PRACTICE EXAM #4

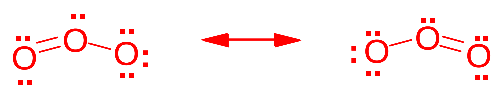
Chem20, Elementary Chemistry

1.) For each of the following compounds, draw the correct Lewis structure and indicate the expected electronic **AND** molecular geometries. Indicate whether the molecule is **polar** or **nonpolar**. Be sure to include **ALL** possible resonance structures where applicable. (30 pts)

Element	O	H	C	N	B
eN	3.5	2.1	2.5	3.0	2.0

a.) O_3

Total: (3)(6 e^-) = 18 total e^-
Used: 2 bonds x (2 e^-) = 4 used e^-
Needed: 6 + 4 + 6 = 16 needed e^-
18 total – 4 used – 16 needed = -2/2 → 1 more bond, with resonance.
All bonds are nonpolar (3.5 – 3.5 = 0), so the molecule is **nonpolar.**



2 bonding + 1 nonbonding groups = 3 total electron groups

ELECTRONIC __**trigonal planar**__________ MOLECULAR __**bent**__________________

b.) HCN (the carbon is central)

Total: (1)(1 e^-) + (1)(4 e^-) + (1)(5 e^-) = 10 total e^-
Used: 2 bonds x (2 e^-) = 4 used e^-
Needed: 4 + 6 = 10 needed e^-, so 10 total – 4 used – 10 needed = -4/2 → 2 more bonds
No resonance; H cannot form a multiple bond.

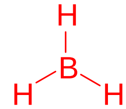
H—C≡N:

H-C bond is nonpolar (2.5-2.1 = 0.4), C-N bond is polar (3.0 – 2.5 = 0.5), so the molecule is **polar** (dipole does not cancel).
2 bonding + 0 nonbonding groups = 2 total electron groups

ELECTRONIC __**linear**________________________ MOLECULAR __**linear**________________

c.) BH_3

Total: (1)(3 e^-) + (3)(1 e^-) = 6 total e^-
Used: 3 bonds x (2 e^-) = 6 used e^-
Needed: 2 needed e^-, so 6 total – 6 used – 2 needed = -2, but no multiple bonds possible on H. Incomplete octet around B.



B-H bond is nonpolar (2.1 - 2.0 = 0.1), so the molecule is **nonpolar**.
3 bonding + 0 nonbonding groups = 3 total electron groups

ELECTRONIC __**trigonal planar**__________ MOLECULAR __**trigonal planar**__________

2.) A sample of $NH_3(g)$ in a 452 mL container has a pressure of 605 torr. A closed valve connects it to a 623 mL container that contains a sample of $CH_4(g)$ at a pressure of 598 torr. When the valve is opened, the two gases are allowed to mix and travel freely between **both** containers. Assume the valve adds no volume. (23 pts)

a.) What is the new partial pressure of $NH_3(g)$ after the valve is opened?

Use Boyle's Law: $P_1V_1 = P_2V_2$

P_1 = 605 torr, V_1 = 452 mL, P_2 = ?, V_2 = 452 mL + 623 mL = 107$\underline{5}$ mL

(605 torr)(452 mL) = (P_2)(107$\underline{5}$ mL)

(27$\underline{3}$460 torr · mL) = (P_2)(107$\underline{5}$ mL)

P_2 = 25$\underline{4}$.3 → **254 torr**

b.) What is the new partial pressure of $CH_4(g)$ after the valve is opened?

Use Boyle's Law: $P_1V_1 = P_2V_2$

P_1 = 598 torr, V_1 = 623 mL, P_2 = ?, V_2 = 623 mL + 452 mL = 107$\underline{5}$ mL

(598 torr)(623 mL) = (P_2)(107$\underline{5}$ mL)

(37$\underline{2}$554 torr · mL) = (P_2)(107$\underline{5}$ mL

P_2 = 34$\underline{6}$.5 → **347 torr**

c.) What is the total pressure of the mixture of $NH_3(g)$ and $CH_4(g)$?

