Gas Laws - Supplemental Problems

1. In one city, a balloon with a volume of 6.0 L is filled with air at 101 kPa pressure. The balloon in then taken to a second city at a much higher altitude. At this second city, atmospheric pres-sure is only 91 kPa. If the temperature is the same in both places, what will be the new volume of the balloon?

   $P_1V_1 = P_2V_2$ $\quad P_1 = 101\,kPa \quad V_1 = 6.0\,L \quad P_2 = 91\,kPa \quad V_2 = ?$

   $V_2 = \frac{P_1V_1}{P_2} = \frac{(100\,kPa)(6.0\,L)}{91\,kPa}$ $\qquad V_2 = 6.7\,L$

2. A certain mass of gas in a 2.25-L container has a pressure of 164 kPa. What will the new pressure be if the volume of the container is reduced to 1.50 L and the temperature stays constant?

   $P_1V_1 = P_2V_2$ $\quad P_1 = 164\,kPa \quad V_1 = 2.25\,L \quad P_2 = ? \quad V_2 = 1.50\,L$

   $P_2 = \frac{P_1V_1}{V_2} = \frac{(164\,kPa)(2.25\,L)}{1.50\,L}$ $\qquad P_2 = 246\,kPa$

3. If 5.80 dm^3 of gas is collected at a pressure of 92.0 kPa, what volume will the same gas occupy at 101.3 kPa if the temperature stays constant?

   $P_1V_1 = P_2V_2$ $\quad P_1 = 92.0\,kPa \quad V_1 = 5.80\,dm^3 \quad P_2 = 101.3\,kPa \quad V_2 = ?$

   $V_2 = \frac{P_1V_1}{P_2} = \frac{(92.0\,kPa)(5.80\,dm^3)}{101.3\,kPa}$ $\qquad V_2 = 5.27 dm^3$

4. If the volume of an air pump used to inflate a football decreases from 480 mL to 375 mL, and the original pressure was 93.5 kPa, what is the new air pressure in the pump if the temperature stays constant?

   $P_1V_1 = P_2V_2$ $\quad P_1 = 93.5\,kPa \quad V_1 = 480\,mL \quad P_2 = ? \quad V_2 = 375\,mL$

   $P_2 = \frac{P_1V_1}{V_2} = \frac{(93.5\,kPa)(480\,mL)}{375\,mL}$ $\qquad P_2 = 120\,kPa$

5. Maintaining constant pressure, the volume of a gas is increased from 18.0 dm^3 to 32.0 dm^3 by heating it. If the original temperature was 18.0°C, what is the new temperature in degrees Celsius?

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

   $V_1 = 18.0\,dm^3 \quad T_1 = 18.0\,°C + 273 = 291\,K \quad V_2 = 32.0\,dm^3 \quad T_2 = ?$

   $T_2 = \frac{V_2T_1}{V_1} = \frac{(32.0\,dm^3)(291\,K)}{18.0\,dm^3}$ $\qquad T_2 = 517K - 273 = 244°C$

6. A natural gas tank is constructed so that the pressure remains constant. On a hot day when the temperature was 33°C, the volume of gas in the tank was determined to be 3000.0 L. What would the volume be on a warm day when the temperature is 11°C?

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

   $V_1 = 3000.0\,L \quad T_1 = 33.0\,°C + 273 = 306\,K \quad V_2 = ? \quad T_2 = 11.0\,°C + 273 = 284\,K$

$V_2 = \frac{V_1 T_2}{T_1} = \frac{(3000.0\ L)(284\ K)}{306\ K}$ $V_2 = 2780\ L$

7. A 50.0-mL sample of gas is cooled from 119°C to 80.0°C. If the pressure remains constant, what is the final volume of the gas?

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

$V_1 = 50.0\ mL$ $T_1 = 119\ °C + 273 = 392\ K$ $V_2 =?$ $T_2 = 80\ °C + 273 = 353\ K$

$V_2 = \frac{V_1 T_2}{T_1} = \frac{(50.0\ mL)(353\ K)}{392\ K}$ $V_2 = 45.0\ mL$

8. A 10.0-L cylinder of gas is stored at room tem-perature (20.0°C) and a pressure of 1800 psi. If the gas is transferred to a 6.0-L cylinder, at what Celsius temperature would it have to be stored in order for the pressure to remain at 1800 psi?

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

$V_1 = 10.0\ L$ $T_1 = 20.0\ °C + 273 = 293\ K$ $V_2 = 6.0\ L$ $T_2 =?$

$T_2 = \frac{V_2 T_1}{V_1} = \frac{(6.0\ L)(293\ K)}{10.0\ L}$ $T_2 = 176K - 273 =- 97°C$

9. If the gas pressure in an aerosol can is 148.5 kPa at 23°C, what is the pressure inside the can if it is heated to 298°C?

