1. The pressure of the first two gases below is determined with a manometer that is filled with mercury (density = 13.6 g/mL). The pressure of the last two gases below is determined with a monometer that is filled with water (density = 1.00 g/mL). Assume an atmospheric pressure of 751.9 mm Hg, and determine the pressure of each gas in (1) mm Hg, (2) torr, and (3) atmospheres.

(a)  
(b)  
(c)  
(d)  

2. Given the following data

<table>
<thead>
<tr>
<th>Volume (mL)</th>
<th>Pressure (torr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>298.5</td>
<td>12.0</td>
</tr>
<tr>
<td>221.5</td>
<td>16.0</td>
</tr>
<tr>
<td>178.8</td>
<td>20.0</td>
</tr>
<tr>
<td>149.4</td>
<td>24.0</td>
</tr>
<tr>
<td>112.3</td>
<td>32.0</td>
</tr>
<tr>
<td>89.7</td>
<td>40.0</td>
</tr>
<tr>
<td>73.9</td>
<td>48.0</td>
</tr>
</tbody>
</table>

(a) graph Pressure versus Volume  
(b) graph Pressure versus 1/Volume  
(c) graph log Pressure versus log Volume  
(d) graph Pressure x Volume versus Pressure  

(continued on next page)
The relationship between the equilibrium vapor pressure of a liquid and temperature is given by:

\[
\ln \text{EVP} = \left( -\frac{\Delta H_{\text{vap}}}{RT} \right) + C
\]

(a) Determine what must be plotted on the x and y axis’s to produce a linear graph. Test this by graphing the following data for water:

<table>
<thead>
<tr>
<th>EVP (torr)</th>
<th>Temperature (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.0</td>
<td>283</td>
</tr>
<tr>
<td>12.4</td>
<td>288</td>
</tr>
<tr>
<td>16.9</td>
<td>293</td>
</tr>
<tr>
<td>22.7</td>
<td>298</td>
</tr>
<tr>
<td>30.3</td>
<td>303</td>
</tr>
<tr>
<td>40.1</td>
<td>308</td>
</tr>
<tr>
<td>52.5</td>
<td>313</td>
</tr>
</tbody>
</table>

(b) Predict the equilibrium vapor pressure of water at 353 K.

### EXTRA HOMEWORK 5B

1. Give the missing information for each gas:

<table>
<thead>
<tr>
<th></th>
<th>p</th>
<th>V</th>
<th>n</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>875 torr</td>
<td>275 mL</td>
<td>0.0105 mol</td>
<td></td>
</tr>
<tr>
<td>(b)</td>
<td>0.100 L</td>
<td>0.200 mol</td>
<td>38°C</td>
<td></td>
</tr>
<tr>
<td>(c)</td>
<td>2.50 atm</td>
<td>3.00 mol</td>
<td>565°C</td>
<td></td>
</tr>
</tbody>
</table>

2. Calculate the density of carbon dioxide gas at STP.

3. A compound is found to be 40.0% carbon, 6.7% hydrogen, and 53.3% oxygen by mass. When the compound was vaporized, a 136 mL flask at 373 K and 752 torr contained 0.264 g of the gaseous compound. For the compound, determine its

(a) empirical formula   (b) molar mass   (c) molecular formula

4. Draw a qualitative graph to show how the first property varies with the second in each of the following. Base the graphs on the following relationship:

\[
\frac{1}{2} M v^2 = \frac{3}{2} R T
\]

(a) \( M \) versus \( T \) with constant \( v \)
(b) \( M \) versus \( v^2 \) with constant \( T \)
(c) \( M \) versus \( 1/v^2 \) with constant \( T \)
(d) \( Mv^2 \) versus \( M \) with constant \( T \)
(e) \log M \) versus \( \log v^2 \) with constant \( T \)
1. Calculate the volume of hydrogen gas that can be produced at 25.0°C and 745 torr from the reaction of 2.00 g of zinc with excess hydrochloric acid.

