Ideal gas law and combined gas law Name: Answers
4 marks each **Due: Monday (01/02) Tuesday (03)**

1. Hummingbirds have an extremely rapid metabolic rate. In order to maintain it, they must consume approximately one third their body mass in sugar every day. Energy is produced when sugar is broken down during cellular respiration.

Cellular respiration reaction: $C_6H_{12}O_{6(aq)} + 6\,O_{2(g)} \rightarrow 6\,CO_{2(g)} + 6\,H_2O_{(l)} + \text{energy}$

If a hummingbird burns 1.00 gram of sugar, $C_6H_{12}O_6$, during cellular respiration, **what is the volume of $CO_{2(g)}$ produced at 37.0°C and 101.3 kPa?**

$\frac{1\text{ mol } C_6H_{12}O_6}{x} = \frac{180.18\text{ g}}{1.00\text{ g}}$

$x = 0.005550\text{ mol } C_6H_{12}O_6$

1:6 ratio

$0.005550 \times 6 = 0.03330\text{ mol } CO_2$

$PV = nRT$ $T = 37.0 + 273 = 310\text{K}$

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

$= \frac{(0.0330)(8.31)(310)}{101.3}$

$V = 0.8468\text{ L}$

$\boxed{V = 847\text{ mL}}$

2. In an experiment, a student places magnesium metal in aqueous sulfuric acid, H_2SO_4, according to the following equation:

$$Mg_{(s)} + H_2SO_{4(aq)} \rightarrow MgSO_{4(aq)} + H_{2(g)}$$

The student must produce 174.1 mL of hydrogen gas by reacting magnesium with an excess of $H_2SO_{4(aq)}$, at a temperature of 30.0°C and a pressure of 100 kPa. **What mass of magnesium is needed?**

$PV = nRT$ $T = 30.0 + 273 = 303\text{K}$

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

$= \frac{(100)(0.1741)}{(8.31)(303)}$

$n = 0.006914\text{ mol } H_2$

$1\text{mol } H_2 = 1\text{mol } Mg$ $\therefore 0.006914\text{ mol } Mg$

$\frac{1\text{mol } Mg}{0.006914} = \frac{24.3\text{ g}}{x}$ $x = 0.1681$

$\boxed{0.168\text{g } Mg}$

3. A science student would like to identify a pure gas sample. She finds the following information:

Mass of empty container	4.40 g
Mass of container + unknown gas	6.03 g
Volume	1210 mL
Temperature	18°C
Pressure	102 kPa

Which of the following is the unknown gas?

H_2 (2g/mol) O_2 (32g/mol) OCl_2 BCl_3

Temp = 18 + 273 = 291 K

Mass of gas $6.03\text{g} - 4.40\text{g} = 1.63\text{g}$

Liters!

$PV = nRT$

$n = \frac{PV}{RT} = \frac{(102)(1.210)}{(8.31)(291)} = 0.05104$

$\frac{1\text{mol}}{0.05104\text{mol}} = \frac{x}{1.63\text{g}}$

$x = 31.9\text{ g/mol}$

4. Inside the school, a balloon occupies a volume of 1.50×10^3 mL at 22.0°C and 101.8 kPa. The balloon is taken outside, where the temperature is 33.0°C and the pressure is 102.3 kPa. **What is the volume of the balloon when it is outside?**

$V_1 = 1.50 \times 10^3$

$T_1 = 22.0 + 273 = 295\text{K}$

$P_1 = 101.8\text{ kPa}$

n = constant

$V_2 = ?$

$T_2 = 33.0 + 273 = 306\text{K}$

$P_2 = 102.3\text{ kPa}$

$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$

$\frac{(101.8)(1.50 \times 10^3)}{295} = \frac{(102.3)(V_2)}{306}$

$46726.200 = 30178.5\,V_2$

$V_2 = 1548.33\text{ mL}$

$\boxed{V_2 = 1.55\text{L}}$