Unit VI. States of Matter. Assignment 11: Unit Review Worksheet *Answer Key*

Show all your work on these problems. If a question involves stoichiometry, be sure to balance the equation

1. Calculate the heat needed to heat 100 g of water from 26 °C to 100 °C. Then calculate the amount of heat needed to vaporize it.

① $\Delta H = m \cdot C \cdot \Delta T$ — 100 g | 1 cal / g C° | (100 − 26) C° = **7400 cal**

② $\Delta H = mLV$ — 100 g | 540 cal / g = **54000 cal**

2. Calculate the amount of water that is needed to cool a 485 g block of aluminum from 277 °C to 25 °C, if the water was originally at 20 °C. (Specific heat of aluminum is 0.22 cal/gC°).

$\Delta H_{gained} = \Delta H_{lost}$

$(m) \cdot C \cdot \Delta T = -(m \cdot C \cdot \Delta T)$ — 485 g Al | 0.22 cal / g C° | −(25 − 277) C° | g C° / 1 cal | (25 − 20) C° H_2O = **5400 g H_2O**

3. A gas in a 600.0 mL cylinder is under a pressure of 650 mm Hg at 298 K. What will be the temperature of the gas if the pressure is increased to 3230 mm Hg?

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$ $T_2 = \frac{P_2 T_1}{P_1}$ — 3200 mmHg | 298 K / 650 mmHg = **1500 K**

4. A syringe contains an enclosed gas that has a volume of $10.0\ cm^3$ at a pressure of 14.7 psi. What pressure is needed to compress the gas to $2.00\ cm^3$?

$P_1V_1 = P_2V_2$ $P_2 = \frac{P_1V_1}{V_2}$ — 14.7 psi | 10.0 cm^3 / 2.00 cm^3 = **73.5 psi**

5. For an ideal gas, calculate the following quantities:
   a. the pressure of the gas if 1.34 moles occupies 3.28 L at 25.0 °C
   b. the volume occupied by 6.72×10^{-3} mol at 145 °C and a pressure of 59.0 torr
   c. the number of moles in 2.50 L at 37.0 °C and 725 mm Hg
   d. the temperature which 0.270 mol occupies 15.0 L at 1.88 atm

$PV = nRT$

a. $P = \frac{nRT}{V}$ — 1.34 mol | 0.0821 L·atm / mol K | (25.0 + 273.15) K / 3.28 L = **10.0 atm**

b. $V = \frac{nRT}{P}$ — 6.72×10^{-3} mol | 0.0821 L·atm / mol K | (145 + 273.15) K / 59.0 torr | 760 torr / 1 atm = **2.97 L**

c) $n = \frac{PV}{RT}$ — 725 mmHg | 1 atm / 760 mmHg | 2.50 L | mol·K / 0.0821 L·atm | 310.15 K = **0.0937 mol**

d) $T = \frac{PV}{nR}$ — 1.88 atm | 15.0 L | mol·K / 0.270 mol | 0.0821 L·atm = **1270 K**

6. A mixture of gases contains 3.50 g of N_2, 2.15 g of H_2 and 5.27 g of NH_3. If the total pressure of the mixture is 2.50 atm, what is the partial pressure of each component? (Hint: percent composition is not by mass but by mole)

3.50 g N_2 | 1 mol / 28.02 g = 0.125 mol N_2

5.27 g NH_3 | 1 mol / 17.04 g = 0.309 mol NH_3

2.15 g H_2 | 1 mol / 2.02 g = 1.06 mol H_2

Total mol = 0.125 mol + 1.06 mol + 0.309 mol = 1.49 mol

$P_{N_2} = \left(\frac{0.125\ mol}{1.49\ mol}\right) \cdot 2.50\ atm$ = 0.21 atm

$P_{H_2} = \left(\frac{1.06\ mol}{1.49\ mol}\right) \cdot 2.50\ atm$ = 1.78 atm

$P_{NH_3} = \left(\frac{0.309}{1.49\ mol}\right) \cdot 2.50\ atm$ = 0.518 atm

7. A quantity of N_2 gas originally held at 3.80 atm pressure in a 1.00 L container at 26.0 °C is transferred into a 10.0 L container at 20.0 °C. A quantity of O_2 gas originally at 4.75 atm and 26.0 °C in a 5.00 L contains is transferred into the same new container. What is the total pressure in the new container?

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

mol N_2 — 3.80 atm | 1.00 L | mol·K / 0.0821 L·atm | 299.15 K = 0.155 mol N_2

4.75 atm | 5.00 L | mol K / 0.0821 L atm | 299.15 K = 0.967 mol O_2

$P = \frac{nRT}{V}$ — (0.155 mol N_2 + 0.967 mol O_2) | 0.0821 L·atm / mol·K | 293.15 K / 10.0 L = **2.70 atm**

8. Magnesium metal reacts with oxygen gas (O_2) to produce magnesium oxide. How many liters of oxygen gas ~~will be produced~~ *are required* at 35.0 °C and a pressure of 1.00 atm from 28.4 g of magnesium?

