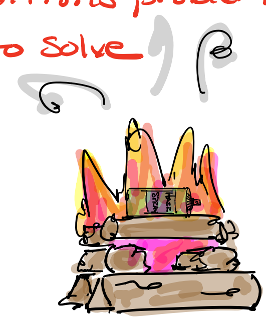
Chapter 8 Homework Key

8.2

27) A spray can is used until it is empty except for the propellant gas, which has a pressure of 1344 Torr at 23°C. If the can is thrown into a fire (T = 475°C), what will be the pressure in the hot can?

This sounds like a changing conditions problem, and it is. Use combined gas law to solve.



$P_1 = 1344 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}} = 1.768421 \text{ atm}$ | $P_2 = ?$

$\cancel{V_1}$ | $\cancel{V_2}$

$T_1 = 23°C + 273.15 = 296.15$ | $T_2 = 475°C + 273.15 = 748.15 \text{ K}$

$\cancel{n_1}$ | $\cancel{n_2}$

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

$$T_2 \times \frac{P_1}{T_1} = \frac{P_2}{\cancel{T_2}} \times \cancel{T_2}$$

$$P_2 = \frac{T_2 P_1}{T_1}$$

$$P_2 = \frac{(748.15 \text{ K})(1.768421 \text{ atm})}{296.15 \text{ K}}$$

$= 4.467480 \text{ atm}$

$= \boxed{4.47 \text{ atm}}$

or

$4.467480 \text{ atm} \times \frac{760 \text{ torr}}{1 \text{ atm}} = 3395.2848 \text{ torr}$

$= \boxed{3400 \text{ torr}}$

28) What is the temperature of an 11.2 L sample of Carbon Monoxide, CO, at 744 torr if it occupies 13.3 L at 55°C.

This is another changing conditions problem. Poorly worded.

$\cancel{P_1} = 744$ torr ← same → $\cancel{P_2} = 744$ torr

$V_1 = 11.2$ L　　$V_2 = 13.3$ L

$\cancel{n_1} =$　　$\cancel{n_2} =$

$T_1 = ?$　　$T_2 = 55°C + 273.15 = 328.15$ K

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

$$\cancel{T_1} \times \frac{V_1}{\cancel{T_1}} = \frac{V_2}{T_2} \times T_1$$

$$\frac{T_2}{V_2} \times V_1 = \frac{T_1\cancel{V_2}}{\cancel{T_2}} \times \frac{\cancel{T_2}}{\cancel{V_2}}$$

$$T_1 = \frac{V_1 T_2}{V_2}$$

$$T_1 = \frac{(11.2\text{ L})(328.15\text{ K})}{13.3\text{ L}}$$

$T_1 = 276.33684$ K

$T_1 = 276.33684 - 273.15$

$T_1 = 3.1868$　must round to 1's place

$$\boxed{T_1 = 3\,°C}$$

31) A Weather balloon contains 8.00 moles of Helium at a pressure of 0.992 atm and a temperature of 25°C at ground level. What is the volume of the balloon under these conditions?

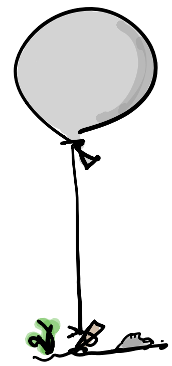
Standard $PV = nRT \Rightarrow$ only 1 set of Conditions

$P = 0.992 \text{ atm}$

$V = ?$

$n = 8.00 \text{ moles He}$

$T = 25°C + 273.15 = 298.15 \text{ K}$



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

$$V = \frac{nRT}{P} = \frac{(\overset{3}{8.00} \cancel{\text{moles}})(\overset{3}{0.0821} \frac{L \cancel{\text{atm}}}{\cancel{\text{mol}} \cancel{K}})(\overset{3}{298.15} \cancel{K})}{\underset{3}{0.992} \cancel{\text{atm}}}$$

$$= 197.4041532 \text{ L}$$

$$\boxed{V = 197 \text{ L of Helium}}$$

33) How many moles of gaseous boron trifluoride (BF_3) are contained in a 4.3410 L bulb at 788.0 K if the pressure is 1.220 atm? How many grams BF_3?

Standard $PV = nRT$

$P = 1.220$ atm

$V = 4.3410$ L

$n = ?$

$T = 788.0$ K

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

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

$$n = \frac{\overset{4}{(1.220\ \text{atm})}\overset{5}{(4.3410\ \text{L})}}{\underset{3}{\left(0.0821\ \frac{\text{L atm}}{\text{mol K}}\right)}\underset{4}{(788.0\ \text{K})}} = 0.0818616025 \text{ moles } BF_3$$

$$\boxed{n = 0.0819 \text{ moles } BF_3}$$

Part B ⇒ How many grams BF_3

molar mass

$BF_3 = 10.81 + 3(19.00) = 67.81$ g/mole

$$\overset{3}{0.0818616025} \text{ moles } BF_3 \times \frac{\overset{4}{67.81\text{ g } BF_3}}{1 \text{ mole } BF_3} = 5.551035 \text{ g } BF_3$$

$$= \boxed{5.55 \text{ g } BF_3}$$

34) Iodine, I_2, is a solid at room temperature but Sublimes (Converts from solid to gas) when warmed. What is the temperature in a 73 mL Bulb that Contains 0.292 g of I_2 vapor at a pressure of 0.462 atm?

