N-33
Partial Pressure Calculations

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Target: I can use Dalton's Law of Partial Pressures to determine how much an individual gas is contributing to the pressure of a mixture of gases.

Link to YouTube Presentation: https://youtu.be/LIDrcBuAafM

Dalton's Law

$$P_{Total} = P_1 + P_2 + P_3 + \cdots$$

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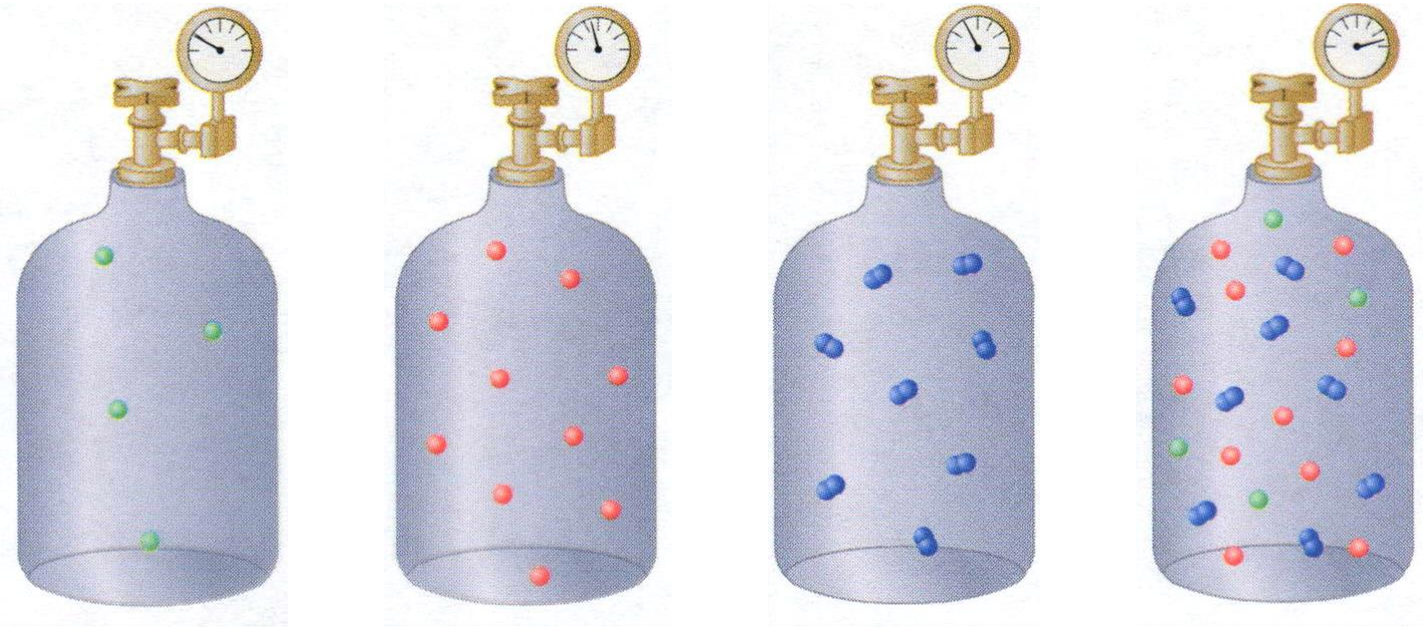
- **Total pressure exerted by a mixture of gases is the same as the sum of all partial pressures.**