2. The chemical reaction that occurs upon the ignition of gunpowder is:

\[
2\text{KNO}_3(s) + S(s) + 3\text{C}(s) \rightarrow \text{K}_2\text{S}(s) + \text{N}_2(g) + 3\text{CO}_2(g)
\]

Calculate the volume of carbon dioxide produced at 22°C and 1.05 atm from the ignition of 7.50 g of potassium nitrate, 1.50 g of sulfur, and 1.00 g of carbon.

3. A sample of condensed air was found to contain 2.917 g of nitrogen gas, 0.854 g of oxygen gas, and 0.048 g of argon gas. Find the mole fractions of each.

*4. A 125 gram sample of octane, C_{8}H_{18}, is combusted. Calculate the volume of air at 43°C and 760.8 torr needed for the reaction. Air is 20.9% oxygen by volume.

*5. Carbon monoxide and molecular oxygen react to form carbon dioxide. A 50.0 L tank at 25°C is charged with 1.00 atm of carbon monoxide. The gas is then pressurized with molecular oxygen to give a total pressure of 3.56 atm. The tank is heated to 350°C to cause the carbon monoxide and oxygen to react, and then cooled back to 25°C.

(a) Calculate the moles of carbon dioxide produced from the reaction.

(b) Calculate the final partial pressures of each gas in the tank at 25°C.

*6. A mixture of 1.00 g of hydrogen gas and 1.00 g of helium gas is placed in a 1.00 L container at 27°C. Calculate the partial pressure of each gas and the total pressure.
EXTRA HOMEWORK 5D

1. Determine the pressure of dry hydrogen gas collected in each of the following eudiometers. Assume an atmospheric pressure of 753.5 torr and a temperature of 21.5°C. Water vapor pressure at 21.5°C is 19.2 torr.

2. Hydrogen gas and calcium hydroxide are produced when solid calcium hydride reacts with water. From a sample containing calcium hydride, 1.72 L of hydrogen are collected over water in a eudiometer. The water level inside the eudiometer is 95.2 mm higher than the outside, the water temperature is 20.5°C, the atmospheric pressure is 752.4 torr, and the water vapor pressure at 20.5°C is 18.1 torr.
   (a) Calculate the mass of the calcium hydride that reacted.
   (b) If the sample was known to be 85.0% calcium hydride by mass, calculate the mass of the sample that reacted.

3. Calculate the root-mean-square-velocity of fluorine molecules at 25°C.

4. The Maxwell-Boltzman distributions of hydrogen gas and oxygen gas at 298K are given below. Identify the gas represented by curve A and B.

(continued on next page)
5. Hydrogen peroxide is reacted with an acidified 0.200 M dichromate ion solution, producing oxygen gas and chromium (III) ions. 1.35 L of oxygen are collected over water in a eudiometer. The water level inside the eudiometer is 40.8 mm higher than the outside, the water temperature is 22.0°C, the atmospheric pressure is 754.3 torr, and the water vapor pressure at 22.0°C is 19.8 torr.

(a) Calculate the mass of the hydrogen peroxide that reacted.
(b) Calculate the volume of 0.200 M dichromate ion solution that reacted.

**EXTRA HOMEWORK 5E**

1. A compound contains 18.1% carbon, 28.6% fluorine, and 53.3% chlorine by mass. The effusion rate of the compound was measured and found to be 32.8 mL/min. Under the same conditions, the effusion rate of oxygen gas was found to be 66.9 mL/min.

(a) Determine the empirical formula of the compound
(b) Determine the molar mass of the compound
(c) Determine the molecular formula of the compound

2. For the following gases:

\[
\text{H}_2 \quad \text{Cl}_2 \quad \text{HCl}
\]

(a) arrange them from smallest to largest according to the van der Waal’s constant \(a\).
(b) arrange them from smallest to largest according to the van der Waal’s constant \(b\).

