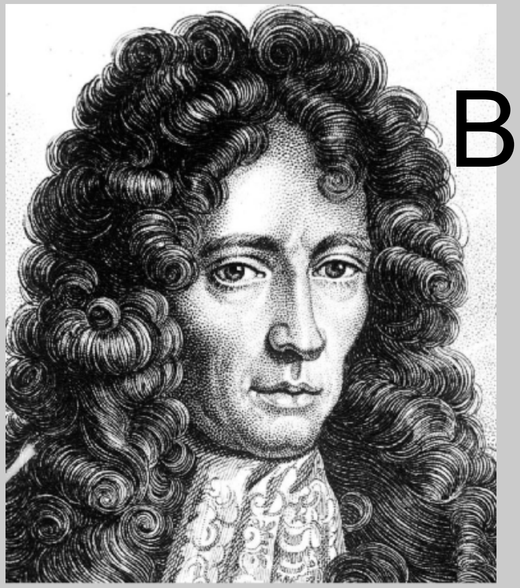


Boyles' Law

P and V

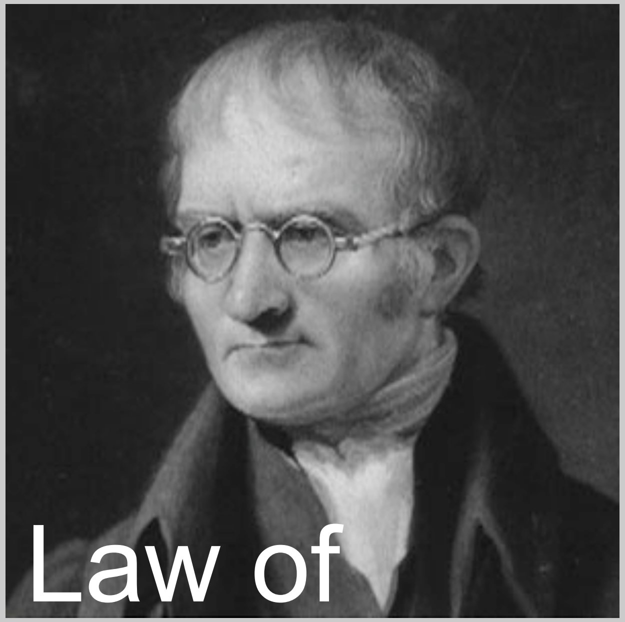
Avogadro's Law

Equal volumes of gases at the same P & T have equal # particles

Gas Laws

Charles' Law

V and T



Dalton's Law of Partial Pressure

$P_1 + P_2 + P_3 \ldots = P_{total}$

Gay-Lussac's Law

P and T

The Combined Gas Law

$$\frac{P_1 V_1}{n_1 T_1} = \frac{P_2 V_2}{n_2 T_2}$$

Remember This ??

The Combined Gas Law

The "Before and After" Gas Law

- Consider 0.5 L of gas in sealed syringe in a 50ºC water bath with a pressure of 200 mmHg. The syringe is compressed to 0.1 L held at 50ºC, what will be the new pressure?

$$\frac{P_1\,V_1}{n_1\,T_1} = \frac{P_2\,V_2}{n_2\,T_2}$$

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The Combined Gas Law

The "Before and After" Gas Law

- Consider 0.5 L of gas in sealed syringe in a 50ºC water bath with a pressure of 200 mmHg. The syringe is compressed to 0.1 L held at 50ºC, what will be the new pressure?

$$\frac{P_1 V_1}{\cancel{n_1} \cancel{T_1}} = \frac{P_2 V_2}{\cancel{n_2} \cancel{T_2}}$$

P_2 = 1000 mmHg

The Combined Gas Law

The "Before and After" Gas Law

- 2 L of oxygen gas in a sealed, rigid metal cylinder is at 0.80 atm at 25ºC. To what temperature, in Celsius should the gas be changed to reduce the pressure to 0.30 atm?

$$\frac{P_1 V_1}{n_1 T_1} = \frac{P_2 V_2}{n_2 T_2}$$

- 2 L of oxygen gas in a sealed, rigid metal cylinder is at 0.80 atm at 25ºC. To what temperature, in Celsius should the gas be changed to reduce the pressure to 0.30 atm?

