

Name: Key  
 Hour: \_\_\_\_\_ Date: \_\_\_\_\_

**Chemistry: Graham's Law**

Do the following problems, showing your work and including all proper units.

1. If neon gas travels at 400 m/s at a given temperature, calculate the velocity of butane, C<sub>4</sub>H<sub>10</sub>, at the same temperature.

$N_e = 20$   
 $C_4H_{10} = 58$   
 $v_1 = 400$   
 $v_2 = ?$   
 $\sqrt{\frac{m_1}{m_2}} = \frac{v_2}{v_1}$   
 $\sqrt{\frac{20}{58}} = \frac{v_2}{400}$   
 $v_2 = 235 \text{ m/s}$

2. Hydrogen sulfide, H<sub>2</sub>S, has a very strong rotten egg odor. Methyl salicylate, C<sub>8</sub>H<sub>8</sub>O<sub>3</sub>, has a wintergreen odor, and benzaldehyde, C<sub>7</sub>H<sub>6</sub>O, has a pleasant almond odor. If the vapors for these three substances were released at the same time from across a room, which odor would you smell first? Show your work and explain your answer.

$H_2S = 2(1) + 32 = 34$  ← smallest mass ⇒ highest velocity  
 $C_8H_8O_3 = 8(12) + 8(1) + 3(16) = 152$   
 $C_7H_6O = 7(12) + 6(1) + 16 = 106$

3. A nitrogen molecule travels at about 505 m/s at room temperature. Find the velocity of a helium atom at the same temperature.

$N_2 = 28$   
 $He = 4$   
 $v_1 = 505$   
 $v_2 = ?$   
 $\sqrt{\frac{m_1}{m_2}} = \frac{v_2}{v_1}$   
 $\sqrt{\frac{28}{4}} = \frac{v_2}{505}$   
 $v_2 = 1336 \text{ m/s}$

4. A carbon dioxide molecule travels at 45.0 m/s at a certain temperature. At the same temperature, find the velocity of an oxygen molecule.

$CO_2 = 44$   
 $O_2 = 32$   
 $v_1 = 45.0$   
 $v_2 = ?$   
 $\sqrt{\frac{m_1}{m_2}} = \frac{v_2}{v_1}$   
 $\sqrt{\frac{44}{32}} = \frac{v_2}{45.0}$   
 $v_2 = 52.8 \text{ m/s}$

5. Nitrogen gas effuses through an opening 1.59 times faster than does an unknown gas.

a. Calculate the molecular mass of the unknown gas.

$N_2 = 28$   
 $v_1 = 1.59 v_2$   
 $\sqrt{\frac{m_1}{m_2}} = \frac{v_2}{v_1} = \frac{1}{1.59} = \sqrt{\frac{m_1}{28}}$   
 $2.53 = \frac{m_1}{28}$   
 $m_1 = 71$

b. Make a reasonable prediction as to what the unknown gas is.

$Cl_2 ? = 70.9 \text{ amu}$

6. An unknown gas diffuses 1.62 times slower than does oxygen gas.

a. Calculate the molecular mass of the unknown gas.

$O_2 = 32$   
 $v_1 = 1.62 v_2$   
 $\sqrt{\frac{m_1}{m_2}} = \frac{v_2}{v_1} = \frac{1}{1.62} = \sqrt{\frac{m_1}{32}}$   
 $2.62 = \frac{m_1}{32}$   
 $m_1 = 83.8$

b. Make a reasonable prediction as to what the unknown gas is.  $Kr = 83.8 \text{ amu}$

- Answers: 1. 236 m/s 2. H<sub>2</sub>S 3. 1336 m/s 4. 52.8 m/s 5a. 71 a.m.u. 5b. Cl<sub>2</sub> 6a. 84 a.m.u. 6b. Kr