Example 5.1

Strategy Because 1 atm = 760 mmHg, the following conversion factor is needed to obtain the pressure in atmospheres:

$$\frac{1\ \text{atm}}{760\ \text{mmHg}}$$

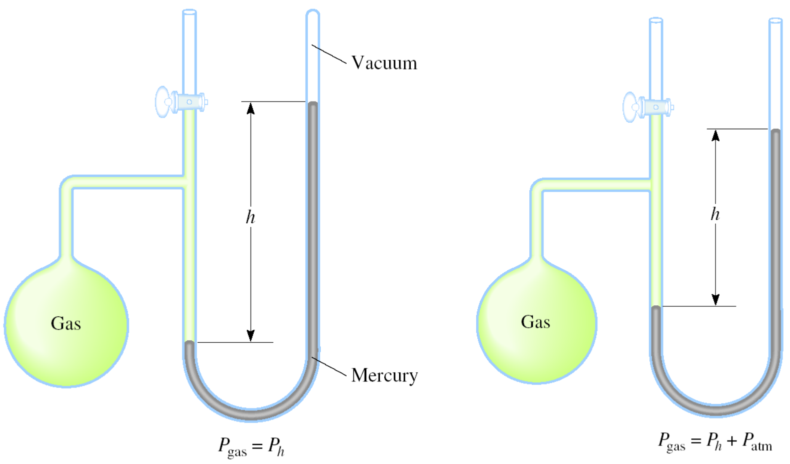
Solution The pressure in the cabin is given by

$$\text{pressure} = 688\ \text{mmHg} \times \frac{1\ \text{atm}}{760\ \text{mmHg}}$$

$$= 0.905\ \text{atm}$$

Manometers Used to Measure Gas Pressures

closed-tube open-tube



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Exercise question:

11.0 g Carbon dioxide gas occupies how many liters of volume at STP?

Ans: 5.6 L

Exercise question:

Calculate the volume occupied by 3.5 g chlorine (Cl_2) gas at STP.

Ans: 1.1 L

Example 5.4

A small bubble rises from the bottom of a lake, where the temperature and pressure are 8°C and 6.4 atm, to the water's surface, where the temperature is 25°C and the pressure is 1.0 atm.

Calculate the final volume (in mL) of the bubble if its initial volume was 2.1 mL.

Example 5.5

A chemist has synthesized a greenish-yellow gaseous compound of chlorine and oxygen and finds that its density is 7.71 g/L at 36°C and 2.88 atm.

Calculate the molar mass of the compound and determine its molecular formula.

Example 5.5

Strategy

Because Equations (5.11) and (5.12) are rearrangements of each other, we can calculate the molar mass of a gas if we know its density, temperature, and pressure.

The molecular formula of the compound must be consistent with its molar mass. What temperature unit should we use?

Exercise question:

From data gathered by *Voyager 1*, scientists have estimated that a 55 g sample of the atmosphere of Titan (Saturn's largest moon) contains 44.01 g N_2, 9.22 g Ar, and the remaining is CH_4. The total pressure on the surface of Titan is 1220 torr. Calculate the partial pressure (in torr) of each of these gases in Titan's atmosphere (1 torr=1 mmHg)

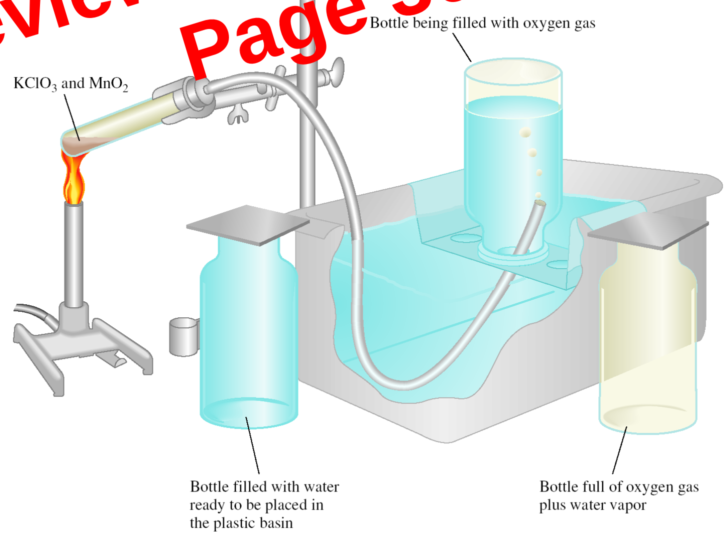
Ans: 1002 torr N_2, 147 torr Ar, and 71 torr CH_4

Example question:

The exhaled air (breath) of a man was found to contain (in mole %) 15.1% O_2, 3.7% CO_2, 75% N_2 and 5.1% H_2O. Calculate the partial pressure, in mmHg, of each gas if the breath has 1.05 atm pressure. 59