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The Combined Gas Law

The "Before and After" Gas Law

- 2 L of oxygen gas in a sealed, rigid metal cylinder is at 0.80 atm at 25ºC. To what temperature, in Celsius should the gas be changed to reduce the pressure to 0.30 atm?

25°C + 273 = 298 K

$$\frac{P_1 \cancel{V_1}}{\cancel{n_1} T_1} = \frac{P_2 \cancel{V_2}}{\cancel{n_2} T_2}$$

do NOT use °C in Gas Law equations

$T_2 \neq 9.4$ ºC

$$\frac{0.80 \text{ atm}}{298 \text{ K}} = \frac{0.30 \text{ atm}}{T_2}$$

$T_2 = 112$ K

$-\ 273$

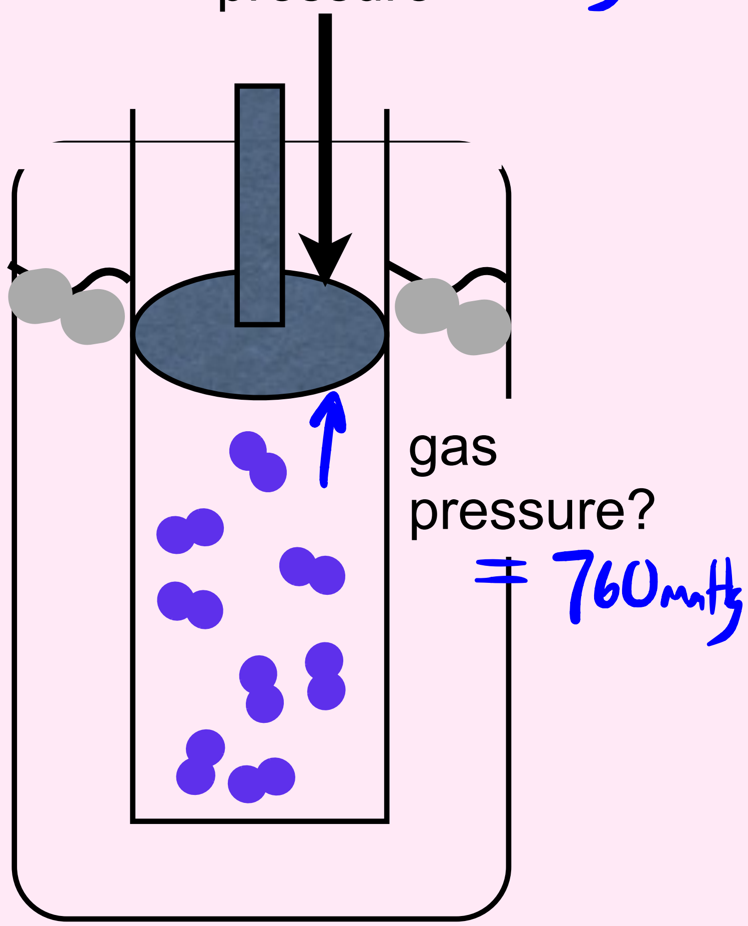
$T_2 = -161$ ºC

Developing the Ideal Gas Law

Just a Manifestation of the Combined Gas Law

Measurements of O_2 gas at particular conditions...

- It just so happens that
  - ✓ 32 g of oxygen, (1 mole)
  - ✓ sealed in a piston cylinder,
  - ✓ plunged into ice water, 0°C
  - ✓ barometric air pressure of 760 mmHg
- The measured volume of the gas will be ???



Measurements of O_2 gas at particular conditions...

