Boyle's Law

Describes the relationship between pressure and volume of a gas
As pressure increases volume decreases
This is called an inverse relationship

$V \propto 1/P$

$V \times P = \text{constant}$

Graphs

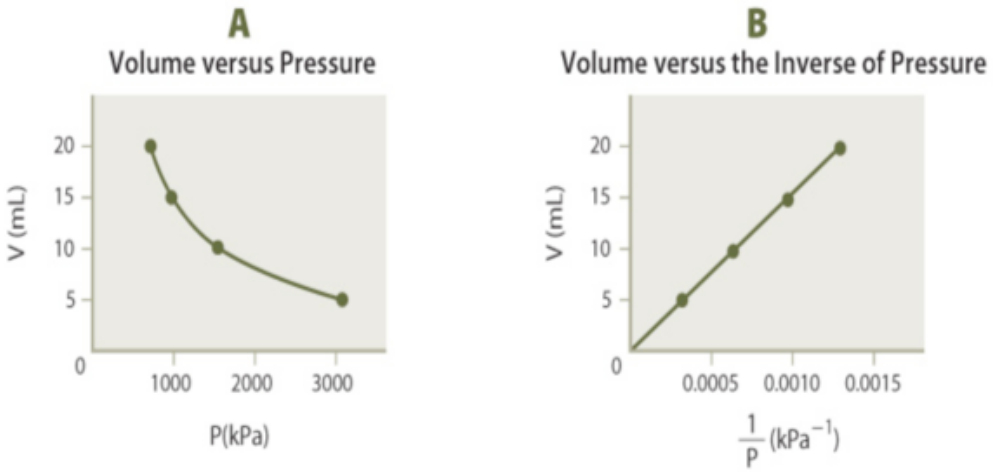


Figure 3.11 The graph for volume versus pressure **(A)** shows an inverse relationship. When you plot volume versus the inverse of pressure **(B)**, you get a straight line.

Equation

$$V_1P_1 = V_2P_2$$

Applies to constant temperature and constant amount (# of moles) of gas

Units of volume and pressure need to be the same on both sides of the equation

Example #1

A sample of gas has a pressure of 750 torr and a volume of 20.5 mL. What will be the new volume of the gas when the pressure is 800 torr?

V_1 P_1 P_2

$$\frac{V_1 \cdot P_1}{P_2} = \frac{V_2 P_2}{P_2}$$

$$\frac{V_1 P_1}{P_2} = V_2$$

$$\frac{(20.5\text{ mL})(750\text{ torr})}{800\text{ torr}} = V_2$$

$$19.2\text{ mL} = V_2$$

Example #2

What will happen to the pressure of a gas if the volume is doubled? (Prove this mathematically)

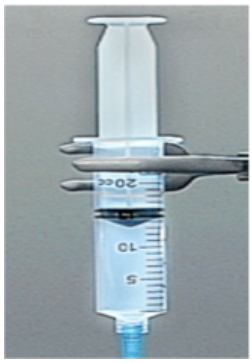
$$V_1 P_1 = V_2 P_2$$

$$\frac{V_1 P_1}{2V_1} = \frac{2V_1 P_2}{2V_1}$$

$$\frac{P_1}{2} = P_2$$

Example #3

A syringe contains 15 mL of gas at a pressure of 101.3 kPa. If the volume of the syringe is reduced to 5.0 mL, what will be the pressure?



$$\frac{V_1 P_1}{V_2} = \frac{V_2 P_2}{V_2}$$

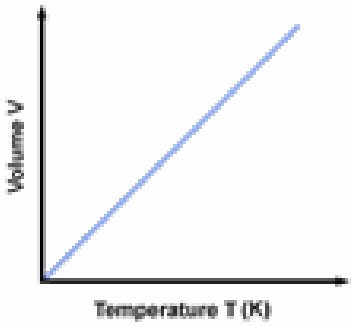
$$\frac{V_1 P_1}{V_2} = P_2$$

$$\frac{(15\text{ml})(101.3\text{ kPa})}{(5.0\text{ml})} = P_2 = 3.0 \times 10^2\text{ kPa}$$

