Outside on a cold winter day a student opened up a cigarette lighter and poured 1.50 grams of liquid butane (b.p. -0.5°C) into an otherwise empty balloon. The balloon was then brought indoors where the temperature was 22°C. If you assume that the pressure was 1 atmosphere, what would be the size of the balloon in liters? If the balloon were to see a spark, it might explode. What volume of air would be needed for the combustion reaction to go to completion?

\[ V = \frac{nRT}{P} \]
\[ T = (273 + 22) \text{ K} \]
\[ m_{\text{wt.}} = 58.1 \]
\[ nRT/P = (1.50 \text{ g}/58.1 \text{ g mol}^{-1})(295 \text{ K})(0.0821 \text{ L atm}^{-1} \text{ mol}^{-1})/1 \text{ atm} \]
\[ V = nRT/P = 0.625 \text{ L} \]

\[ C_4H_{10} + 6.5O_2 \rightarrow 4CO_2 + 5H_2O \quad \text{Air is 21% O}_2 \]
\[ V = nRT/P \]
\[ = 0.625 \text{ L} \]
\[ = 6.5 \times 0.625 = 4.02 \text{ L of O}_2 \]
\[ 4.02 \text{ L O}_2 / (0.21 \text{ L O}_2 \text{ per L air}) = 19.3 \text{ L air} \]
Boyle’s law: \( V \alpha \frac{1}{P} \) (at constant \( n \) and \( T \))

**Charles’ law**

\( PV = nRT \)

\( V \alpha T \)

\( V = \text{constant} \times T \)

\( \frac{V_1}{T_1} = \frac{V_2}{T_2} \)

Temperature must be in Kelvin

\( T(K) = t({}^\circ C) + 273.15 \)

**Ideal Gas Equation**

Boyle’s law: \( V \alpha \frac{1}{P} \) (at constant \( n \) and \( T \))

Charles’ law: \( V \alpha T \) (at constant \( n \) and \( P \))

Avogadro’s law: \( V \alpha n \) (at constant \( P \) and \( T \))

Combining the above, we obtain:

\[ V \alpha \frac{nT}{P} \]

Which becomes:

\[ PV = nRT \]

A sample of chlorine gas occupies a volume of 946 mL at a pressure of 0.955 atm. What is the pressure of the gas (in mmHg) if the volume is reduced at constant temperature to 154 mL?

\[ P_1 \times V_1 = P_2 \times V_2 \]

\[ P_1 = 0.955 \text{ atm} \]

\[ V_1 = 946 \text{ mL} \]

\[ V_2 = 154 \text{ mL} \]

\[ P_2 = \frac{P_1 \times V_1}{V_2} = \frac{0.955 \text{ atm} \times 946 \text{ mL}}{154 \text{ mL}} = 5.86 \text{ atm} \]

A) 0.154 atm  B) 1.56 atm  C) 2.75 atm  D) 5.86 atm

**PV = nRT**

Using “PV=nRT” and “algebra”, we can solve all sorts of problems.

P&V&T Calculations

Stoichiometry

Density

Molecular Weight

Partial Pressure and Mole Fraction
What is the volume in liters of 1 mole of a gas at 0° and 1 atm?  

A 12.2  B 15.3  C 18.7  D 22.4  E 28.3  F 46.2  

**STP** Standard Temperature and Pressure

\[ V = \frac{nRT}{P} = 1 \text{ mol} \cdot 0.082 \text{ L atm K}^{-1}\text{mol}^{-1} \cdot 273 \text{ K} / 1 \text{ atm} = 22.4 \text{ L} \]

22.4 L 1 mol at 0° and 1 atm

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How many Liters in a cubic Meter?  

A 10  B 100  C 1000  

D 10,000  E 100,000  F 1,000,000  

1 L = 1000 cm³  1 m³ = 1000000 cm³

How many grams of N₂ in a cubic meter at STP?  

A about 50  B about 250  C about 500  

D about 750  E about 1000  F about 1250

\[ 28 \text{ g mol}^{-1} \cdot 1000 \text{ L} / (22.4 \text{ L mole}^{-1}) = 1250 \text{ g} \]

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A sample of carbon monoxide gas occupies 3.20 L at 125 °C. At what temperature will the gas occupy a volume of 1.54 L if the pressure remains constant?  

\[ \frac{V_1}{T_1} = \frac{V_2}{T_2} \]

\[ V_1 = 3.20 \text{ L} \quad V_2 = 1.54 \text{ L} \]

\[ T_1 = 398.15 \text{ K} \]

\[ T_2 = \frac{V_2 \times T_1}{V_1} = \frac{1.54 \text{ L} \times 398.15 \text{ K}}{3.20 \text{ L}} = 192 \text{ K} \]

A -81° C  B 33° C  C 60° C  D 265° C