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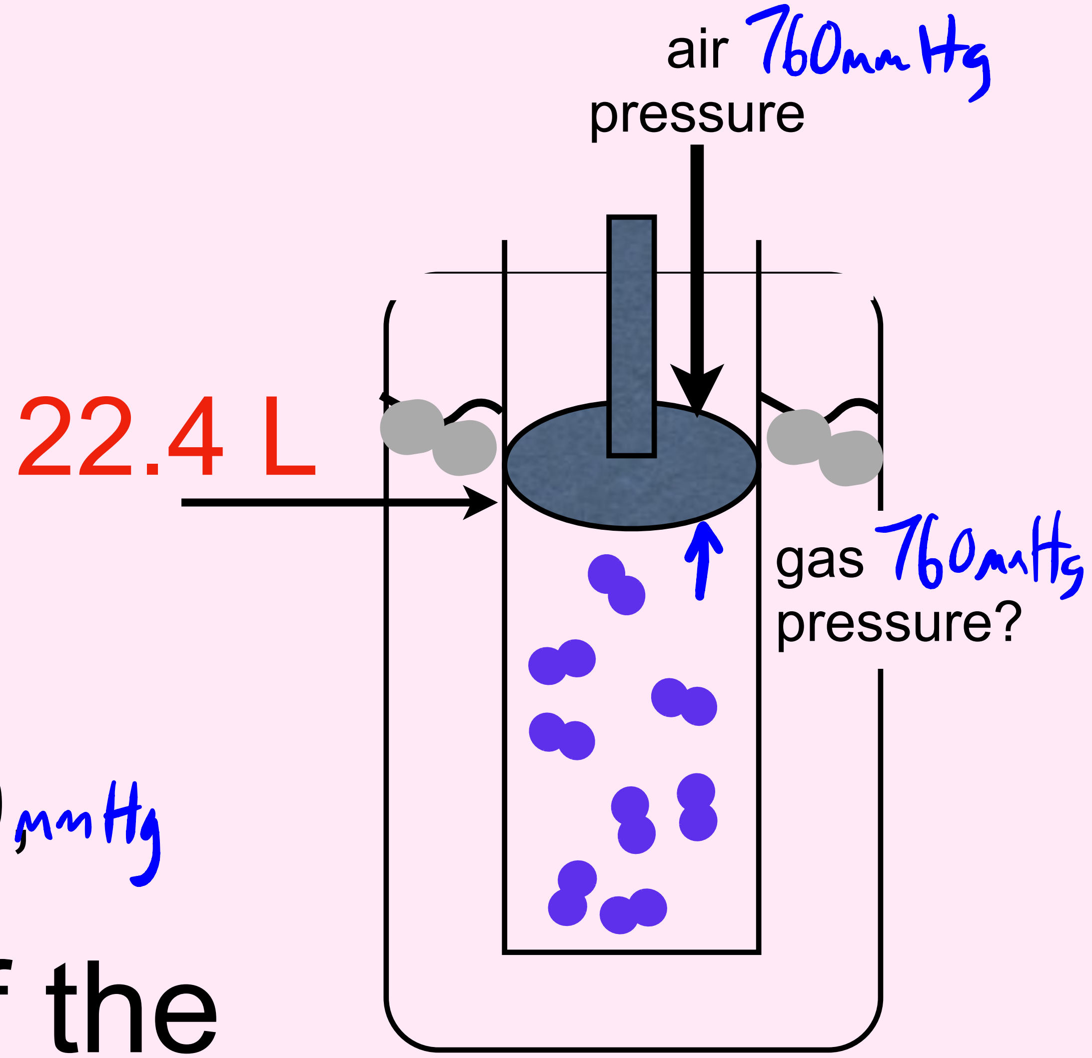
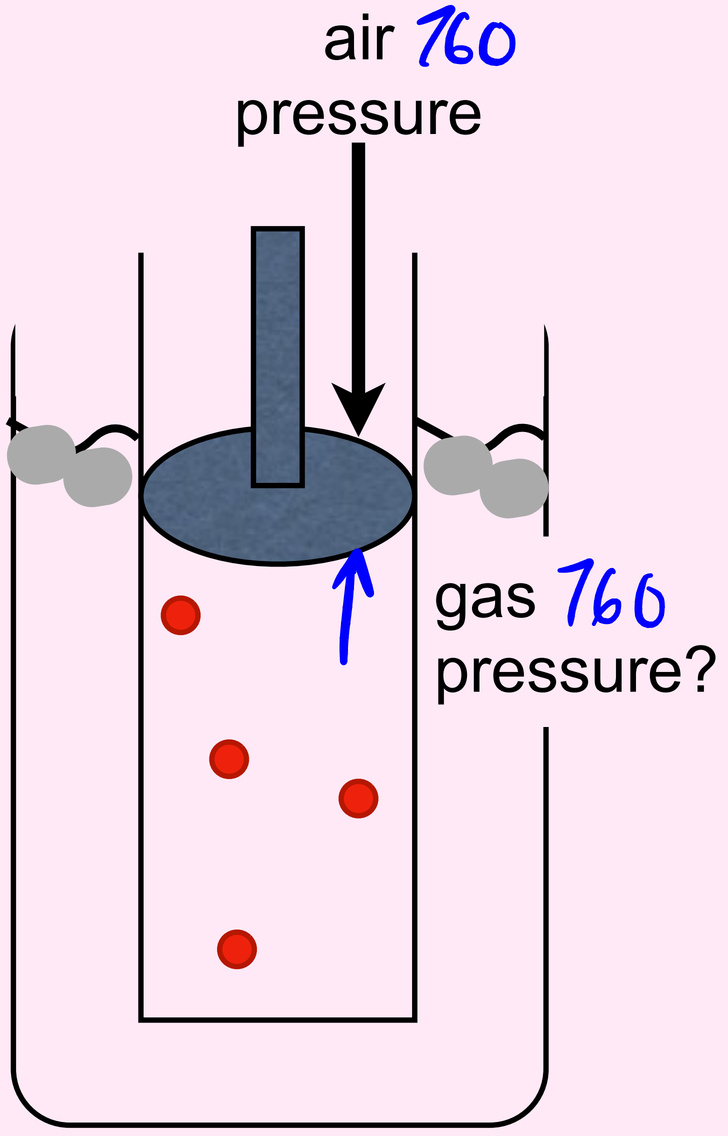