- **We assume that the gases to not react with each other!**

Partial Pressures

200 kPa + 500 kPa + 400 kPa = 1100 kPa

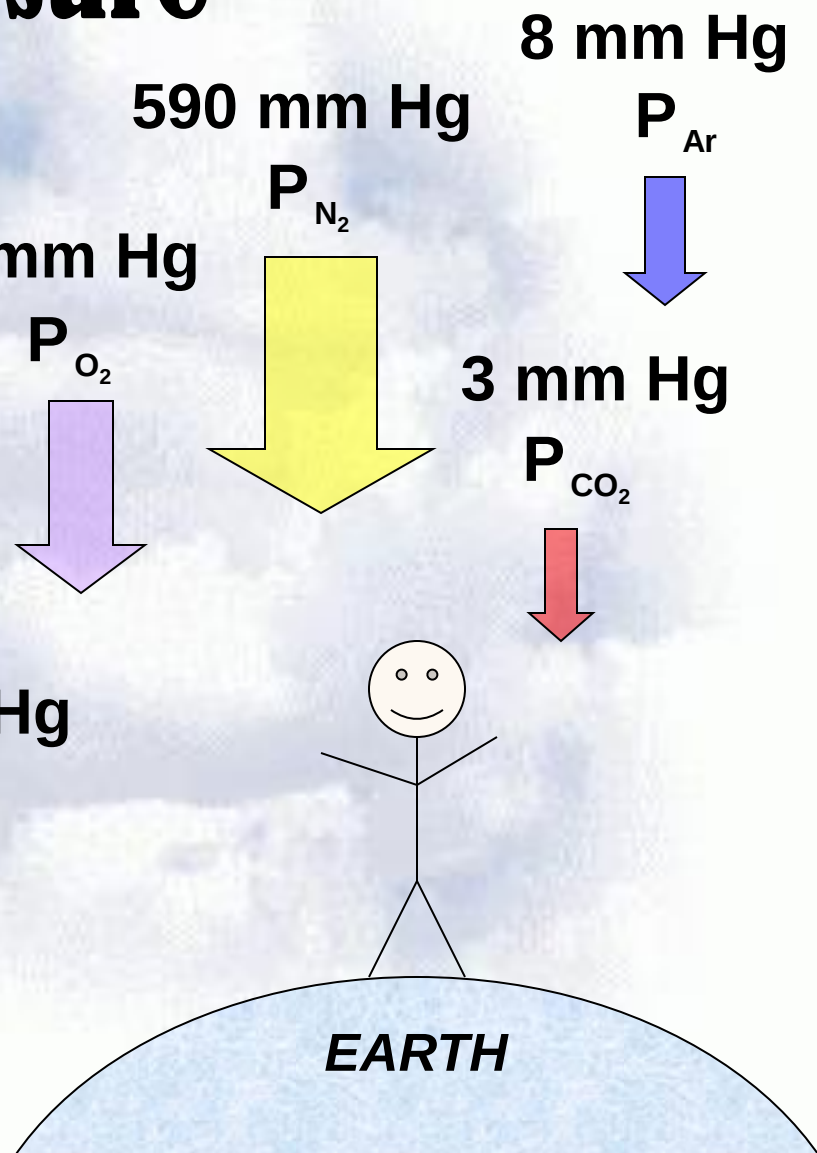


Dalton's Law of Partial Pressures & Air Pressure

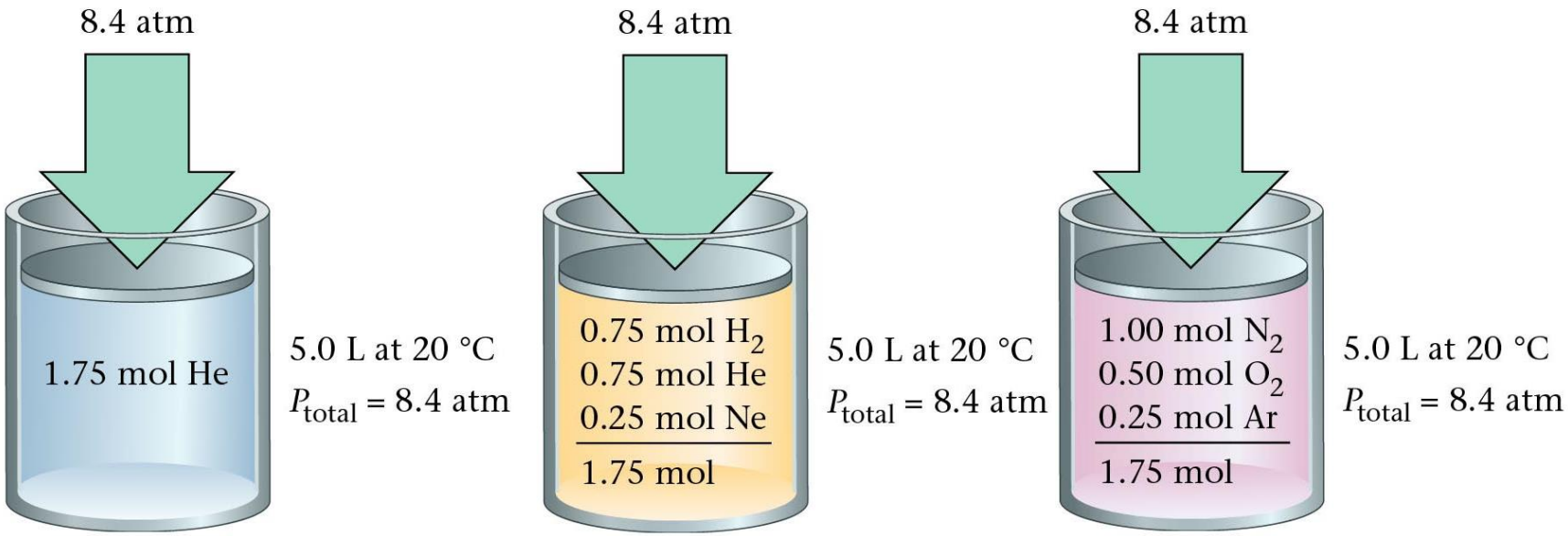
$P_{Total} = P_{O_2} + P_{N_2} + P_{CO_2} + P_{Ar}$

