

SI Chemistry - Full Discipline Demo

Ideal Gas Law

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Classify each statement as true or false.

⚡ A graph of volume versus 1/pressure displays a linear relationship.	
⚡ Boyle's law describes the relationship of a gas's pressure and temperature at constant volume.	
⚡ Force is equal to mass times acceleration.	
⚡ Gas particle collisions decrease as volume decreases.	
⚡ Pressure is the ratio of force per unit area.	
True	False
1	2

Correct answers:

1 Force is equal to mass times acceleration.

Pressure is the ratio of force per unit area.

A graph of volume versus 1/pressure displays a linear relationship.

2

Boyle's law describes the relationship of a gas's pressure and temperature at constant volume.

Gas particle collisions decrease as volume decreases.

Match each term with the best description.

⚡ $A = \pi r^2$ ⚡ k ⚡ Newton ⚡ Pascal	➡	Constant value used in Boyle's law International System unit of force Area of a circle International System unit of pressure	1 2 3 4
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Correct answers:

1 k 2 Newton 3 $A = \pi r^2$ 4 Pascal

According to the ideal gas law, match the relationship between the following properties and how they relate to volume of an ideal gas.

⚡ Direct Relationship ⚡ Inversely proportional	➡	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="padding: 5px;">Temperature</th> <th style="padding: 5px;">Amount</th> <th style="padding: 5px;">Pressure</th> </tr> </thead> <tbody> <tr> <td style="height: 40px; position: relative;"> 1 </td> <td style="height: 40px; position: relative;"> 2 </td> <td style="height: 40px; position: relative;"> 3 </td> </tr> </tbody> </table>	Temperature	Amount	Pressure	1	2	3
Temperature	Amount	Pressure						
1	2	3						

Correct answers:

1 Direct Relationship 2 Direct Relationship

3 Inversely proportional

Exploration

The gas phase of matter has no fixed volume or shape.

- ☒ True ✓
- ☐ False

What is the relationship between temperature and volume?

- ☐ Inverse
- ☒ Direct ✓
- ☐ No Relationship

For defining standard temperature and pressure of an ideal gas, what is the temperature for STP?

- ☐ 0 K
- ☐ 100 K
- ☒ 273 K ✓
- ☐ 1000 K

The relationship between volume and moles for an ideal gas is a direct relationship.

- ☒ True ✓
- ☐ False

When volume of gas in a closed system decreases, the pressure of the gas in the system ____.

- ☐ decreases
- ☒ increases ✓
- ☐ remains constant

When pressure is plotted against volume, the relationship is ____.

- ☐ linear
- ☒ nonlinear ✓
- ☐ exponential
- ☐ static

Pressure is dependent upon ____.

- ☐ mass
- ☐ acceleration due to gravity
- ☐ surface area of the force
- ☒ All of above ✓

A Newton is the International System unit of pressure.

- ☐ True
- ☒ False ✓

Exercise 1

State Boyle's law, including the associated equation(s).

Boyle's law states that when a fixed amount of an ideal gas is maintained at a constant temperature, the pressure and volume of the gas are inversely proportional (when one increases, the other decreases). $PV = k$ or $P_1V_1 = P_2V_2$.

What are sources of error for this experiment?

Sources of error include improperly reading the volume of the apparatus, weighing errors with the books, measurement errors from calculating the area of the piston, and air leakage from the apparatus.

Would you expect your experimental results to change if a different gas, such as CO₂, were used instead of air? Explain your answer.

There should not be a difference in the concept; the gas laws (including Boyle's Law) can be applied to all gases.

How does Graph 2 illustrate Boyle's law?

Graph 2 indicates a linear relationship between P and 1/V. The pressure of the gas is inversely proportional to its volume.