- The measured volume of the gas will = 22.4 L

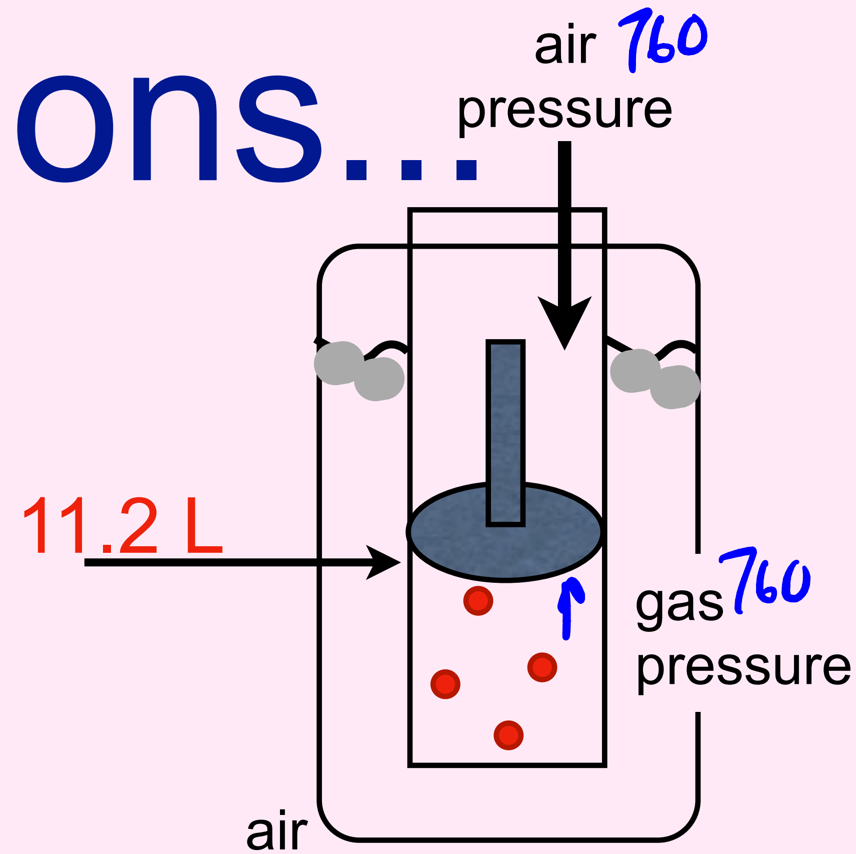
Measurements of He gas at particular conditions...

