The Gas Laws: Boyle's, Charles', Gay-Lussac's, and the Combined

Answer Key!

1. Temperature conversions:
   a. 35.0°C = ?K $35.0°C + 273 = \boxed{308\ K}$
   b. 576.2K = ? °C $576.2\ K - 273 = \boxed{303.2\ °C}$
2. Pressure conversions:
   a. 695mmHg = ?atm $\frac{695\ mmHg}{1} \times \frac{1\ atm}{760\ mmHg} = \boxed{0.914\ atm}$
   b. 1.34atm = ?kPa $\frac{1.34\ atm}{1} \times \frac{101.3\ kPa}{1\ atm} = \boxed{135.7\ kPa}$
   c. 95.6kPa = ?mmHg $\frac{95.6\ kPa}{1} \times \frac{760\ mmHg}{101.3\ kPa} = \boxed{717.2\ mmHg}$
3. A sample of sulfur trioxide gas occupies a volume of 350ml at 100.1kPa. How many milliliters will the gas occupy at 175.5kPa if the temperature remains constant?

   $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $P_1V_1 = P_2V_2$ $\frac{(100.1\ kPa)(350\ mL)}{175.5\ kPa} = \frac{(175.5\ kPa)(V_2)}{175.5\ kPa}$ $\boxed{V_2 = 199.6\ mL}$
4. A sample of oxygen gas is compressed at constant temperature from a volume of 540ml to 320ml. If the initial pressure was 88.2kPa, what is the final pressure?

   $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $P_1V_1 = P_2V_2$ $\frac{(88.2\ kPa)(540\ mL)}{320\ mL} = \frac{P_2(320\ mL)}{320\ mL}$ $\boxed{P_2 = 148.8\ kPa}$
5. A sample of CO_2 gas has a pressure of 655torr at 50.0°C. To what **Celsius** temperature must it be heated to raise its pressure to 825torr if the volume remains constant? (hint: convert to K then answer back to °C)

   $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ $\frac{655\ torr}{323\ K} = \frac{825\ torr}{T_2}$ $T_2 = 406.8\ K - 273 = \boxed{133.8\ °C}$
6. A sample of ammonia gas occupies 285ml at 25°C. At what temperature in Celsius will it occupy 350.ml if the pressure remains constant? (→ 298K)

   $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\frac{285\ mL}{298\ K} = \frac{350\ mL}{T_2}$ $T_2 = 366\ K - 273 = \boxed{93.0\ °C}$
7. Nitrogen gas exerts a pressure of 350mmHg at 20°C. How many kPa will it exert if its temperature is raised to 40°C without a change in volume? (→ 293 K; 40°C → 313 K)

   $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $\frac{350\ mmHg}{293\ K} = \frac{P_2}{313\ K}$ $P_2 = \frac{373.9\ mmHg}{1} \times \frac{101.3\ kPa}{760\ mmHg} = \boxed{49.8\ kPa}$
8. A fixed quantity of CO gas at a constant temperature exhibits a pressure of 737torr &occupies a volume of 20.5L. (→ 0.970 atm)

   $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

   a. Calculate the volume if the pressure increases to 1.80atm.
      $(0.970\ atm)(20.5\ L) = (1.80\ atm)(V_2)$ $\boxed{V_2 = 11.04\ L}$
   b. Calculate the pressure if the volume increases to 16.0L.
      $(0.970\ atm)(20.5\ L) = (P_2)(16.0\ L)$ $\boxed{P_2 = 1.24\ atm}$
9. A fixed quantity of methane gas at a constant pressure occupies a volume of 8.50L at a temperature of 29.0°C. (→ 302 K)

   $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

   a. Calculate the volume if the temperature increases to 125°C. (→ 398 K)
      $398\ K \times \frac{8.50\ L}{302\ K} = \frac{V_2}{398\ K} \times 398\ K$ $\boxed{V_2 = 11.20\ L}$
   b. Calculate the temperature in Celsius if the volume decreases to 5.00L.
      $\frac{8.50\ L}{302\ K} = \frac{5.00\ L}{T_2}$ $T_2 = 177.65\ K - 273 = \boxed{-95.4\ °C}$
10. A fixed quantity of a gas at a constant volume exhibits a pressure of 200.kPa at a temperature of 15°C. (→ 288 K)

    $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

    a. Calculate the pressure if the temperature increases to 200°C. (→ 473 K)
       $473\ K \cdot \frac{200.\ kPa}{288\ K} = \frac{P_2}{473\ K} \cdot 473\ K$ $\boxed{P_2 = 328.5\ kPa}$
    b. Calculate the temperature if the pressure is increased to 500.kPa.
       $\frac{200.\ kPa}{288\ K} = \frac{500.\ kPa}{T_2}$ $\boxed{T_2 = 720\ K}$
11. At 46°C and 0.880atm, helium gas occupies a volume of 0.600L. How many liters will it occupy at STP? (46°C → 319 K; STP → 1 atm, 273 K)

