

# Under Pressure



## Dalton's Law of Partial Pressures

### Dalton's law of partial pressures

Read pages 460 - 461

1. In the 18<sup>th</sup> century what did many scientists believe about the earth's atmosphere?
2. The % of which component of air varies the most?
3. Argon makes up about 0.93% of dry air. List the other 3 gases present in dry air (with their %s). Around what % of dry air is made up by gases other than these 4?
4. Give Dalton's law of partial pressures & the equation.
5. 1 L of N<sub>2</sub> at 50 kPa is mixed with 1 L of O<sub>2</sub> at 60 kPa, to form a 1 L mixture of the gases. What is the resulting pressure? What are the partial pressures?
6. A balloon contains 75 kPa N<sub>2</sub>, 15 kPa O<sub>2</sub>, 5 kPa CO<sub>2</sub>, and water vapour. If atmospheric pressure is 100 kPa what is the partial pressure of water vapour?

### Summary

Dalton found that the total pressure of mixed gases is equal to the sum of their individual pressures (provided the gases do not react).

50 kPa

100 kPa

150 kPa

Note: all of these volumes are the same

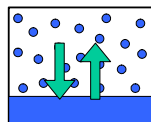


1 L oxygen + 1 L nitrogen = 1 L mixed gas

This works according to the KMT because at the same temperature molecules of different gases have the same Ek. It doesn't matter if the molecules are O<sub>2</sub> or H<sub>2</sub>. Both collide with the container or other molecules with the same force.

### Vapour Pressure Defined

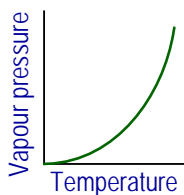
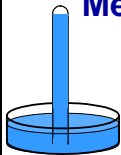
- Vapour pressure is the pressure exerted by a vapour. E.g. the H<sub>2</sub>O(g) in a sealed container.



Eventually the air above the water is filled with vapour pushing down. As temperature ↑, more molecules fill the air, and vapour pressure ↑.

- Yet, molecules both leave and join the surface, so vapour pressure also pushes molecules up.
- To measure vapour pressure we can heat a sample of liquid on top of a column of Hg and see the pressure it exerts at different °C.

### Measuring Vapour Pressure



Vapour pressure for H <sub>2</sub> O			
°C	kPa	°C	kPa
10	1.23	50	12.33
20	2.34	75	38.54
30	4.17	100	

See pg. 464 for more

- When the vapour pressure is equal to the atmospheric pressure (P<sub>atm</sub>), the push out is enough to overcome P<sub>atm</sub> and boiling occurs.
- Thus, water will boil at a temperature below 100 °C if the atmospheric pressure is reduced.

### Collecting gases over water

- Many times gases are collected over H<sub>2</sub>O
- Often we want to know the volume of dry gas at STP (useful for stoichiometry).

For this we must make 3 corrections:

1. The level of water inside and outside the tube must be level (so pressure inside is equal to the pressure outside).
2. The water vapour pressure must be subtracted from the total pressure (to get the pressure of the dry gas).
3. Finally, values are converted to STP using the combined gas law.

### Sample calculation

A gas was collected over 21°C H<sub>2</sub>O. After equalizing water levels, the volume was 325 mL. Give the volume of dry gas at STP (P<sub>atm</sub>=102.9 kPa).

Step 1: Determine vapour pressure (pg. 464)

At 21°C vapour pressure is 2.49 kPa

Step 2: Calculate the pressure of dry gas

$$P_{\text{gas}} = P_{\text{atm}} - P_{\text{H}_2\text{O}} = 102.9 - 2.49 = 100.41 \text{ kPa}$$

Step 3: List all of the data

$$T_1 = 294 \text{ K}, \quad V_1 = 325 \text{ mL}, \quad P_1 = 100.41 \text{ kPa}$$

Step 4: Convert to STP

$$= 299 \text{ mL}$$

$$V_2 = \frac{(P_1)(V_1)(T_2)}{(P_2)(T_1)} = \frac{(100.4 \text{ kPa})(325 \text{ mL})(273 \text{ K})}{(101.325 \text{ kPa})(294 \text{ K})}$$

### Assignment

1. 37.8 mL of O<sub>2</sub> is collected by the downward displacement of water at 24°C and an atmospheric pressure of 102.4 kPa. What is the volume of dry oxygen measured at STP?
2. Try questions 8 – 10 on page 465.
3. 236 mL of H<sub>2</sub> is collected over water at 22°C and at an atmospheric pressure of 99.8 kPa. What is the volume of dry H<sub>2</sub> at STP?
4. If H<sub>2</sub> is collected over water at 22°C and an atmospheric pressure of 100.8 kPa, what is the partial pressure of the H<sub>2</sub> when the water level inside the gas bottle is equal to the water level outside the bottle?