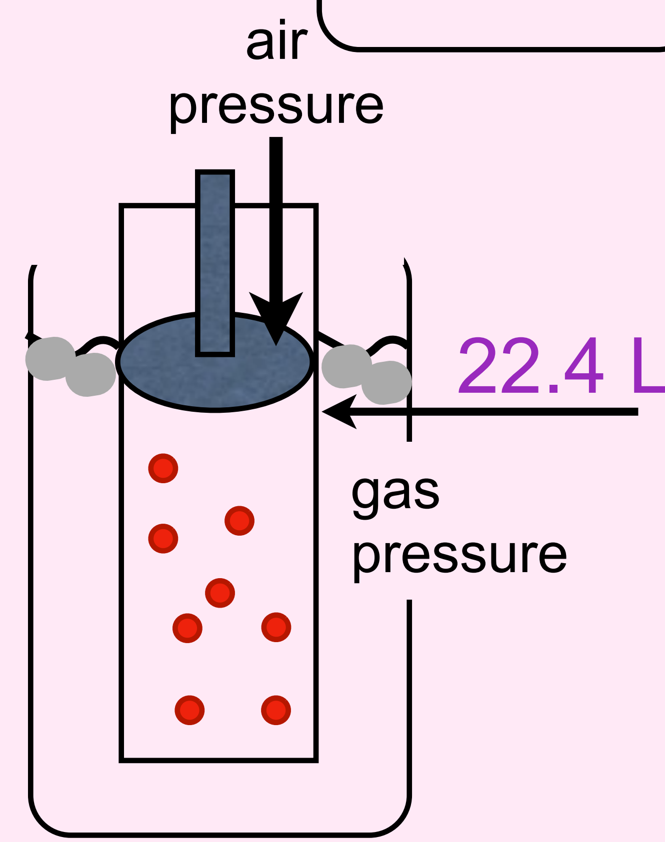
- It just so happens that
  - ✓ 2 g of helium, (½ mole)
  - ✓ sealed in a piston cylinder,
  - ✓ plunged into ice water,
  - ✓ barometric air pressure of 760,
- The measured volume of the gas will = ???



Measurements of He gas at particular conditions...