Charles's Law
The relationship between the volume and Kelvin temperature of a gas is direct

as one increases so does the other one

a graph of volume and temperature of a gas is a straight line



Formula

This formula can be used when pressure and moles of gas are constant

T must be in Kelvin

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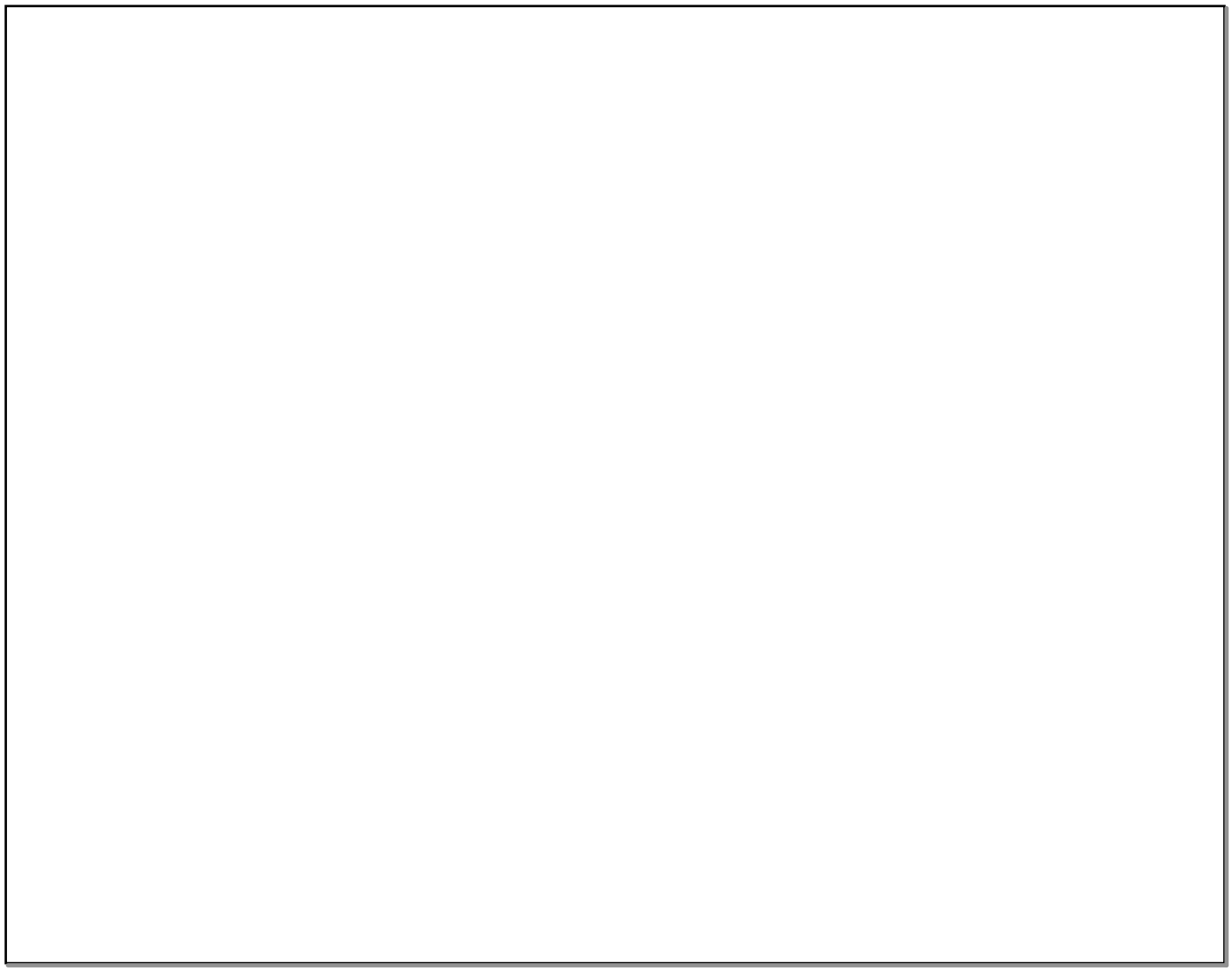

Example 2
What will happen to the volume of a gas if the pressure is tripled? (Prove this mathematically

Example 3

How hot will a 2.30 L balloon have to get to expand to a volume of 400 L? Assume that the initial temperature of the balloon is 25.0 °C.

Boyle's Law or Charles' Law?

A toy balloon filled with air has an internal pressure of 1.25 atm and a volume of 2.50 L. If I take the balloon to the bottom of the ocean where the pressure is 95 atmospheres, what will the new volume of the balloon be if the temperature remains constant?