A gas sample in a Boyle's law apparatus is compressed to a volume of 22.0 mL. If its original volume was 37.0 mL at 12,000 Pa, what is the new pressure of the gas sample. Show your calculations.

$$P_1V_1 = P_2V_2$$

$$P_2 = (P_1V_1)/V_2 = (37.0 \text{ mL} \times 12,000 \text{ Pa})/22.0 \text{ mL}$$

$$P_2 = 20,000 \text{ Pa}$$

Data Table 1: Calculating Force
(SAMPLE ANSWER BELOW)

Book #	Mass of Book (kg)	Force (N)
1	2.03	19.9
2	2.32	22.8

3	2.43	23.8
4	2.38	23.4
5	2.41	23.6

Data Table 2: Calculating Surface Area
(SAMPLE ANSWER BELOW)

Diameter of Syringe (mm)	27
Diameter of Syringe (m)	0.027
Radius of Syringe (m)	0.014
Surface Area of Syring Tip (m^2)	0.0006

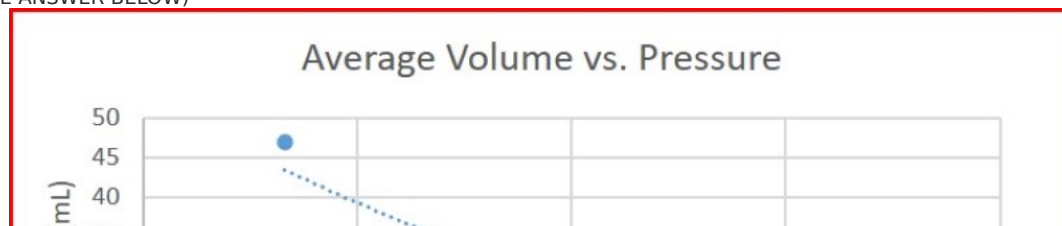
Data Table 3: Calculating Pressure
(SAMPLE ANSWER BELOW)

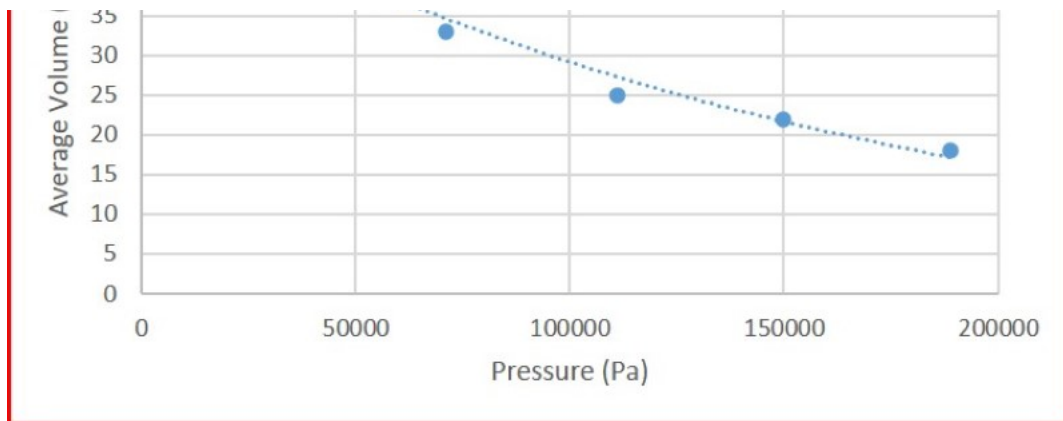
Book #	Pressure (Pa)
1	33,000
2	38,000
3	40,000
4	39,000
5	39,000
1 and 2	71,000
1,2, and 3	111,000
1,2,3, and 4	150,000
1,2,3,4, and 5	189,000

Data Table 4: Volume and Inverse Volume
(SAMPLE ANSWER BELOW)

Book #	Volume: Trial 1 (mL)	Volume: Trial 2 (mL)	Volume: Trial 3 (mL)	Average Volume V_{avg} (mL)	1/Average Volume $1/V_{\text{avg}}$ (1/mL)
1	47	48	45	47	0.021
1,2	32	33	33	33	0.030
1,2,3	25	25	25	25	0.040
1,2,3,4	22	22	22	22	0.045
1,2,3,4,5	18	19	17	18	0.056