3. Calculate the pressure of 0.2500 moles of methane in a 2.000 L container at 20.0°C using:

(a) the ideal gas law equation
(b) the van der Waals equation

**EXTRA HOMEWORK 5F**

1. Using the bond energies from Table 8.4 in the text book, estimate the heat of reaction for each of the following:

(a) 

\[
\begin{align*}
\text{H} & \quad \text{H} \\
\text{H-} & \quad \text{C-} \\
\text{Br} & \quad \text{O} \\
\text{Br} & \quad \text{O}
\end{align*}
\]

(b) 

\[
\begin{align*}
\text{H} & \quad \text{H} \\
\text{H-} & \quad \text{C-} \\
\text{O} & \quad \text{O} \\
\text{H} & \quad \text{O}
\end{align*}
\]

2. In a coffee-cup calorimeter, 25.0 mL of 1.00 M lead (II) nitrate is mixed with 25.0 mL of 1.00 M sodium hydroxide, both at 20.62°C. After the reaction, the solution drops to a minimum temperature of 16.21°C, and the solution’s mass is measured to be 52.8 g. If the specific heat capacity of the solution is 4.184 J/g°C, calculate the heat of the reaction, in kJ per mole of lead (II) hydroxide.
1. A 0.0325 g sample of aluminum metal is added to 15 mL of 6 M hydrochloric acid in a calorimeter, and the temperature of the solution increases from 22.5°C to 33.4°C. If the mass of the solution is 15.31 g and the specific heat capacity of the solution is 4.184 J/g°C, calculate the heat of the reaction, in kJ per gram of aluminum.

2. Using your answer from question 1, calculate the amount of heat released or absorbed when the given amounts of aluminum metal react with excess hydrochloric acid.
   (a) 2.15 grams of Al
   (b) 0.875 moles of Al

3. The reaction between silver nitrate and sodium chloride has a heat of reaction of +12.7 kJ per mole of silver chloride. In a coffee-cup calorimeter, 100.0 mL of 0.200 M silver nitrate is mixed with 200.0 mL of 0.150 M sodium chloride, both at 22.10°C. After the reaction, the final mixture has a mass of 303.8 g and has a specific heat capacity of 4.184 J/g°C. Calculate the final temperature of the mixture.

4. A 1.35 g sample of caffeine (C₈H₁₀N₄O₂) is burned in a bomb calorimeter that has a heat capacity of 7.85 kJ/C, and the temperature of the calorimeter rises from 24.65°C to 29.04°C. Calculate the heat of combustion of caffeine in kJ per gram of caffeine.

5. Using your answer from question 4, calculate the amount of heat released or absorbed when the given amounts of caffeine are burned.
   (a) 5.50 grams of caffeine
   (b) 0.463 moles of caffeine

6. To determine the heat capacity of a bomb calorimeter, an electric heater was used to add 19.75 kJ of heat to the bomb calorimeter, causing the temperature of the bomb calorimeter to increase by 4.22 C°. When the bomb calorimeter has an initial temperature of 23.32°C, a 1.75 g sample of methanol is combusted in the calorimeter. If the methanol has a heat of combustion of –22.65 kJ/g, calculate the final temperature of the bomb calorimeter.

*7. The heat of combustion of glucose is -15.57 kJ/g. When a 1.750 g sample of glucose burns in a bomb calorimeter, the calorimeter temperature increases from 21.45°C to 23.34°C. Calculate the heat capacity of the calorimeter.