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

$P_1 = 148.5\ kPa$ $T_1 = 23\ °C + 273 = 296\ K$ $P_2 =?$ $T_2 = 298\ °C + 273 = 571\ K$

$P_2 = \frac{P_1 T_2}{T_1} = \frac{(148.5\ kPa)(571\ K)}{296\ K}$ $P_2 = 286\ kPa$

10. A tank for compressed gas has a maximum safe pressure limit of 850 kPa. The pressure gauge reads 425 kPa when the temperature is 28°C. What is the highest temperature in degrees Celsius the tank can withstand safely?

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

$P_1 = 425\ kPa$ $T_1 = 28\ °C + 273 = 301\ K$ $P_2 = 850\ kPa$ $T_2 =?$

$T_2 = \frac{T_1 P_2}{P_1} = \frac{(148.5\ kPa)(301\ K)}{296\ K}$ $T_2 = 602K - 273 = 330°C$

11. In a steel container, it was found that the pres-sure of the gas inside was 160 kPa when the container had been heated to 98°C. What had been the pressure of the gas when the temperature had been 50°C the previous day?

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

$P_1 =?$ $T_1 = 50\ °C + 273 = 323\ K$ $P_2 = 160\ kPa$ $T_2 = 98\ °C + 273 = 371\ K$

$P_1 = \frac{P_2 T_1}{T_2} = \frac{(160\ kPa)(323\ K)}{371\ K}$ $P_2 = 140\ kPa$

12. A steel cylinder is filled with a gas at a temperature of 25.0°C and a pressure of 225.0 kPa. What will the pressure be if the temperature is raised to 47°C?

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

$P_1 = 225.0\ kPa$ $T_1 = 25.0\ °C + 273 = 298\ K$ $P_2 = ?$ $T_2 = 47\ °C + 273 = 320\ K$

$P_2 = \frac{P_1 T_2}{T_1} = \frac{(225.0\ kPa)(320\ K)}{298\ K}$ $P_2 = 242\ kPa$

13. A balloon is filled with gas at a pressure of 102.3 kPa and a temperature of 45.5°C. Its volume under these conditions is 12.5 L. The balloon is then taken into a decompression chamber where the volume is measured as 2.50 L. If the temperature is 36.0°C, what is the pressure in the chamber?

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

$P_1 = 102.3\ kPa$ $V_1 = 12.5\ L$ $T_1 = 45.5\ °C + 273 = 318.5\ K$

$P_2 = ?$ $V_2 = 2.50\ L$ $T_2 = 36.0\ °C + 273 = 309\ K$

$P_2 = \frac{P_1 V_1 T_2}{T_1 V_2} = \frac{(102.3\ kPa)(12.5\ L)(309\ K)}{(318.5\ K)(2.50\ L)}$ $P_2 = 496\ kPa$

14. A weather balloon contains 14.0 L of helium at a pressure of 95.5 kPa and a temperature of 12.0°C. If this had been stored in a 1.50-L cylinder at 21.0°C, what must the pressure in the cylinder have been?

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

$P_1 = ?$ $V_1 = 1.50\ L$ $T_1 = 21.0\ °C + 273 = 294\ K$

$P_2 = 95.5\ kPa$ $V_2 = 14.0\ L$ $T_2 = 12.0\ °C + 273 = 285\ K$

$P_1 = \frac{P_2 V_2 T_1}{V_1 T_2} = \frac{(95.5\ kPa)(14.0\ L)(294\ K)}{(1.50\ L)(285\ K)}$ $P_2 = 919\ kPa$

15. How many moles of a gas will occupy 2.50 L at STP?

$1\ mole\ of\ gas\ at\ STP = 22.4\ L\ of\ gas$

$\frac{2.50\ L}{1} \times \frac{1\ mol}{22.4\ L} = 0.112\ mol$

16. Calculate the volume that 3.60 g H_2 gas will occupy at STP.

$1\ mole\ of\ gas\ at\ STP = 22.4\ L\ of\ gas$

$\frac{3.60\ g\ H_2}{1} \times \frac{1\ mol\ H_2}{2.02\ g\ H_2} \times \frac{22.4\ L\ H_2}{1\ mol\ H_2} = 39.9\ L\ H_2$

17. What volume is occupied by 0.580 mol of gas at 98.4 kPa and 11°C?

$PV = nRT$

$P = 98.4\,kPa \quad V = ? \quad n = 0.580\,mol \quad R = 8.31\,\frac{L\cdot kPa}{mol\cdot K} \quad T = 11°C + 273 = 284K$

$V = \frac{nRT}{P} = \frac{(0.580\,mol)(8.31\,\frac{L\cdot kPa}{mol\cdot K})(284\,K)}{98.4\,kPa} \qquad V = 13.9\,L$

18. When a sample of a gas was placed in a sealed container with a volume of 3.35 L and heated to 105°C, the gas vaporized and the resulting pressure inside the container was 170.0 kPa. How many moles of the gas was present?