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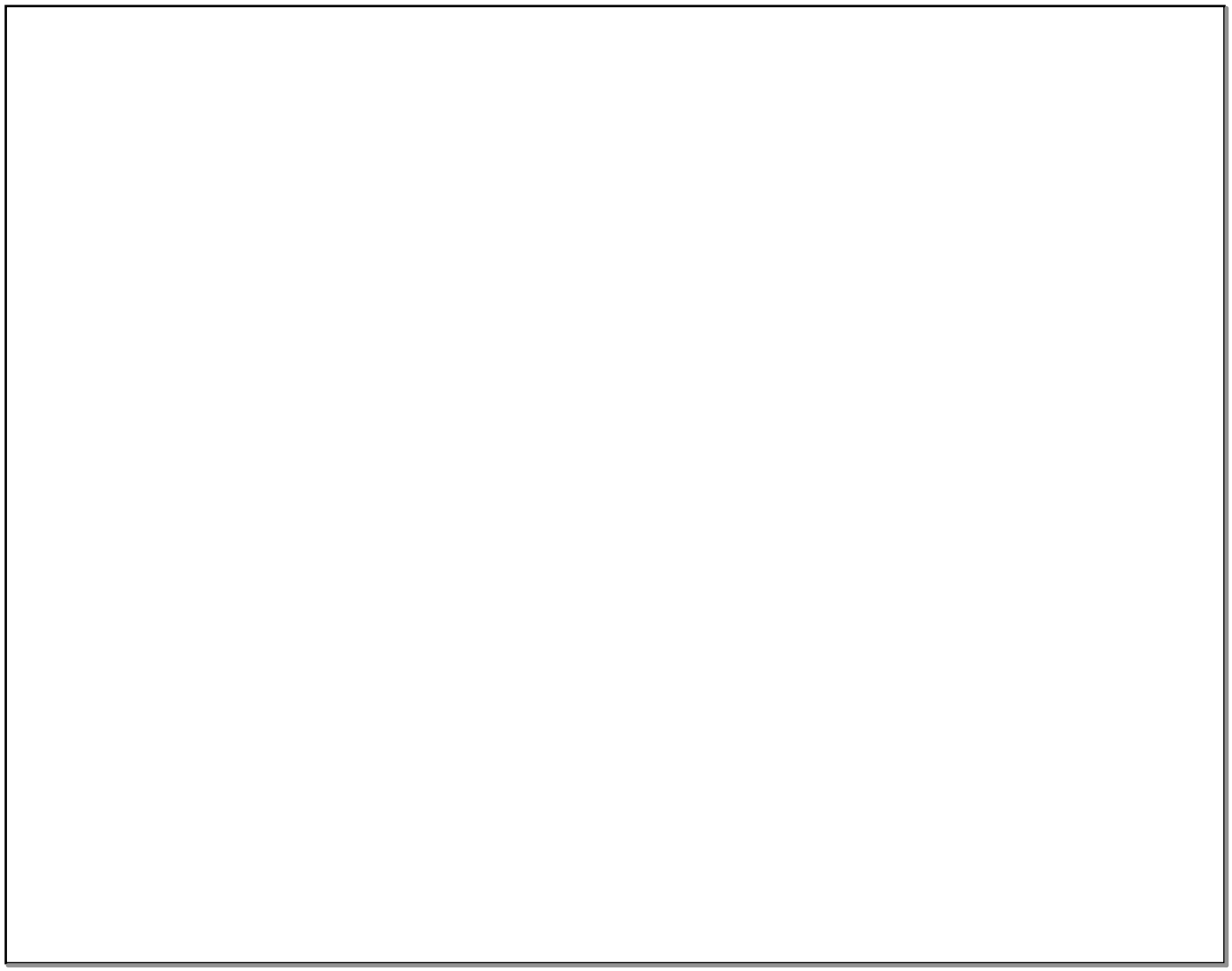

Some students believe that teachers are full of hot air. If I inhale 2.2 liters of gas at a temperature of 18 °C and it heats to a temperature of 38 °C in my lungs, what is the new volume of the gas?

Combined Gas Law

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Example 1
A gas occupies a volume of 20.0 L at a pressure of 5.00 atm and a temperature of 500 K. What will the volume be if the pressure is raised to 10.0 atm and temperature is changed to 250K

Example 2
A cylinder of compressed nitrogen has a volume of 45.0 L and a pressure of 980 kPa and is kept at a temperature of 30.0˚C. The cylinder is heated until it reaches a temperature of 45.0˚C. What will the pressure in the cylinder be after it is heated?

Example 3
If I initially have a gas at a pressure of 500 mm Hg, a volume of 23 liters, and a temperature of 200 K, and then I raise the pressure to 6000 mm Hg and increase the temperature to 300 K, what is the new volume of the gas?

Example 4
I have an unknown volume of gas at a pressure of 0.5 atm and a temperature of 325 K. If I raise the pressure to 1.2 atm, decrease the temperature to 320 K, and measure the final volume to be 48 liters, what was the initial volume of the gas?

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