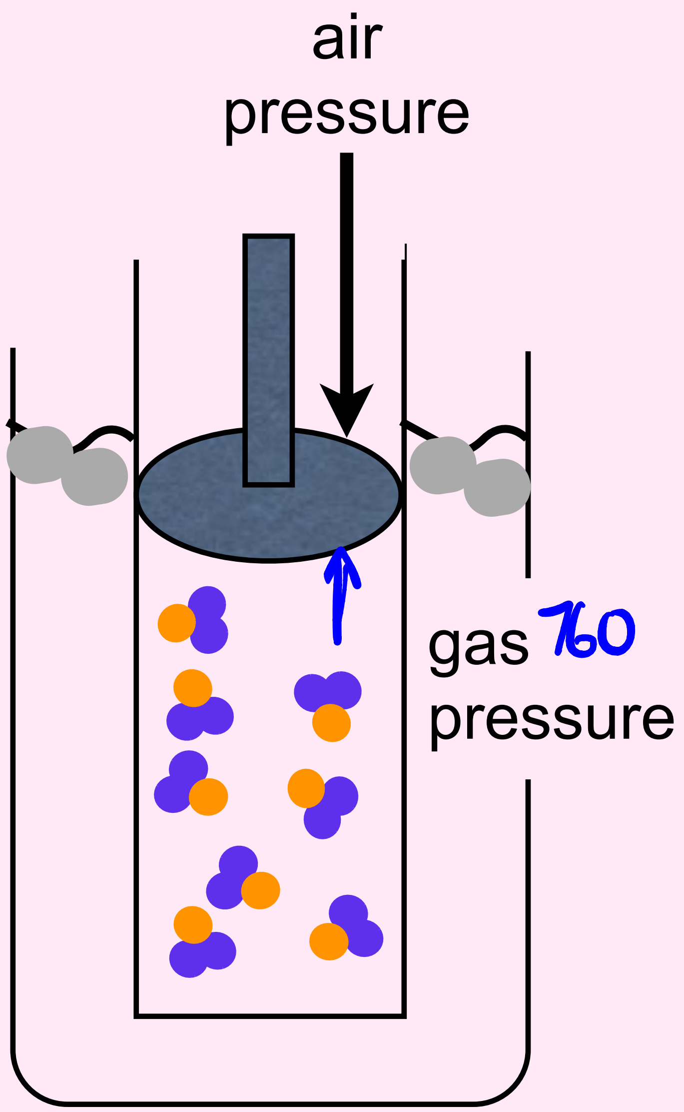
- It just so happens that
  - ✓ 2 g of helium, (½ mole)
  - ✓ sealed in a piston cylinder,
  - ✓ plunged into ice water,
  - ✓ barometric air pressure of 760 mmHg
- The measured volume of the gas will = 11.2 L
- When increased to 4 g, = 1mole the volume of the gas = 22.4 L





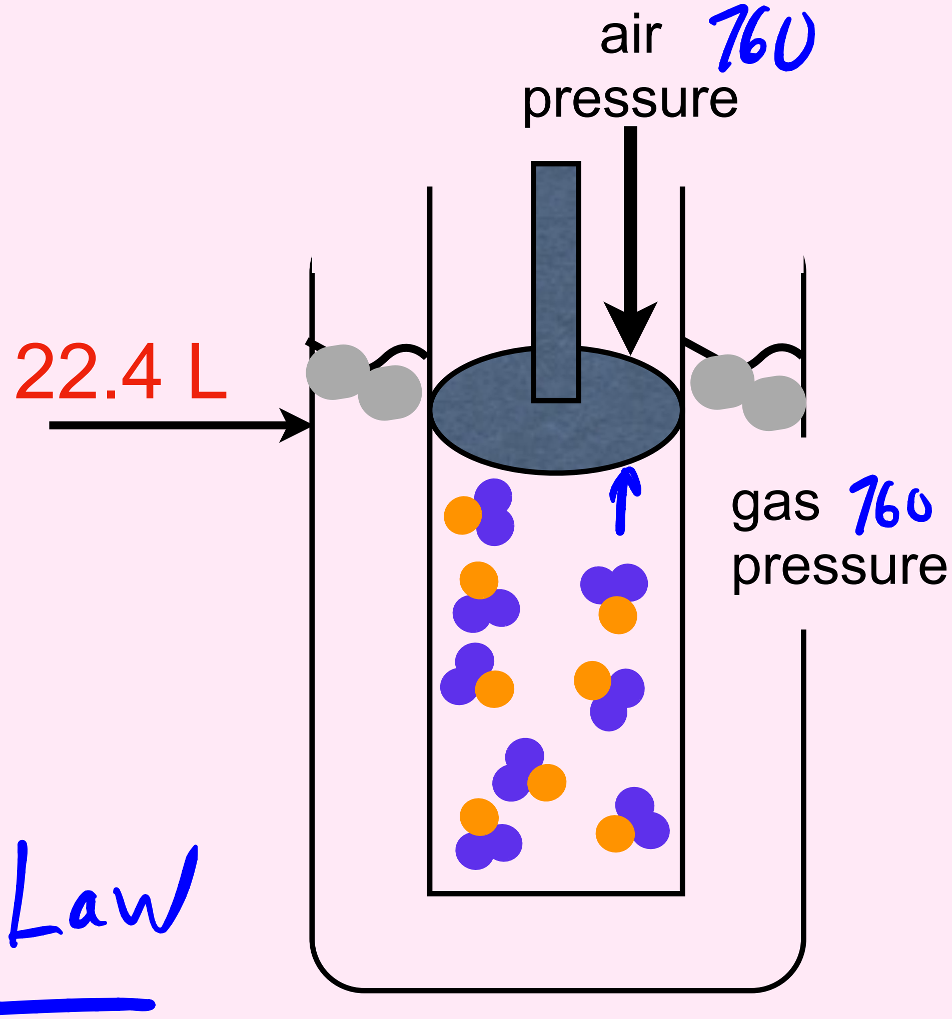
Measurements of CO_2 gas at particular conditions...