$P_{Total} = 149 + 590 + 3 + 8$ mm Hg

$P_{Total} = 750$ mm Hg



Type of Gas Doesn't Matter



Same T, same V, same # moles…

SAME PRESSURE!

You can use mole fractions to find partial pressures!

In a gaseous mixture, a gas's partial pressure is the one the gas would exert if it were by itself in the container.

The mole fraction in a mixture of gases determines each gas's partial pressure.

Mole Fractions

$$X_{gas\ 1} = \frac{n_{gas\ 1}}{n_{total}}$$

$$X_{gas\ 2} = \frac{n_{gas\ 2}}{n_{total}}$$

Etc…

Partial Pressure

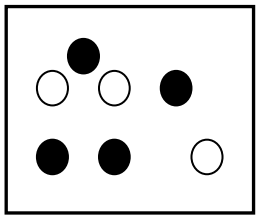
$$P_{gas\,1} = (X_{gas\,1}) \bullet (P_{total})$$

$$P_{gas\,2} = (X_{gas\,2}) \bullet (P_{total})$$

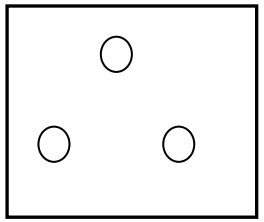
Etc…

Total pressure of mixture (3.0 mol He and 4.0 mol Ne) is 97.4 kPa.

Find partial pressure of each gas

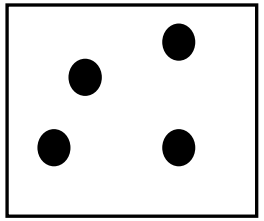


$$P_{He} = \frac{3 \text{ mol He}}{7 \text{ mol gas}} (97.4 \text{ kPa}) =$$



41.7 kPa

$$P_{Ne} = \frac{4 \text{ mol Ne}}{7 \text{ mol gas}} (97.4 \text{ kPa}) =$$



55.7 kPa

Add in some molar conversions!

80.0 g each of He, Ne, and Ar are in a container. The total pressure is 780 mm Hg. Find each gas's partial pressure.

$$80\text{ g He}\left(\frac{1\text{ mol}}{4\text{ g}}\right)=20\text{ mol He}$$

$$80\text{ g Ne}\left(\frac{1\text{ mol}}{20\text{ g}}\right)=4\text{ mol Ne}$$

$$80\text{ g Ar}\left(\frac{1\text{ mol}}{40\text{ g}}\right)=2\text{ mol Ar}$$

Total: 26 mol gas

$X_{He} = {}^{20}/_{26}$ of total

$X_{Ne} = {}^{4}/_{26}$ of total

$X_{Ar} = {}^{2}/_{26}$ of total

x 780 mmHg

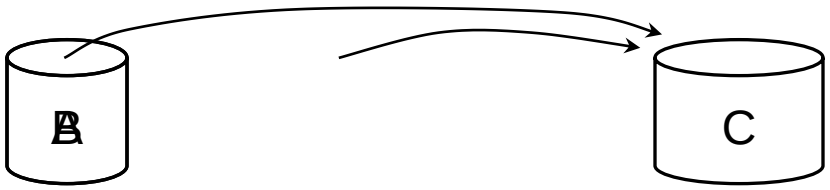
$$P_{He} = 600\text{ mm Hg},\ P_{Ne} = 120\text{ mm Hg},\ P_{Ar} = 60\text{ mm Hg}$$

Combine Partial Pressure and Boyle's Law!