Straight PV = nRT problem

$P = 0.462 \text{ atm}$

$V = 73 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 0.073 \text{ L}$

$n = 0.292 \text{ g } I_2 \times \frac{1 \text{ mole } I_2}{253.8 \text{ g } I_2} = 0.0011505122 \text{ mole } I_2$

$T = ?$

$$\frac{PV}{nR} = \frac{\cancel{n}\cancel{R}T}{\cancel{n}\cancel{R}}$$

$$\frac{PV}{nR} = T$$

$$T = \frac{\overset{4}{(0.462 \text{ atm})}\overset{2}{(0.073 \text{ L})}}{\underset{3}{(0.0011505122 \text{ mole } I_2)}\underset{3}{\left(0.0821 \frac{\text{L atm}}{\text{mol K}}\right)}}$$

$T = 357.051157 \text{ K}$

$$\boxed{= 360 \text{ K} \quad = 80^\circ\text{C}}$$

$$\begin{array}{r} 357.051157 \\ -\ 273.15 \\ \hline 83.901157 \end{array}$$

It would be nice if they would specify temp units.

36) A high altitude balloon is filled with 1.41×10^4 L of hydrogen at a temperature of 21°C and a pressure of 745 torr. What is the volume of the balloon at a height of 20 km where the temperature is −48°C and the pressure is 63.1 torr?

A changing conditions problem $\Rightarrow \frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$

$P_1 = 745 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}} = 0.980263 \text{ atm}$

$V_1 = 1.41 \times 10^4 \text{ L}$

$\cancel{n_1 =}$

$T_1 = 21°C + 273.15 = 294.15 \text{ K}$

$P_2 = 63.1 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}} = 0.083026 \text{ atm}$

$V_2 = ?$

$\cancel{n_2 =}$

$T_2 = -48°C + 273.15 = 225.15 \text{ K}$

$$\frac{P_1V_1}{\cancel{n_1}T_1} = \frac{P_2V_2}{\cancel{n_2}T_2}$$

$$\frac{T_2}{P_2} \times \frac{P_1V_1}{T_1} = \frac{\cancel{P_2}V_2}{\cancel{T_2}} \times \frac{\cancel{T_2}}{\cancel{P_2}}$$

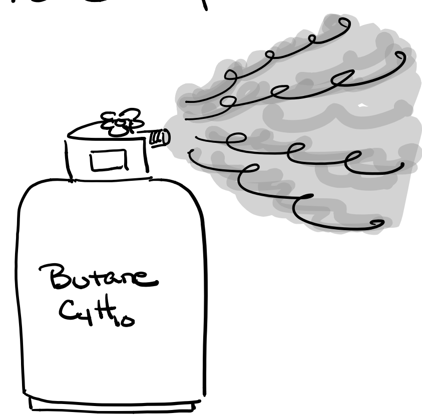
$$\frac{T_2P_1V_1}{T_1P_2} = V_2$$

$$V_2 = \frac{(22\underset{3}{5}.15 \text{ K})(0.98\underset{3}{0}263 \text{ atm})(1.4\overset{3}{1} \times 10^4 \text{ L})}{(29\underset{3}{4}.15 \text{ K})(0.083\underset{3}{0}26 \text{ atm})}$$

$V_2 = 127|423.3811 \text{ L}$

$$\boxed{V_2 = 1.27 \times 10^5 \text{ L hydrogen}}$$

39) A 20.0 L Cylinder Containing 11.34 kg of butane C_4H_{10}, was opened to the atmospher. Calculate the mass of the gas remaining in the Cylinder if it were opened and the gas escaped until the pressure in the cylinder was equal to the atmospheric pressure, 0.983 atm and temperature of 27 °C.



Straight PV = nRT

P = 0.983 atm

V = 20.0 L

n = ?

T = 27 °C + 273.15 = 300.15 K

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

$$n = \frac{PV}{RT} = \frac{(0.983\,\text{atm})(20.0\,\text{L})}{\left(0.0821\,\frac{\text{L atm}}{\text{mol K}}\right)(300.15\,\text{K})} = 0.7978146534 \text{ moles}$$

molar mass C_4H_{10} = 4 × 12.01 + 10 × 1.008 = 58.12 g/mole C_4H_{10}

$$0.7978146534 \text{ moles } C_4H_{10} \times \frac{58.12\,\text{g } C_4H_{10}}{1 \text{ mole } C_4H_{10}} = 46.368987166\,\text{g } C_4H_{10}$$

$$= \boxed{46.4\,\text{g } C_4H_{10}}$$

45) A balloon with a volume of 100.21 L at 21°C and 0.981 atm is released and just barely clears the top of mount Crumpet in British Columbia. If the final volume of the balloon is 144.53 L at a temperature of 5.24°C, what is the pressure experienced by the balloon as it clears Mount Crumpet?

