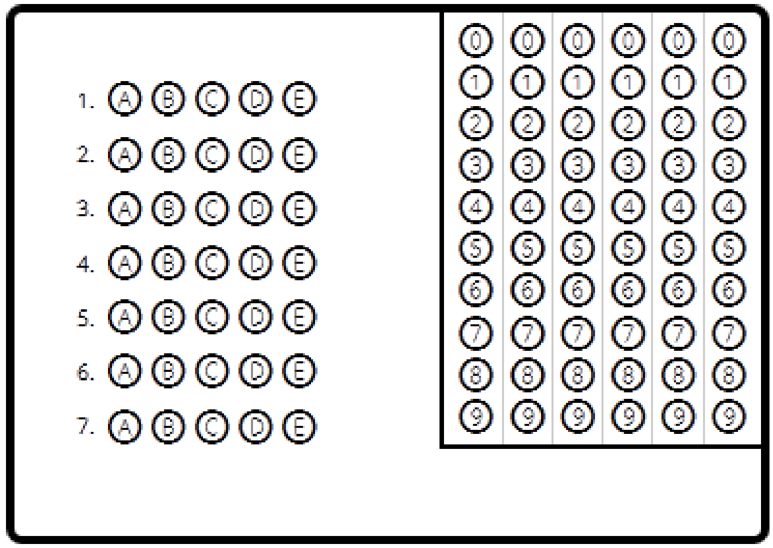
1. How many atoms of helium are required to fill a spherical balloon with a diameter of 50 cm at a temperature of 27 °C?

2. What is the average kinetic energy of each atom of helium?

3. What is the root-means-squared (rms) velocity of each atom of helium?

AP Physics 2	Unit 2.A Review - Kinetic Theory					
Points:	**/ 14**	**Late or Incomplete Fee:**	**-2 -4 -6**	**Correction Credit:**		**Final Score:**	

Solve these problems here, THEN enter your responses in the bubble sheet provided.
Each question is worth two points.



1. A steel cable spanning a river is 200.000 m long when the temperature is 20.0 °C. What will its length be when the temperature drops to 0.0 °C? (The coefficient of thermal expansion of steel is 12.0 E – 6/K)

A) 0.048 m B) 198.952 m
C) 199.952 m D) 200.048 m
E) 200.146 m

2. Consider an aluminum rod encircling the Earth (radius 6378. km). If the linear thermal expansion coefficient of the aluminum is 24.0 E – 6/˚C, and if the temperature of the rod increases by 1.0 C°, how high off the ground would the expanded ring be (assuming uniform space all around)?

A) 50.0 m B) 100. m C) 125 m D) 150 m E) 155 m

3. A mercury thermometer has a bulb of volume 0.100 cm^3 at 10.0 °C. The capillary tube above the bulb has a cross-sectional area of 0.012 mm^2. The thermal expansion coefficient of volume for mercury is 1.80 E – 4/K. How much will the mercury rise when the temperature rises to 30.0 °C?

A) 25 mm B) 27 mm C) 30. mm D) 32 mm E) 35 m

4. How many moles are there in 2.0 kg of copper?

A) 32 moles B) 36 moles C) 41 moles D) 44 moles E) 48 moles

5. At what temperature is the average kinetic energy of an atom in helium equal to 6.21 E – 21 J?

A) 280. K B) 300. K C) 310. K D) 320. K E) 340 K

Given the following four speeds (in m/s) 16.0, 22.0, 36.0, and 38.0:

6. What is the average speed?

A) 24 m/s B) 28 m/s C) 32 m/s D) 36 m/s E) 44 m/s

7. What is the RMS speed of the previous problem?

A) 26.5 m/s B) 27.5 m/s C) 28.5 m/s D) 29.5 m/s E) 33.3 m/s