Ans: 120 mmHg O_2, 29 mmHg CO_2, 598 mmHg N_2 and 41 mmHg H_2O

Collecting a Gas over Water



$$2KClO_3\,(s) \longrightarrow 2KCl\,(s) + 3O_2\,(g)$$

$$P_T = P_{O_2} + P_{H_2O}$$

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Vapor of Water and Temperature

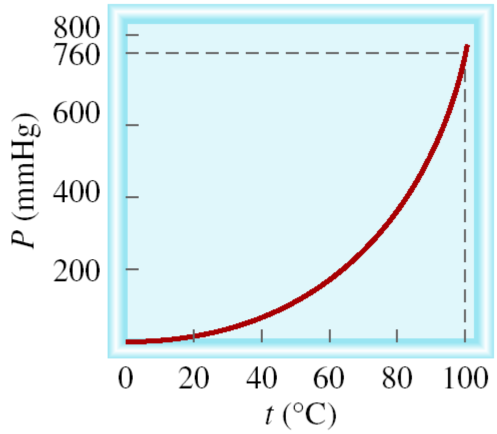

Table 5.3 van der Waals Constants of Some Common Gases

Gas	a $\left(\frac{atm \cdot L^2}{mol^2}\right)$	b $\left(\frac{L}{mol}\right)$
He	0.034	0.0237
Ne	0.211	0.0171
Ar	1.34	0.0322
Kr	2.32	0.0398
Xe	4.19	0.0266
H_2	0.244	0.0266
N_2	1.39	0.0391
O_2	1.36	0.0318
Cl_2	6.49	0.0562
CO_2	3.59	0.0427
CH_4	2.25	0.0428
CCl_4	20.4	0.138
NH_3	4.17	0.0371
H_2O	5.46	0.0305

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Example 5.[illegible]

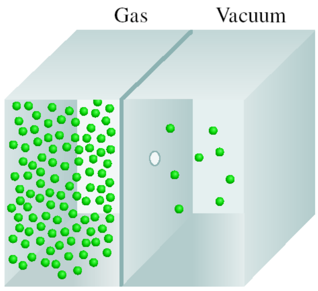
Oxygen gas generated by the decomposition of potassium chlorate is collected as shown in Figure 5.15.

The volume of oxygen collected at 24°C and atmospheric pressure of 762 mmHg is 128 mL.

Calculate the mass (in grams) of oxygen gas obtained.

The pressure of the water vapor at 24°C is 22.4 mmHg.

Gas effusion is the process by which gas under pressure escapes from one compartment of a container to another by passing through a small opening.



$$\frac{r_1}{r_2} = \frac{t_2}{t_1} = \sqrt{\frac{\mathcal{M}_2}{\mathcal{M}_1}}$$

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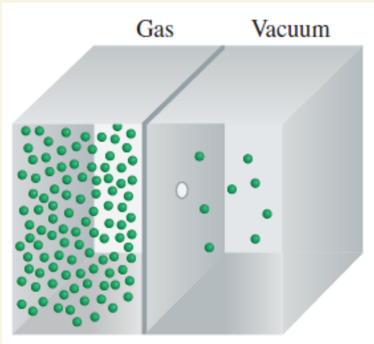
Example 5.10

A flammable gas made up only of carbon and hydrogen is found to effuse through a porous barrier in 1.50 min.

Under the same conditions of temperature and pressure, it takes an equal volume of bromine vapor 4.73 min to effuse through the same barrier.

Calculate the molar mass of the unknown gas, and suggest what this gas might be.



Gas effusion. Gas molecules move from a high-pressure region (left) to a low-pressure one through a pinhole.

Exercise question:

A sample of unknown gas effuse through a porous container 1.65 times faster than carbon dioxide gas. Estimate the molar mass of the unknown gas.

Ans: 16 g/mol

Example question:

Time required for a sample of O_2 to effuse through a container having a small orifice (opening, pore) is 27 seconds. What is it for Xe?

Ans: 54.7 s

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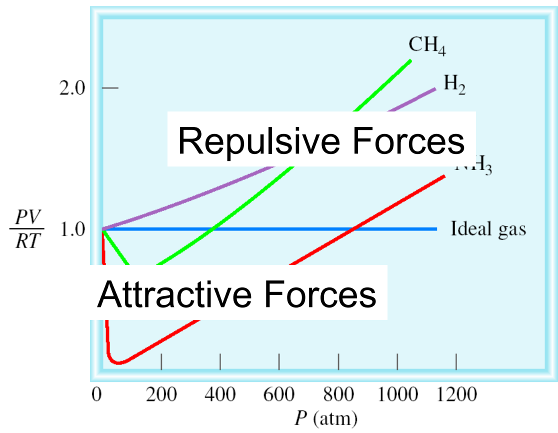
Deviations from Ideal Behavior

1 mole of ideal gas

$$PV = nRT$$

$$n = \frac{PV}{RT} = 1.0$$



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