$P_1 = 0.981\ atm$ $\qquad$ $P_2 = ?$

$V_1 = 100.21\ L$ $\qquad$ $V_2 = 144.53\ L$

$\cancel{n_1} =$ $\qquad$ $\cancel{n_2} =$

$T_1 = 21°C + 273.15 = 294.15°C$ $\qquad$ $T_2 = 5.24°C + 273.15 = 278.39°C$

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

$$P_2 = \frac{T_2 V_1 P_1}{T_1 V_2} = \frac{\overset{5}{(278.39°C)}\overset{5}{(100.21\ L)}\overset{3}{(0.981\ atm)}}{\underset{3}{(294.15°C)}\underset{5}{(144.53\ L)}}$$

$P_2 = 0.6437346\ atm$

$\boxed{P_2 = 0.644\ atm}$

8.3

66) Cavandish prepared hydrogen in 1766 by the novel method of passing steam through a red-hot gun barrel:

$$4H_2O_{(g)} + 3Fe_{(s)} \longrightarrow Fe_2O_3{}_{(s)} + 4H_2{}_{(g)}$$

a) Outline the steps necessary to answer the following: What volume of H_2 at a pressure of 745 torr and a temperature of 20 °C can be prepared from the reaction of 15.0 g H_2O?

b) Solve the question

$$4H_2O_{(g)} + 3Fe_{(s)} \longrightarrow Fe_2O_3{}_{(s)} + 4H_2{}_{(g)}$$

15.0 g (H_2O) → ? L, 20 °C, 745 torr (H_2)

Road Map

$g\ H_2O \rightarrow mole\ H_2O \rightarrow mole\ H_2 \xrightarrow{PV=nRT} L\ H_2O$

$P = 745\ torr \times \frac{1\ atm}{760\ torr}$

$V = ?$

$n = 15.0 g\ H_2O \times \frac{1\ mole\ H_2O}{18.02 g\ H_2O} \times \frac{4\ mole\ H_2}{4\ mole\ H_2O}$

$T = 20°C + 273.15 = 293.15\ K$

$PV = nRT$

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

$$V = \frac{\left(\overset{3}{15.0} g\ H_2O \times \frac{1\ mole\ H_2O}{\underset{}{\overset{4}{18.02}} g\ H_2O} \times \frac{\overset{exact}{4\ mole\ H_2}}{4\ mole\ H_2O}\right)\left(\overset{3}{0.0821} \frac{L\,atm}{mol\,K}\right)\left(\overset{3}{293.15 K}\right)}{\left(\underset{3}{745}\ torr \times \frac{1\ atm}{\underset{exact}{760\ torr}}\right)}$$

$V = 20.437457\ L$

$\boxed{V = 20.4\ L}$

69) Lime, CaO, is produced by heating Calcium Carbonate, $CaCO_3$; Carbon dioxide is the other product.

a) Outline the steps to answer the following: What volume of Carbon dioxide at 875°C and 0.966 atm is produced by the decomposition of 1 ton (1.000×10^3 kg) of Calcium Carbonate?

b) answer the question

$$CaCO_3 \longrightarrow CaO + CO_2$$ Balanced ✓

1.000×10^3 kg $\qquad$? L, 875 °C, 0.966 atm

Road Map

$$\text{kg } CaCO_3 \rightarrow \text{g } CaCO_3 \rightarrow \text{mole } CaCO_3 \rightarrow \text{mole } CO_2 \xrightarrow{PV=nRT} \text{L } CO_2$$

$P = 0.966$ atm

$V = ?$

$$n = 1.000 \times 10^3 \text{ kg } CaCO_3 \times \frac{1000 \text{ g } CaCO_3}{1 \text{ kg } CaCO_3} \times \frac{1 \text{ mole } CaCO_3}{100.09 \text{ g } CaCO_3} \times \frac{1 \text{ mole } CO_2}{1 \text{ mole } CaCO_3}$$

$T = 875$ °C

$$PV = nRT$$

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

$$V = \frac{\left(\overset{4}{1.000 \times 10^3} \text{ kg } CaCO_3 \times \frac{\overset{\text{def}}{1000 \text{ g } CaCO_3}}{1 \text{ kg } CaCO_3} \times \frac{1 \text{ mole } CaCO_3}{\underset{}{\overset{5}{100.09}} \text{ g } CaCO_3} \times \frac{\overset{\text{exact}}{1 \text{ mole } CO_2}}{1 \text{ mole } CaCO_3}\right)\left(\overset{3}{0.0821} \frac{\text{L atm}}{\text{mol K}}\right)\left(\overset{3}{875} \text{ K}\right)}{\underset{3}{0.966 \text{ atm}}}$$

$V = 742990.7286$ L

$$V = \boxed{743000 \text{ L} = 7.43 \times 10^5 \text{ L}}$$