Use Dalton's Law of Partial Pressure: $P_T = P_{NH3} + P_{CH4}$

P_T = 254 torr + 347 torr = 60$\underline{1}$ → **601 torr**

3.) Complete the following statements. (12 pts)

a.) Kinetic Molecular Theory assumes that gas particles have no _**volume**_______________, meaning that they take up no space and behave as points.

b.) The Duet Rule for Lewis dot structures applies to two elements: _**hydrogen**_________ and __**helium**_____________, whose valence shell is the n = 1 level.

c.) A(n) __**perfect (nonpolar) covalent**___________ bond forms between two atoms that have a difference in electronegativity between 0.0 – 0.4.

4.) Consider the combustion of propane gas by the following reaction.

$$C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(l)$$

The reaction was carried out in a 1.20 L container at 25°C. Initially, 0.365 mols of $C_3H_8(g)$ were added to 1.27 mols $O_2(g)$ and then allowed to fully react. (35 pts)

a.) Determine the **limiting reactant** and the **theoretical yield** of $CO_2(g)$, in mols.

Convert each reactant into mols $CO_2(g)$ to find the least produced.

$0.365 \text{ mols } C_3H_8 \times \frac{3 \text{ mols } CO_2}{1 \text{ mol } C_3H_8} = 1.0\underline{9}6 \text{ mols } CO_2$

$1.27 \text{ mols } O_2 \times \frac{3 \text{ mols } CO_2}{5 \text{ mols } O_2} = 0.76\underline{2} \text{ mols } CO_2$

Limiting Reactant: $O_2(g)$, Theoretical Yield: 0.762 mols $CO_2(g)$

b.) What is the partial pressure in atm of the leftover **reactant in excess**?

Convert theoretical yield back to reactant in excess and subtract from the initial.

$0.762 \text{ mols } CO_2 \times \frac{1 \text{ mol } C_3H_8}{3 \text{ mols } CO_2} = 0.25\underline{4} \text{ mols } C_3H_8 \text{ used}$

$0.365 \text{ mols } C_3H_8 \text{ initial} - 0.25\underline{4} \text{ mols } C_3H_8 \text{ used} = 0.11\underline{1} \text{ mols } C_3H_8 \text{ in excess}$

Use the Ideal Gas Law ($PV = nRT$) to solve for P.

$P = ?$, $V = 1.20$ L, $n = 0.11\underline{1}$ mols C_3H_8, $R = 0.08206$ L·atm/(mol·K),

$T = 25 + 273.15 = 29\underline{8}.15$ K

$(P)(1.20 \text{ L}) = (0.11\underline{1} \text{ mols})(0.08206 \text{ L·atm/(mol·K)})(29\underline{8}.15 \text{ K})$

$(P)(1.20 \text{ L}) = (2.7\underline{1}5 \text{ L·atm})$

$P = 2.2\underline{6}3 \rightarrow$ **2.26 atm**

c.) The total pressure of the mixture of water vapor, $CO_2(g)$, and reactant was 5.22 atm. The vapor pressure of water at this temperature is 23.8 mmHg. What is the partial pressure of $CO_2(g)$ actually collected, in atm?

Convert 23.8 mmHg into atm.

$23.8 \text{ mmHg} \times \frac{1 \text{ atm}}{760 \text{ mmHg}} = 0.031\underline{3}1 \text{ atm}$

Use Dalton's Law to solve for P_{CO2}: $P_T = P_{H2O} + P_{C3H8} + P_{CO2}$

$5.22 \text{ atm} = (0.031\underline{3}1 \text{ atm}) + (2.26 \text{ atm}) + P_{CO2}$

$P_{CO2} = 2.9\underline{2}8 \rightarrow$ **2.93 atm**

d.) Calculate the percent yield of $CO_2(g)$.

Use the Ideal Gas Law ($PV = nRT$) to solve for the actual yield of $CO_2(g)$, in mols.

$P = 2.93$ atm, $V = 1.20$ L, $n = ?$, $R = 0.08206$ L·atm/(mol·K), $T = 29\underline{8}.15$ K

$(2.93 \text{ atm})(1.20 \text{ L}) = (n)(0.08206 \text{ L·atm/(mol·K)})(29\underline{8}.15 \text{ K})$

$3.5\underline{1}6 \text{ L·atm} = (n)(24.\underline{4}6 \text{ L·atm/mol})$

$n = 0.14\underline{3}7 \text{ mols } CO_2$

Use the percent yield equation (% yield = actual yield/theoretical yield x 100%).

$\% \text{ yield} = \frac{0.144 \text{ mols}}{0.762 \text{ mols}} \times 100\% = 18.\underline{8}5 \rightarrow$ **18.9 % yield**