Gets hard to keep track of starting and ending values because there are so many!

Charts are your friend!!!!!!!

Two 1.0 L containers, A and B, contain gases under 2.0 and 4.0 atm, respectively. Both gases are forced into Container C (w/vol. 2.0 L). Find total pres. of mixture in C.



$$P_{1A}V_{1A} = P_{2CA}V_{2CA}$$

$2.0 \text{ atm } (1.0 \text{ L}) = P_{2CA} (2.0 \text{ L})$

$P_{2CA} = 1.0 \text{ atm}$

$$P_{1B}V_{1B} = P_{2CB}V_{2CB}$$

$4.0 \text{ atm } (1.0 \text{ L}) = P_{2CB} (2.0 \text{ L})$

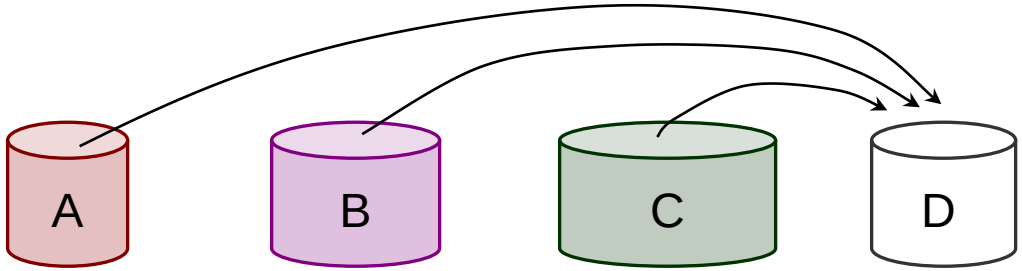
$P_{2CB} = 2.0 \text{ atm}$

	P_1	V_1	V_{2C}	P_{2C}
A	2.0 atm	1.0 L	2.0 L	1.0 atm
B	4.0 atm	1.0 L		2.0 atm

$$P_{2CTotal} = 3.0 \text{ atm}$$

Now do a partial pressure problem and add up your two partial pressures to find total pressure!

Find total pressure of mixture in Container D.



1.3 L
3.2 atm

2.6 L
1.4 atm

3.8 L
2.7 atm

2.3 L
X atm

	P_1	V_1	V_{2D}	P_{2D}
A	3.2 atm	1.3 L	2.3 L	1.8 atm
B	1.4 atm	2.6 L		1.6 atm
C	2.7 atm	3.8 L		4.5 atm

$P_{2DTotal}$ = 7.9 atm

$P_{1A}V_{1A} = P_{2DA}V_{2DA}$

3.2 atm (1.3 L) = P_{2DA}(2.3 L)

P_{2DA} = 1.8 atm

$P_{1B}V_{1B} = P_{2DB}V_{2DB}$

1.4 atm (2.6 L) = P_{2DB}(2.3 L)

P_{2DB} = 1.6 atm

$P_{1C}V_{1C} = P_{2DC}V_{2DC}$

2.7 atm (3.8L) = P_{2DC} (2.3L)