    $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $\frac{(0.880\ atm)(0.600\ L)}{319\ K} = \frac{(1\ atm)(V_2)}{273\ K}$

    $\boxed{V_2 = 0.452\ L}$

The Combined Gas Law, Ideal Gas Law, and Dalton's Law of Partial Pressures

1. Chlorine is widely used to purify municipal water supplies and to treat swimming pool water. Suppose that the volume of a particular sample of chlorine gas is 5.62L at 740torr and 33°C. (→ 306 K)

   a. What volume will the chlorine gas occupy at 680torr and 107°C? (→ 380 K)

   $$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \quad \frac{(740\ \text{torr})(5.62\ L)}{306\ K} = \frac{(680\ \text{torr})(V_2)}{380\ K} \quad \boxed{V_2 = 7.59\ L}$$

   b. What volume will the chlorine gas occupy at STP?

   $$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \quad \frac{(740\ \text{torr})(5.62\ L)}{306\ K} = \frac{(760\ \text{torr})(V_2)}{273\ K} \quad \boxed{V_2 = 4.88\ L}$$

   c. At what temperature will the chlorine gas occupy 3.00L at 800mmHg? (→ 800 torr)

   $$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \quad \frac{(740\ \text{torr})(5.62\ L)}{306\ K} = \frac{(800\ \text{torr})(3.00\ L)}{T_2}$$

   $$\boxed{T_2 = 176.59\ K}$$

   d. At what pressure will the chlorine gas occupy a volume of 5.00L at 67°C? (→ 340 K)

   $$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \quad \frac{(740\ \text{torr})(5.62\ L)}{306\ K} = \frac{P_2\ (5.00\ L)}{340\ K} \quad \boxed{P_2 = 924.18\ \text{torr}}$$

2. Calculate the following quantities for an ideal gas: PV=nRT

   a. The pressure in atmospheres, if 0.00825moles occupies 174ml at -15°C. (→ 258 K) (→ .174 L)

   $PV = nRT$

   $$P = \frac{nRT}{V} \quad P = \frac{(0.00825\ \text{mol})(0.082)(258\ K)}{0.174\ L} = \boxed{1.00\ \text{atm}}$$

   b. The quantity of gas, in moles, if 6.38L is occupied at 35°C and 955mmHg. (→ 308 K) (→ $\frac{955\ \text{mmHg}}{1} \times \frac{1\ \text{atm}}{760\ \text{mmHg}} = 1.257\ \text{atm}$)

   $PV = nRT$

   $$n = \frac{PV}{RT} \quad n = \frac{(1.257\ \text{atm})(6.38\ L)}{(0.082)(308\ K)} = \boxed{0.317\ \text{mol}}$$

   c. The volume of the gas, in liters, if 2.95mol is at 0.76atm and 52°C. (→ 325 K)

   $PV = nRT$

   $$V = \frac{nRT}{P} \quad V = \frac{(2.95\ \text{mol})(0.082)(325\ K)}{0.76\ \text{atm}} = \boxed{103.44\ L}$$

   d. The absolute temperature at which 0.270mol occupies 15.0L at 1.88atm.

   $PV = nRT$

   $$T = \frac{PV}{nR} \quad T = \frac{(1.88\ \text{atm})(15.0\ L)}{(0.270\ \text{mol})(0.082)} = \boxed{1273.7\ K}$$

3. A sample of nitrogen gas is collected over water at a temperature of 23.0°C. What is the pressure of the nitrogen gas if the atmospheric pressure is 785mmHg? (Use Table A8 on page 859 in Appendix A of the Text)

   763.9 mmHg

   $P_{atmosphere} = P_{H_2O} + P_{N_2}$

   $P_{N_2} = P_{atmosphere} - P_{H_2O}$ (→ Looked up ...)

   $P_{N_2} = 785\ \text{mmHg} - 21.1\ \text{mmHg}$

   $\boxed{P_{N_2} = 763.9\ \text{mmHg}}$

4. The Hindenburg was a famous hydrogen-filled dirigible (blimp) that exploded in 1937. If the Hindenburg held 2.0×10^8L of hydrogen gas at 27°C and 1.0atm, what mass of hydrogen was present? (solve for n then convert) (→ 300 K)

   $PV = nRT$

   $$n = \frac{PV}{RT} \quad n = \frac{(1.0\ \text{atm})(2.0\times10^8\ L)}{(0.082)(300\ K)} = 8130081.301\ \text{mol}\ H_2 \times \frac{2.016\ g\ H_2}{1\ \text{mol}\ H_2} = \boxed{16389268.29\ g\ H_2}$$