- It just so happens that
  - ✓ 44 g of CO_2, (1 mole)
  - ✓ sealed in a piston cylinder,
  - ✓ plunged into ice water,
  - ✓ barometric air pressure of 760 mmHg
- The measured volume of the gas will = ???



Measurements of CO_2 gas at particular conditions...

- It just so happens that
  - ✓ 44 g of CO_2, (1 mole)
  - ✓ sealed in a piston cylinder,
  - ✓ plunged into ice water,
  - ✓ barometric air pressure of 760, mmHg
- The measured volume of the gas will = 22.4 L, yet again!
- Something is going on here…. Avogadro's Law
- There must be some relationship between the proportions of P, V, n, and T for any gas



$$\frac{PV}{nT}$$

Let's plug in some of these measured values and calculate.

The Ideal Gas Constant, R

- ✓ 44 g of CO_2, (1 mole)
- ✓ plunged into ice water, 0ºC = 273 K
- ✓ barometric air pressure of 760 mmHg
- ✓ 22.4 L

$$\frac{PV}{nT}$$

- Plug these values into one side of the Combined Gas Law, and solve

$$\frac{760mmHg \times 22.4L}{1mol \times 273K} = 62.4 mmHg \bullet L \bullet mol^{-1} K^{-1}$$

or $62.4 \frac{mmHg \cdot L}{mol \cdot K}$

- Since the same proportional values will exist for any gas, this number is a constant.
- The Ideal Gas Constant, R

Different Values for R?

- The units on the gas constant R are very important.
- If we plug the values into the gas law measuring in different units, R will be different.

$$\frac{PV}{nT} = R$$

$$\frac{760mmHg \times 22.4L}{1mol \times 273K} = 62.36mmHg \bullet L \bullet mol^{-1}K^{-1}$$

still the Gas constant, R, different units

$$\frac{1atm \times 22.4L}{1mol \times 273K} = 0.08206atm \bullet L \bullet mol^{-1}K^{-1}$$