$2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$

28.4 g Mg | 1 mol / 24.31 g Mg | 1 mol O_2 / 2 mol Mg | 0.0821 L·atm / mol·K | (35.0 + 273.15) K / 1.00 atm = 14.8 L O_2

$CaH_{2(s)} + 2H_2O_{(l)} \rightarrow 2H_{2(g)} + Ca(OH)_2$

9. Calcium hydride (CaH_2) reacts with water to form hydrogen gas and calcium hydroxide [$Ca(OH)_2$]. How many grams of CaH_2 are needed to generate 10.0L of H_2 gas if the pressure is 740 torr at 23.0 °C?

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

$g\,CaH_2 = \frac{740\text{ torr}}{} \cdot \frac{1\text{ atm}}{760\text{ torr}} \cdot \frac{10.0\text{ L}}{} \cdot \frac{\text{mol}\cdot\text{K}}{0.0821\text{ L}\cdot\text{atm}} \cdot \frac{1}{(23+273.15)\text{K}} \cdot \frac{1\text{ mol }CaH_2}{2\text{ mol }H_2} \cdot \frac{42.10\text{ g }CaH_2}{1\text{ mol }CaH_2} = 8.4\text{ g }CaH_2$

10. The metabolic breakdown of glucose, $C_6H_{12}O_6$, in our bodies produces carbon dioxide, which is expelled from our lungs when we breath:

$$C_6H_{12}O_6 + 6\,O_2 \rightarrow 6\,H_2O + 6\,CO_2$$

Calculate the volume of dry CO2 produced at body temperatures (37 °C) and 1.00 atm when 5.00 g of glucose is consumed in this reaction.

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

$V\,CO_2 = \frac{5.00\text{ g }C_6H_{12}O_6}{} \cdot \frac{1\text{ mol}}{180.18\text{ g}} \cdot \frac{6\text{ mol }CO_2}{1\text{ mol }C_6H_{12}O_6} \cdot \frac{0.0821\text{ L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \cdot \frac{(37+273.15)\text{K}}{} \cdot \frac{1}{1.00\text{ atm}} = 4.24\text{ L }CO_2$

11. Calculate the density (D = mass/volume) of chlorine gas at STP. (Hint: assume you have 1 mole of Cl_2)

$d = \frac{m.m}{m.v} : \frac{70.9\text{ g }Cl_2}{\text{mol}} \cdot \frac{1\text{ mol}}{22.4\text{ L}} = 3.17\text{ g/L}$

12. A chemist isolated a gas in a glass bulb with a volume of 255 mL at a temperature of 25.0 °C and a pressure of 10.0 torr. The gas weighed 12.1 mg. What is the molar mass of the gas

$= 88.3\text{ g/mL}$

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

$m.m = \frac{m}{n} = \frac{mRT}{PV} \quad \frac{12.1\text{ mg}}{} \cdot \frac{1\text{ g}}{1000\text{ mg}} \cdot \frac{0.0821\text{ L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \cdot \frac{(25.0+273.15)\text{K}}{10.0\text{ torr}} \cdot \frac{760\text{ torr}}{1\text{ atm}} \cdot \frac{1}{255\text{ mL}} \cdot \frac{1000\text{ mL}}{1\text{ L}}$

13. What will be the effusion rate (v_1/v_2) of helium versus sulfur dioxide (SO_2)? (Hint: use Grahams Law)

(He) (SO2) $\frac{V_1}{V_2} = \sqrt{\frac{m_2 (SO_2)}{m_1 (He)}} \quad \frac{V_1}{V_2} = \sqrt{\frac{64.07\text{ g/mol}}{4.00\text{ g/mol}}} = 4.00\text{ x's faster}$

14. Ammonia effuses at a rate that is 2.93 times faster than an unknown gas. What is the molecular mass of the unknown gas?

(NH3) $\frac{V_1}{V_2} = \sqrt{\frac{m_2}{m_1 (NH_3)}} \Rightarrow \frac{2.93}{1} = \sqrt{\frac{x}{17.04\text{ g/mol}}} \quad x = 146.9\text{ g/mol}$

15. A sample of an unknown gas with a mass of 3.620 g was made to decompose inot 2.172 g of O_2 and 1.448 g of Sulfur. Prior to the decomposition, this sample occupied a volume of 1120 mL at 750 torr and 25.0 °C.

a. What is the percentage composition of the elements in this gas?
b. What is the empirical formula of the gas?
c. What is its molecular formula?

a) $\%\,O_2 = \frac{2.172\text{ g}}{3.626\text{ g}} = 59.9\%$

$\%\,S = \frac{1.448\text{ g}}{3.626\text{ g}} = 39.9\%$

b) $\frac{2.172\text{ g O}}{} \cdot \frac{1\text{ mol}}{16.00\text{ g}} = \frac{0.1358\text{ mol O}}{0.452} = 3$

$\frac{1.448\text{ g S}}{} \cdot \frac{1\text{ mol}}{32.07\text{ g}} = \frac{0.0452\text{ mol S}}{0.0452} = 1$

E.F. = SO_3

$m.m = \frac{mRT}{PV} \quad \frac{3.620\text{ g}}{} \cdot \frac{0.0821\text{ L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \cdot \frac{(25.0+273.15)\text{K}}{750\text{ torr}} \cdot \frac{760\text{ torr}}{1\text{ atm}} \cdot \frac{1}{1120\text{ mL}} \cdot \frac{1000\text{ mL}}{1\text{ L}} = 80.3\text{ g/mol}$

$\frac{80.3\text{ g/mol}}{80.07} = 1$

M.F. = SO_3