P_{2DC} = 4.5 atm

Collecting Gas Over Water via Displacement

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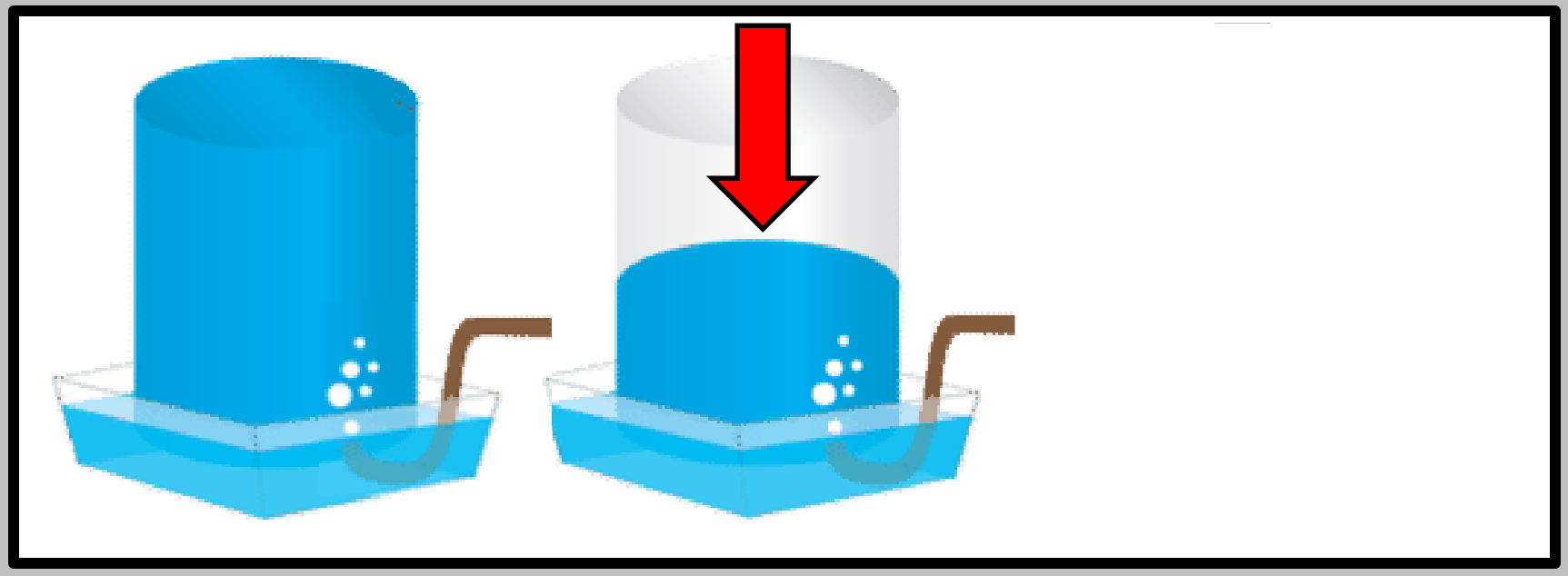
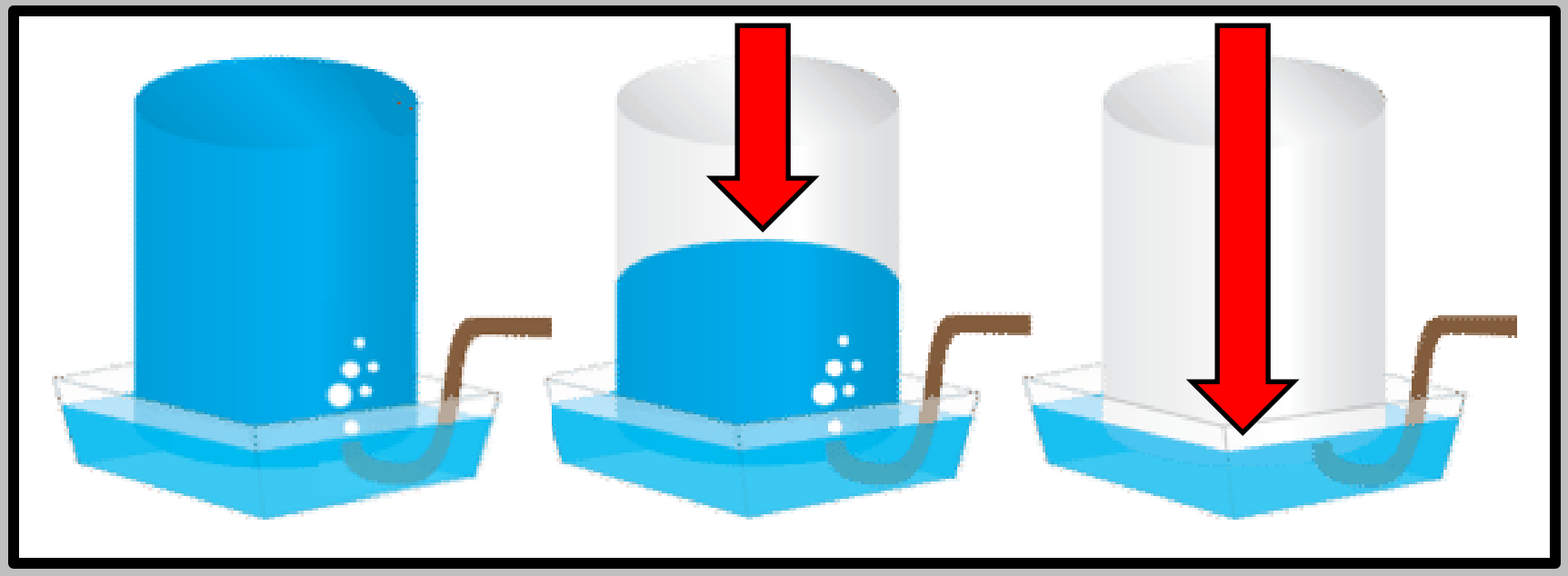
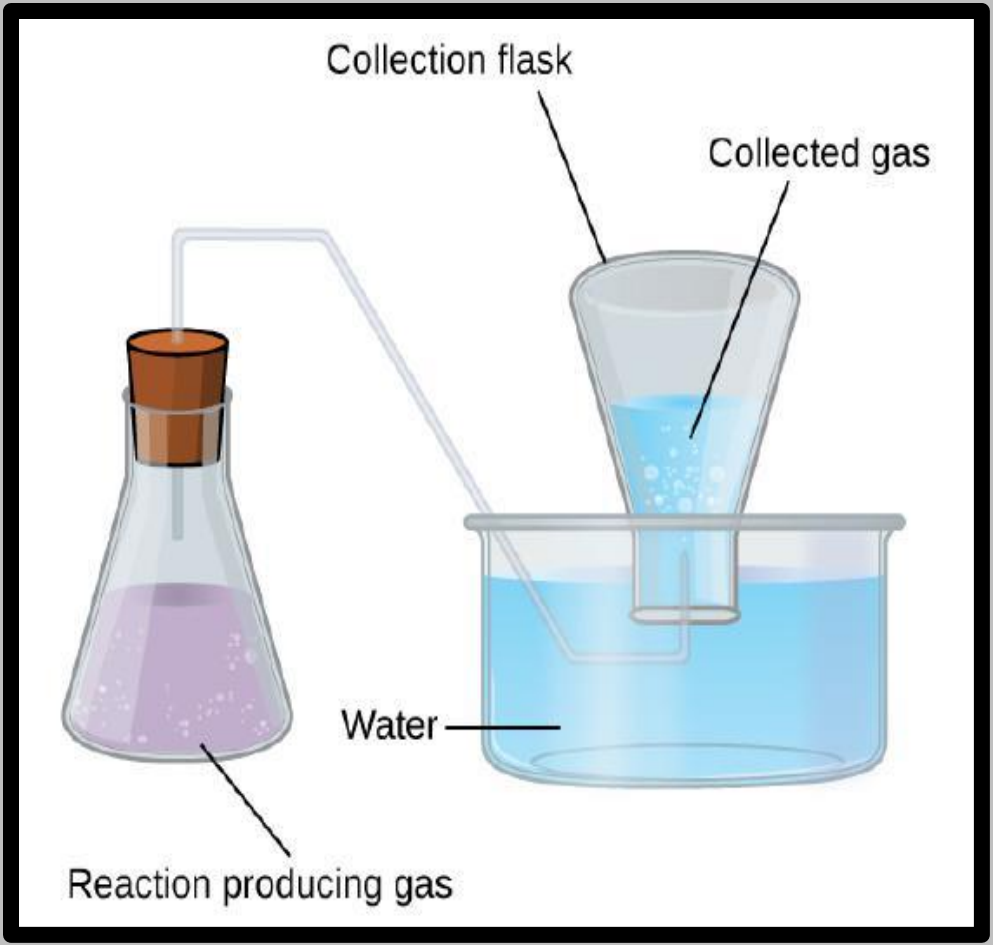


