

4.18 This problem uses Charles's law, as in 4.16, but now a volume is to be determined:

$$V_2 = \left(\frac{T_2}{T_1} \right) V_1$$

T_2 is 503.15 K and T_1 is 293.15 K. Substituting gives

$$V_2 = \left(\frac{503.15 \text{ K}}{293.15 \text{ K}} \right) \times 3.41 \text{ L} = 5.85 \text{ L}$$

4.20 To prevent dangerous spurring from the container, the pressure inside must be brought below 0.96 atm. The pressure at 20°C (293.15 K) is 1.47 atm, and the pressure of an ideal gas at constant volume is directly proportional to the absolute temperature. Because $0.96/1.47 = 0.653$, the required absolute temperature is $0.653 \times 293.15 = 191.4 \text{ K}$. Subtracting 273.15 K from this Kelvin temperature and multiplying the result by $1^\circ\text{C}/1 \text{ K}$ converts to -82°C .

4.22 The amount of gas n does not change when T and P change, so:

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

4.30 Using the ideal gas law for chlorine gives its number of moles as

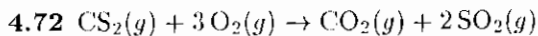
$$n = \frac{PV}{RT} = \frac{(0.953 \text{ atm})(5.32 \text{ L})}{(0.08206 \text{ L atm mol}^{-1}\text{K}^{-1})(306.15 \text{ K})} = 0.2018 \text{ mol}$$

This is also the chemical amount of MnO_2 reacting, because one mole of MnO_2 generates one mole of Cl_2 . The mass is then found by multiplying by the molar mass of MnO_2 , $86.937 \text{ g mol}^{-1}$, to give 17.5 g MnO_2 .

4.38 (a) Before the reaction, the mole fraction of the Br_2 is $4.5/(4.5 + 33.1) = 0.12$.
 (b) According to the balanced equation, the formation of 2.2 mol of BrF_5 consumes 1.1 mol of Br_2 and 5.5 mol of F_2 . At the indicated point in the reaction, there are 3.4 mol of Br_2 and 27.6 mol of F_2 left. This plus the 2.2 mol of BrF_5 means that there is 33.2 mol of substances of all kinds present. The mole fraction of Br_2 is $3.4/33.2 = 0.10$. Despite the fact that about a quarter of the Br_2 has been consumed, the mole fraction of Br_2 has dropped by only a sixth.

4.56 We solve the van der Waals equation for the pressure and substitute:

$$\begin{aligned} P &= \frac{nRT}{V - nb} - a \left(\frac{n^2}{V^2} \right) \\ &= \frac{(140 \times 10^6 / 18.0153) \text{ mol} (0.08206 \text{ L atm mol}^{-1}\text{K}^{-1}) (813.15 \text{ K})}{(2500 \times 10^3 \text{ L}) - (140 \times 10^6 / 18.0153) \text{ mol} (0.03049 \text{ L mol}^{-1})} \\ &\quad - (5.464 \text{ atm L}^2 \text{ mol}^{-2}) \left(\frac{(140 \times 10^6 / 18.0153)^2 (\text{mol})^2}{(2500 \times 10^3 \text{ L})^2} \right) \\ &= 176 \text{ atm} = 2590 \text{ psi} \end{aligned}$$



For every mole of $\text{CS}_2(g)$ that reacts, the total number of moles changes by 1. Because the temperature and volume are the same before and after, the initial partial pressure of CS_2 must be equal in magnitude to the change in total pressure, namely $3.00 - 2.40 = 0.60$ atm.

$$n_{\text{CS}_2} = \frac{PV}{RT} = \frac{(0.60 \text{ atm})(10.0 \text{ L})}{(0.08206 \text{ L atm mol}^{-1}\text{K}^{-1})(373.15 \text{ K})} = 0.196 \text{ mol}$$

$$n_{\text{CS}_2} = (0.196 \text{ mol})(76.14 \text{ g mol}^{-1}) = 14.9 \text{ g}$$

4.71

$$n_1 = \frac{P_1 V_1}{RT} \quad n_2 = \frac{P_2 V_2}{RT} \quad n_3 = \frac{P_3 V_3}{RT}$$

$$V_t = V_1 + V_2 + V_3 \quad n_t = n_1 + n_2 + n_3$$

$$P_t V_t = n_t R T$$

$$P_t = \frac{RT}{V_t} [P_1 V_1 + P_2 V_2 + P_3 V_3] \frac{1}{RT}$$

$$P_t = P_1 \frac{V_1}{V_t} + P_2 \frac{V_2}{V_t} + P_3 \frac{V_3}{V_t}$$

$$P_t = 2.51 \text{ atm} \frac{5.00}{12.00} + 0.792 \frac{4.00}{12.00} \text{ atm}$$

$$+ 1.23 \frac{3.00 \text{ atm}}{12.00} = \boxed{1.62 \text{ atm}}$$

4.72

$$P_t = P_{\text{CS}_2} + P_{\text{O}_2}$$

$$P_t = n_{\text{CS}_2} \frac{RT}{V} + n_{\text{O}_2} \frac{RT}{V}$$

$$P_t' = n_{\text{CO}_2} \frac{RT}{V} + n_{\text{SO}_2} \frac{RT}{V} + n_{\text{O}_2}' \frac{RT}{V}$$

$$n_{\text{CO}_2} = n_{\text{CS}_2}$$

$$n_{\text{SO}_2} = 2 n_{\text{CS}_2}$$

$$n_{\text{O}_2}' = n_{\text{O}_2} - 3 n_{\text{CS}_2}$$

$$P_t' = n_{\text{O}_2} \frac{RT}{V}$$

$$P_t = n_{\text{CS}_2} \frac{RT}{V} + P_t'$$

5.28 Hydrogen peroxide will have extensive hydrogen bonding and display anomalies similar to those displayed by water. It should have a higher boiling point than F_2 and H_2S .

$$6.16 \left(\frac{2200 \times 10^3 \text{ g}}{504.3 \text{ g mol}^{-1}} \right) = 4.36 \times 10^3 \text{ mol Ca}_5(\text{PO}_4)_3\text{F}$$

$$4.63 \times 10^3 \text{ mol Ca}_5(\text{PO}_4)_3\text{F} \left(\frac{3 \text{ mol H}_3\text{PO}_4}{1 \text{ mol Ca}_5(\text{PO}_4)_3\text{F}} \right) = 1.31 \times 10^4 \text{ mol H}_3\text{PO}_4$$

$$\frac{1.31 \times 10^4 \text{ mol}}{6.3 \text{ mol L}^{-1}} = 2.1 \times 10^3 \text{ L}$$

6.30 In the equation the iodine is in the +5 oxidation state on the left side of the equation and ends up in the 0 oxidation state on the right side. Carbon is in the +2 oxidation state on the left side and goes to the +4 oxidation state on the right. All oxygen stays in the -2 oxidation state throughout the reaction. I_2O_5 is reduced. CO is oxidized.

6.32 In acidic solution, H_3O^+ and H_2O may be added either as reactants or as products to achieve balance.