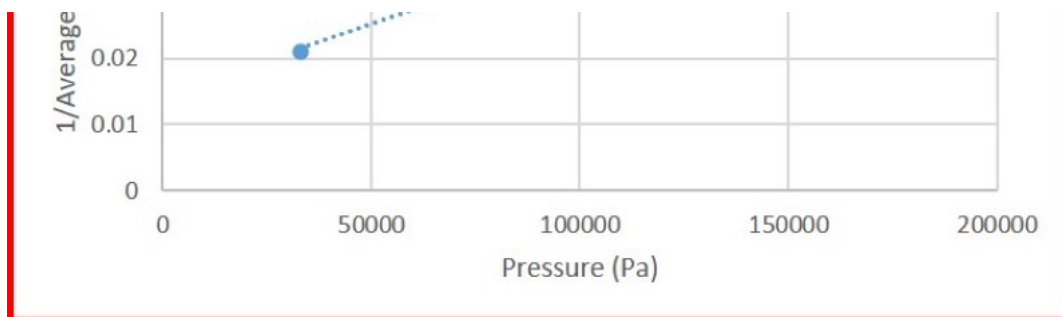
Graph 1: Average Volume vs. Pressure
(SAMPLE ANSWER BELOW)





Graph 2: 1/Average Volume vs. Pressure
(SAMPLE ANSWER BELOW)





Exercise 2

Explain Charles Law. Which variables were held constant in this exercise?

In this experiment the two variable that were tested were temperature and volume. Using the Ideal gas law the amount (moles) and the pressure (atm) were assumed to be kept constant throughout the experiment.

Based on the results you obtained in the Charles Law experiment, if a gas was allowed to heat to 200°C, how would the volume of the gas change?

If the gas was heat from 24°C or 100°C to 200°C this means that the gas is increasing in temperature. Charles Law state that temperature and volume are directly proportional so the gas would increase in volume as the temperature increased.

Data Table 5: Small Tube with Insertable Cap, 12x75 mm
(SAMPLE ANSWER BELOW)

	Data
Temperature of gas at boil inside tube (°C) T_1	90.0
Temperature of gas at room temperature (°C) T_2	17.8
Volume of water partially filling tube (mL) V_p	2.3
Volume of gas in tube at boil (mL) V_1	4.8
Volume of gas in tube at room temperature (mL) V_2	2.5

Data Table 6: Volumetric Flask
(SAMPLE ANSWER BELOW)

	Data
Temperature of gas at boil inside flask (°C) T_1	91.9
Temperature of gas at room temperature (°C) T_2	16.4
Volume of water partially filling flask (mL) V_p	4.9
Volume of gas in flask at boil (mL) V_1	27.4
Volume of gas in flask at room temperature (mL) V_2	22.5

Data Table 7: Small Tube with Flat Cap, 12x75 mm
(SAMPLE ANSWER BELOW)

	Data
Temperature of gas at boil inside tube (°C) T_1	91.0
Temperature of gas at room temperature (°C) T_2	16.0
Volume of water partially filling tube (mL) V_p	2.3
Volume of gas in tube at boil (mL) V_1	4.9
Volume of gas in tube at room temperature (mL) V_2	2.6

Data Table 8: Large Tube, 17x100 mm
(SAMPLE ANSWER BELOW)

	Data
Temperature of gas at boil inside tube ($^{\circ}\text{C}$) T_1	90.9
Temperature of gas at room temperature ($^{\circ}\text{C}$) T_2	16.0
Volume of water partially filling tube (mL) V_p	4.2
Volume of gas in tube at boil (mL) V_1	14.8
Volume of gas in tube at room temperature (mL) V_2	10.6

Competency Review

Gas particles in a closed system ____.

- ☐ are in constant motion
- ☐ move randomly
- ☐ collide with one another and the sides of the container
- ☒ All of the above

✓

A graph that describes the relationship of volume versus the inverse value of pressure ($1/P$) displays a linear relationship.