Collecting Gas Over Water via Displacement



Collecting Gas Over Water via Displacement

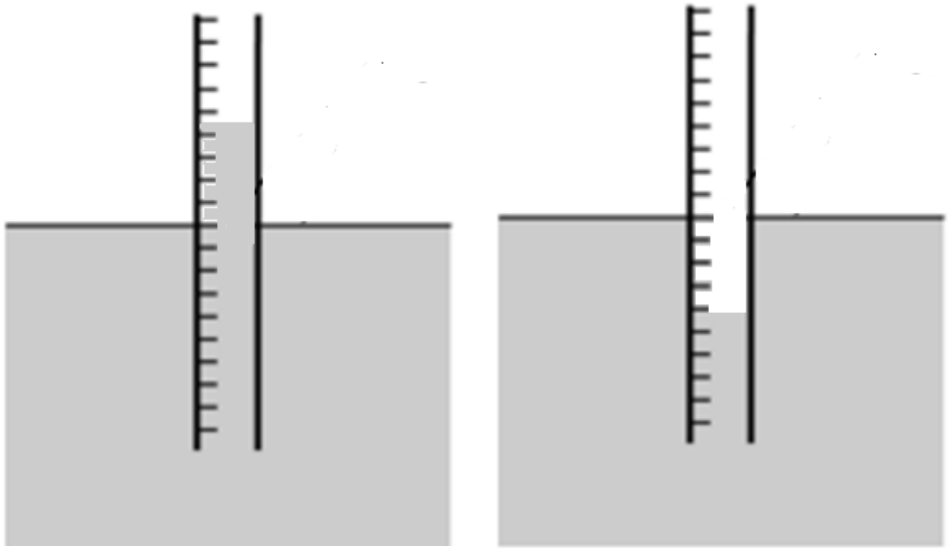


The gas being created will push the water out of the collection container and "displace" it – allows you to find the volume collected.

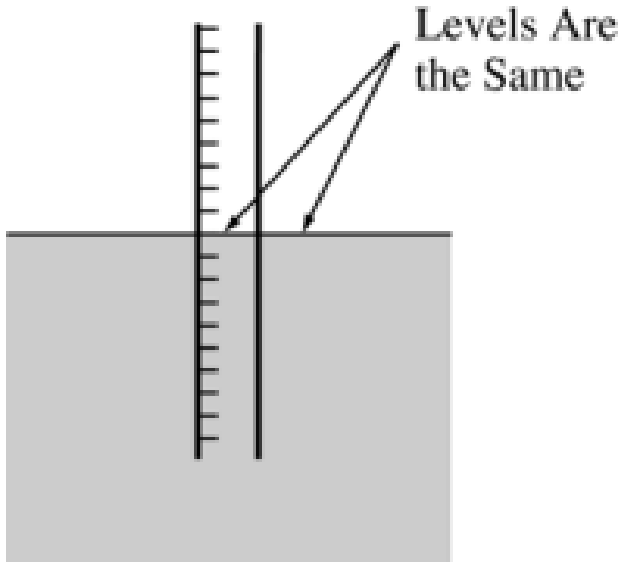
The total pressure in the collection container is the same as atmospheric pressure in the room.

If you line up the water level line of the collection container, with the water level line of the water bath, then the pressure inside the collection container will be the SAME as the pressure in the room!