*8. The heat of combustion of octane is -47.0 kJ/g. Assuming a car’s gas tank can hold 20.0 gallons of octane, calculate the amount of heat energy released by the combustion of the 20.0 gallons of octane. The density of octane is 0.703 g/mL.
1. Given the following data:

\[
\begin{align*}
C_6H_4(OH)_2(aq) & \rightarrow C_6H_4O_2(aq) + H_2(g) & \Delta H = +177 \text{ kJ} \\
H_2(g) + O_2(g) & \rightarrow H_2O_2(aq) & \Delta H = -191 \text{ kJ} \\
H_2(g) + \frac{1}{2}O_2(g) & \rightarrow H_2O(g) & \Delta H = -242 \text{ kJ} \\
H_2O(g) & \rightarrow H_2O(l) & \Delta H = -44 \text{ kJ}
\end{align*}
\]

calculate the \( \Delta H \) for the reaction:

\[
C_6H_4(OH)_2(aq) + H_2O_2(aq) \rightarrow C_6H_4O_2(aq) + 2H_2O(l)
\]

2. Using the heat of combustions for \( C_2H_2 \) (–1256 kJ/mol), \( C_6H_8 \) (–2344 kJ/mol), and \( H_2 \) (–242 kJ/mol), calculate the \( \Delta H \) for the reaction:

\[
3C_2H_2 + H_2 \rightarrow C_6H_8
\]

*3. Given the following data:

- Lattice Energy of BaCl\(_2\) \(-2056 \text{ kJ/mol}\)
- First Ionization Energy of Ba \(503 \text{ kJ/mol}\)
- Second Ionization Energy of Ba \(965 \text{ kJ/mol}\)
- Electron Affinity of Cl \(-349 \text{ kJ/mol}\)
- Bond Energy of Cl\(_2\) \(239 \text{ kJ/mol}\)
- Sublimation Energy of Ba \(178 \text{ kJ/mol}\)

determine the standard heat of formation for solid barium chloride.
1. The space shuttle orbiter utilizes the oxidation of methyl hydrazine by dinitrogen tetraoxide for propulsion:

\[ 5\text{N}_2\text{O}_4(l) + 4\text{N}_2\text{H}_3\text{CH}_3(l) \rightarrow 12\text{H}_2\text{O}(g) + 9\text{N}_2(g) + 4\text{CO}_2(g) \]

Calculate \( \Delta H^\circ \), in kJ/gram \( \text{N}_2\text{O}_4 \), for this reaction using the standard heat of formations in Appendix 4 of your textbook.

2. The standard heat of combustion of cyclohexane, \( \text{C}_6\text{H}_{12} \), is \( -3657 \text{kJ/mole of cyclohexane} \). Using the standard heat of formations in Appendix 4 of your textbook, calculate the standard heat of formation of cyclohexane.

*3. Calculate \( \Delta H^\circ \) for each of the following reactions in kJ per gram of sodium, using the standard heat of formations in Appendix 4 of your textbook:

(a) \( 4\text{Na}(s) + \text{O}_2(g) \rightarrow 2\text{Na}_2\text{O}(s) \)

(b) \( 2\text{Na}(s) + 2\text{H}_2\text{O}(l) \rightarrow 2\text{NaOH}(aq) + \text{H}_2(g) \)

(c) \( 2\text{Na}(s) + \text{CO}_2(g) \rightarrow \text{Na}_2\text{O}(s) + \text{CO}(g) \)

Explain why a water or carbon dioxide fire extinguisher might not be effective in putting out a sodium fire.

*4. The heat of combustion of octane is \(-5.06 \times 10^3 \text{kJ/mol}\).

(a) If the gasoline tank of a car has a capacity of 20.4 gallons, and octane has a density of 0.702 g/mL, calculate the amount of energy produced in the car engine by the combustion of a full tank of octane.

(b) If the amount of energy transferred to the wheels of the car is \(3.5 \times 10^5 \text{kJ/hr} \) at 65 mph, calculate how far the car can travel at 65 mph on one tank of octane.

1. Calculate the change in internal energy for each of the following:

(a) a gas absorbs 63 kJ of heat while being compressed, having 41 kJ of work done on it.

(b) a gas releases 78 kJ of heat and expands, doing 59 kJ of work on the surroundings.