$PV = nRT$

$P = 170.0\,kPa \quad V = 3.35\,L \quad n = ? \quad R = 8.31\,\frac{L\cdot kPa}{mol\cdot K} \quad T = 105°C + 273 = 378K$

$n = \frac{PV}{RT} = \frac{(170.0\,kPa)(3.35\,L)}{(8.31\,\frac{L\cdot kPa}{mol\cdot K})(378\,K)} \qquad n = 0.181\,mol$

19. An engineer wishes to design a container that will hold 14.0 mol of gas at a pressure no greater than 550 kPa and a temperature of 48°C. What is the minimum volume the container can have?

$PV = nRT$

$P = 550\,kPa \quad V = ? \quad n = 14.0\,mol \quad R = 8.31\,\frac{L\cdot kPa}{mol\cdot K} \quad T = 48°C + 273 = 321K$

$V = \frac{nRT}{P} = \frac{(14.0\,mol)(8.31\,\frac{L\cdot kPa}{mol\cdot K})(321\,K)}{550\,kPa} \qquad V = 67.9\,L$

20. What is the molar mass of a sample of gas that has a density of 2.85g/L at 101 kPa pressure and 29°C?

$PV = nRT \quad n = \frac{m}{M} \rightarrow m = nM \quad D = \frac{m}{V} \rightarrow m = DV \quad nM = DV \rightarrow n = \frac{DV}{M}$

$PV = nRT \rightarrow PV = (\frac{DV}{M})RT \rightarrow P = \frac{DRT}{M}$

$P = 101\,kPa \quad D = 2.85\,g/L \quad R = 8.31\,\frac{L\cdot kPa}{mol\cdot K} \quad T = 29°C + 273 = 302K \quad M = ?$

$M = \frac{DRT}{P} = \frac{(2.85\,g/L)(8.31\,\frac{L\cdot kPa}{mol\cdot K})(302\,K)}{101\,kPa} \qquad M = 70.8\,g/mol$

21. How many grams of gas are present in a sample that has a molar mass of 44 g/mol and occupies a 1.8-L container at 108 kPa and 26.7°C?

$PV = nRT \quad n = \frac{m}{M} \quad PV = nRT \rightarrow PV = (\frac{m}{M})RT$

$P = 108\,kPa \quad V = 1.8\,L \quad m = ? \quad M = 44\,g/mol \quad R = 8.31\,\frac{L\cdot kPa}{mol\cdot K}$

$T = 26.7°C + 273 = 299.7K$

$m = \frac{MPV}{RT} = \frac{(44\,g/mol)(108\,kPa)(1.8\,L)}{(8.31\,\frac{L\cdot kPa}{mol\cdot K})(299.7\,K)} \qquad m = 3.4\,g$

22. What is the molar mass of a gas if 142 g of the gas occupies a volume of 45.1 L at 28.4°C and 94.6 kPa?

$PV = nRT \quad n = \frac{m}{M} \quad PV = nRT \rightarrow PV = (\frac{m}{M})RT$

$P = 94.6\, kPa \quad V = 45.1\, L \quad m = 142\, g \quad M = ? \quad R = 8.31\, \frac{L \cdot kPa}{mol \cdot K}$

$T = 28.4°C + 273 = 301.4K$

$M = \frac{mRT}{PV} = \frac{(142\, g)(8.31\, \frac{L \cdot kPa}{mol \cdot K})(301.4\, K)}{(94.6\, kPa)(45.1\, L)} \qquad m = 83.4\, g/mol$

23. Determine the volume of hydrogen gas needed to make 8 L of water vapor.
$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

$\frac{8\, L\, H_2O}{1} \times \frac{1\, mol\, H_2O}{22.4\, L\, H_2O} \times \frac{2\, mol\, H_2}{2\, mol\, H_2O} \times \frac{22.4\, L\, H_2}{1\, mol\, H_2} = 8\, L\, H_2$

24. Calculate the volume of chlorine gas at STP that is required to completely react with 3.50 g of silver, using the following equation:
$2Ag(s) + Cl_2(g) \rightarrow 2AgCl(s)$.

$\frac{3.50\, g\, Ag}{1} \times \frac{1\, mol\, Ag}{107\, g\, Ag} \times \frac{1\, mol\, Cl_2}{2\, mol\, Ag} \times \frac{22.4\, L\, Cl_2}{1\, mol\, Cl_2} = 0.366\, L\, Cl_2$

25. Use the reaction shown to calculate the mass of iron that must be used to obtain 0.500 L of hydrogen at STP. $3Fe(s) + 4H_2O(l) \rightarrow Fe_3O_4(s) + 4H_2(g)$

$\frac{0.500\, L\, H_2}{1} \times \frac{1\, mol\, H_2}{22.4\, L\, H_2} \times \frac{3\, mol\, Fe}{4\, mol\, H_2} \times \frac{55.8\, g\, Fe}{1\, mol\, Fe} = 0.934\, g\, Fe$