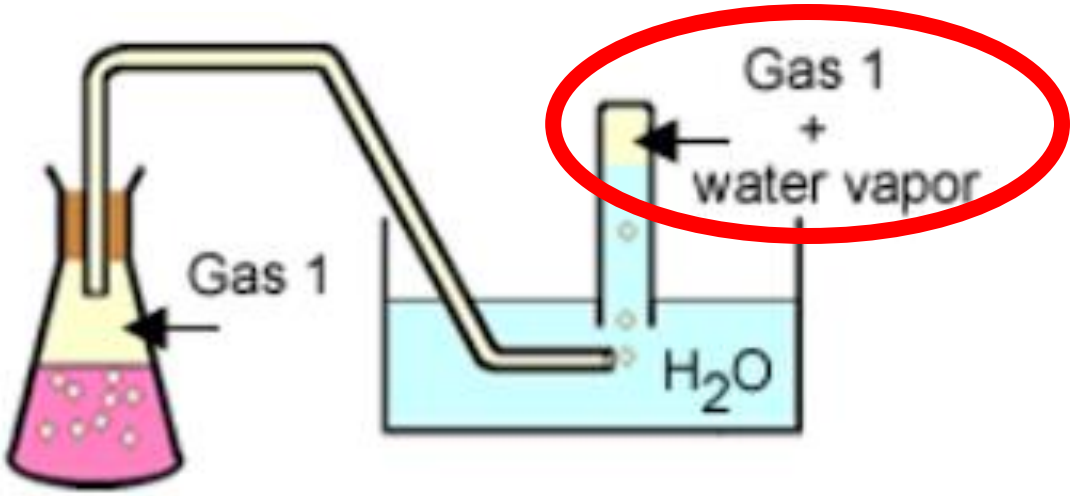
Water lines don't match, pressure inside not the same as pressure outside!



Water lines match, pressure inside is the same as pressure outside!



Water vapor is a bit of a problem though…



The collected gas will have water vapor in it as well. The amount of water vapor will change based on the temperature.

“Wet Gas” versus “Dry Gas”

The total pressure will be a result of the partial pressure of the desired collected gas being generated by the reaction, and the partial pressure of the water vapor.

$$P_{total} = P_{dry\ gas} + P_{H_2O}$$

$$P_{dry\ gas} = P_{total} - P_{H_2O}$$

"Wet Gas" versus "Dry Gas"

The total pressure will be a result of the partial pressure of the desired collected gas being generated by the reaction, and the partial pressure of the water vapor.

$$P_{total} = P_{dry\ gas} + P_{H_2O}$$

$$P_{dry\ gas} = P_{total} - P_{H_2O}$$

Table of Partial Pressures of Water

You can find a
"Water Vapor Pressure Chart"
on your R-36 Reference Sheet

Water Vapor Pressure at Various Temperatures for Dalton's Partial Pressure Problems - Collecting a Gas Over Water							
Temperature (°C)	*Pressure (mmHg)*	*Temperature (°C)*	*Pressure (mmHg)*	*Temperature (°C)*	*Pressure (mmHg)*	*Temperature (°C)*	*Pressure (mmHg)*
0.0	4.6	21.0	18.6	27.0	26.7	50.0	92.5
5.0	6.5	22.0	19.8	28.0	28.3	60.0	149.4
10.0	9.2	23.0	21.1	29.0	30.0	70.0	233.7
15.0	12.8	24.0	22.4	30.0	31.8	80.0	355.1
18.0	15.5	25.0	23.8	35.0	42.2	90.0	525.8
20.0	17.5	26.0	25.2	40.0	55.3	100.0	760.0

Example #1

Hydrogen gas is collected over water at 22°C. Find the pressure of the dry gas if the atmospheric pressure is 708 mmHg.

Remember: *The total pressure in the collection bottle is equal to atmospheric pressure and is a mixture of H_2 and water vapor.*

GIVEN:	WORK:
$P_{H_2} = ?$ $P_{total} = 708$ mmHg $P_{H_2O} = 19.8$ mmHg ***Look up water-vapor pressure on chart for 22°C.***	$P_{total} = P_{H_2} + P_{H_2O}$ $708 \text{ mmHg} = P_{H_2} + 19.8 \text{ mmHg}$ $P_{H_2} = 688.2 \text{ mmHg}$

Example #2

A gas is collected over water at a temp of 35°C while the barometric pressure is 0.976 atm. What is the partial pressure of the dry gas?

Remember: *The total P in the collection bottle is equal to barometric pressure and is a mixture of collection gas and water vapor.*

GIVEN:	WORK:
$P_{gas} = ?$ $P_{total} = 0.976$ atm $P_{H_2O} = 42.2$ mmHg $= 0.0555$ atm ***Make sure your units match!!!***	$P_{total} = P_{gas} + P_{H_2O}$ $0.976 \text{ atm} = P_{gas} + 0.0555 \text{ atm}$ $P_{gas} = 0.921$ atm

YouTube Link to Presentation

- https://youtu.be/LIDrcBuAafM