- ☒ True
- ☐ False

✓

The International System unit of force is the ____, and the unit of pressure is the ____.

- ☒ Newton; Pascal
- ☐ Pascal; Newton

✓

A syringe is filled with gas and sealed to create a closed system. What will happen when the plunger of the syringe is depressed?

- ☐ The volume of the gas will increase.
- ☐ The number of gas particles will decrease.
- ☒ Gas particles will have an increased rate of collisions.
- ☐ Pressure will decrease slightly.

✓

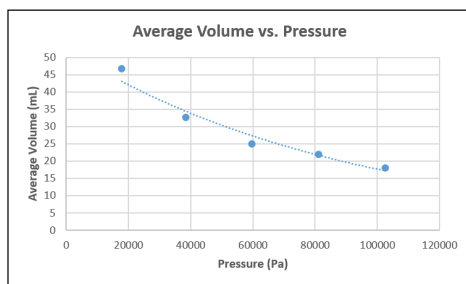
The diameter and radius of the syringe were measured to determine the ____ of the Boyle's law apparatus.

- ☐ surface area
- ☐ volume
- ☐ mass
- ☐ All of the above

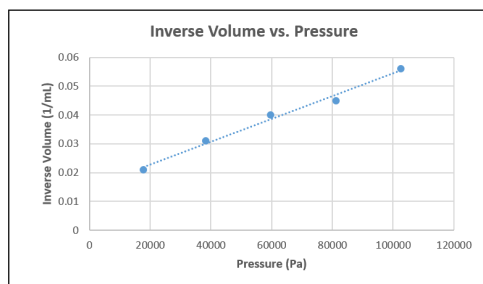


Which scatter plot describes a linear relationship?

A:



B:



- ☐ A
- ☐ B
- ☐ Both A and B
- ☐ Neither A nor B



At a constant temperature the volume of a gas is increased ten times, resulting in the pressure of the gas ____.

- ☐ decreasing by 10 times
- ☐ decreasing by 20 times
- ☐ increasing by 10 times
- ☐ remaining constant



A ____ phase of matter has no fixed volume or shape.

- ☐ solid
- ☐ liquid
- ☒ gas

✓

Charles Law states that ____ and ____ are directly proportional.

- ☒ Temperature; Volume
- ☐ Volume; Amount
- ☐ Volume; Pressure
- ☐ Temperature; Pressure

✓

In the ideal gas law equation, what unit of measurement represents volume?

- ☐ milliliter
- ☒ liter
- ☐ ounce
- ☐ moles

✓

Avogadro's Law states that the relationship between ____ and ____ are directly proportional.

- ☐ amount; temperature
- ☐ temperature; volume
- ☐ pressure; volume
- ☒ volume; amount

✓

_____ states that temperature and pressure are directly proportional.

- ☐ Boyle's Law
- ☐ Charles' Law
- ☒ Gay-Lussac's law
- ☐ Avogadro's Law



Extension Questions

A car engine is powered by the burning of octane (C_8H_{18}) with oxygen (O_2). The combustion reaction forms carbon dioxide (CO_2) and water (H_2O).

a) write a balanced chemical equation for this combustion reaction.

b) Assuming a reaction starts with 1 mole of octane, which burns at $220^\circ C$, and is at a pressure of 1 atm, what volume will the products occupy upon reaction completion?

(SAMPLE ANSWER BELOW)

- a. The balanced chemical equation is $2C_8H_{18} + 25 O_2 \rightarrow 16 CO_2 + 18 H_2O$
- b. 1 mole of C_8H_{18} yields 8 moles CO_2 and 9 moles H_2O with a total of 17 moles. Solving the ideal gas equation $PV = nRT$
 $V = 17 \text{ moles } (0.082 \text{ L}\cdot\text{atm}/\text{K}\cdot\text{mol})(493\text{K})/(1\text{atm})$
 $V = 687 \text{ L}$