Voila, The Ideal Gas Law

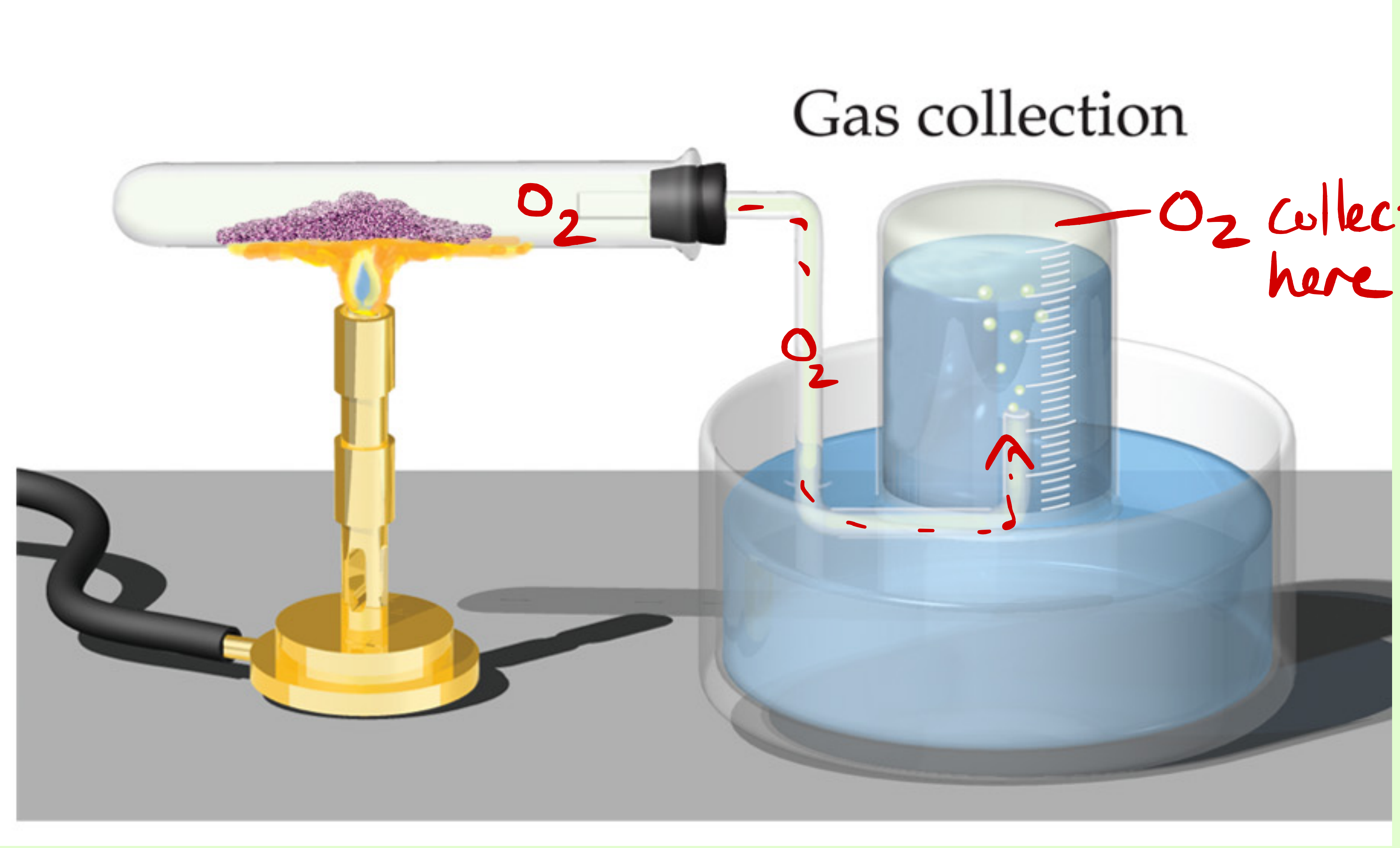
$$\frac{PV}{nT} = R$$

$$PV = nRT$$

- This will be very useful to us as we work stoichiometry problems for reactions that involve gases.

Collecting gas from a Rxn

- Consider the decompostion of potassium chlorate into potassium choride and oxygen gas.
- Write a balanced chemical equation for this reaction.



$$2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$$

$KClO_3$ 122.55 g/mol

- Suppose you decomposed 1.72 g of potassium chlorate, what volume of oxygen could be produced if the oxygen were collected at 25ºC at 740 mmHg pressure?

$$PV = nRT$$

Answer → on next slide

R = 62.4 L•mmHg/mol•K or R = 0.0821 L•atm/mol•K

$2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$

$KClO_3$ 122.55 g/mol

- Suppose you decomposed 1.71 g of potassium chlorate, what volume of oxygen could be produced if the oxygen were collected at 25ºC at 740 mmHg pressure?

$$1.71\,g\,\cancel{KClO_3} \times \frac{1\,\cancel{mol\,KClO_3}}{122.5\,\cancel{g\,KClO_3}} \times \frac{3\,mol\,O_2}{2\,\cancel{mol\,KClO_3}} = 0.0209\,mol\,O_2$$

$$PV = nRT$$

$$V = \frac{0.209\,\cancel{mol}\;\frac{62.4\,L\,\cancel{mmHg}}{\cancel{mol}\,\cancel{K}}\;298\,\cancel{K}}{740\,\cancel{mmHg}}$$

$$V = \frac{nRT}{P}$$

V = 0.526 L of O_2 (526 ml)