2. A gas contracts from 7.25 L to 3.43 L as a result of a constant pressure of 1.67 atm. Calculate the work for the gas in each of the following units:

(a) Latm

(b) J

3. A cylinder containing 85.5 g oxygen has a volume of 31.4 L at 25.0°C. The temperature of the oxygen increases to 43.0°C and the volume of the cylinder expands to 42.5 L against a constant pressure of 0.209 atm. The specific heat capacity of oxygen is 0.918 J/g°C. For the oxygen, calculate

(a) \( q \)

(b) \( w \)

(c) \( \Delta E \)

(d) \( \Delta H \)

*4. Gasoline vapor and air are contained in a cylinder with an initial volume of 40 mL. If the combustion of this mixture does 950.0 J of work on its surroundings, determine the final volume that the cylinder will expand to against a constant pressure of 650.0 torr.
EXTRA 5A ANSWERS

1. (a) 340. mm Hg, 340. torr, 0.447 atm
   (b) 1092 mm Hg, 1092 torr, 1.437 atm
   (c) 25.0 mm Hg, 25.0 torr, 0.0329 atm
   (d) 739.4 mm Hg, 739.4 torr, 0.9729 atm

2. (a) (b) (c) (d)

   ![Graphs](image)

   *3. (a) \( \ln \) EVP vs. 1/T
   (b) 344.9 torr

EXTRA 5B ANSWERS

1. (a) 367 K
   (b) 51.0 atm
   (c) 82.5 L

2. 1.964 g/L

3. (a) CH\(_2\)O
   (b) 60.0 g/mol
   (c) C\(_2\)H\(_4\)O\(_2\)

4. (a) (b) (c) (d) (e)

   ![Graphs](image)
EXTRA 5C ANSWERS
1. 0.763 L
2. 1.92 L
3. $X_{N_2} = 0.7887, X_{O_2} = 0.202, X_{Ar} = 0.0091$
4. 1,690 L air
5. (a) 2.04 mol CO$_2$ (b) 2.06 atm O$_2$, 1.00 atm CO$_2$
6. 12.2 atm H$_2$, 6.15 atm He, 18.3 atm total

EXTRA 5D ANSWERS
1. 753.5 torr, 618 torr, 734.3 torr, 724.3 torr
2. (a) 1.44 g (b) 1.69 g
3. 442 m/s
4. A – oxygen, B – hydrogen
5. (a) 1.82 g H$_2$O$_2$ (b) 89.4 mL

EXTRA 5E ANSWERS
1. (a) CFCI (b) 133 g/mol (c) C$_2$F$_2$Cl$_2$
2. (a) H$_2$, Cl$_2$, HCl (b) H$_2$, HCl, Cl$_2$
3. (a) 3.007 atm (b) 2.989 atm

EXTRA 5F ANSWERS
1. (a) -92 kJ (b) -303 kJ
2. 77.9 kJ/mol
### EXTRA 5G ANSWERS

1. -21.5 kJ/g  
2. (a) -46.2 kJ  (b) -508 kJ  
3. 21.90°C  
4. -25.5 kJ/g  
5. (a) -140. kJ  (b) -2290 kJ  
6. 31.79°C  
*7. 14.4 kJ/C°  
*8. -2.80 \times 10^6 kJ

### EXTRA 5H ANSWERS

1. -204 kJ  
2. -1666 kJ  
*3. -869 kJ

### EXTRA 5I ANSWERS

1. -9.985 kJ/g  
2. -156 kJ/mol  
*3. (a) -832 kJ  (b) -368 kJ  (c) -133 kJ  
Sodium reacts exothermically with both water and carbon dioxide

*4. (a) -2.39 \times 10^6 kJ  (b) 440 miles

### EXTRA 5J ANSWERS

1. (a) 104 kJ  (b) -137 kJ  
2. (a) 6.38 Latm  (b) 646 J  
3. (a) 1410 J  (b) -235 J  (c) 1180 J  (d) 1410 J  
*4. 11.00 L