Part I. **4 points each** – ***Circle your answers***

1. You are holding two containers of equal volume. One container is filled with H_2 gas and the other is filled with Ne gas. Which of the following best represents the ratio (H_2:Ne) of total masses of the gases in the containers?

   A) 1:1
   B) 1:20
   C) 1:10
   D) 2:1
   E) 1:2

   Question not worded especially well... implies = mols, but doesn't say it...

2. Which of the following best represents the ratio (H_2:Ne) of pressures of the gases in the containers from Question 1?

   A) 1:1
   B) 1:20
   C) 1:10
   D) 2:1
   E) 1:2

3. What is the ratio of cations to anions in a 2.0 M solution of ammonium phosphate?

   A) 1:1
   B) 2:1
   C) 3:2
   D) 3:1
   E) 1:3

   D

4. What volume of 10.0 M H_2SO_4 is required to prepare 4.0 L of 0.50 M sulfuric acid?

   A) 0.20 L
   B) 0.40 L
   C) 0.50 L
   D) 1.0 L
   E) 4.0 L

   $V_1 \cdot 10.0\ M = 4.0\ L \cdot 0.50\ M$
   $V_1 = 0.20\ L$

5. If the ΔH° for the reaction, $2\ Mg_{(s)} + 2\ Cl_{2\,(g)} \rightarrow 2\ MgCl_{2\,(s)}$, is -1283.6 kJ, what is the standard enthalpy of formation of magnesium chloride?

   A) 0 kJ/mol
   B) -320.9 kJ/mol
   C) -641.8 kJ/mol
   D) 1283.6 kJ/mol
   E) -1283.6 kJ/mol

   This IS a formation reaction... just need to divide by 2 so it's for 1 mol.

6. Which of the following pairs of compounds include a *weak acid* and an *insoluble ionic compound*?

   A) HF, $Ca_3(PO_4)_2$
   B) HCl, $Ca_3(PO_4)_2$
   C) CH_3COOH, K_2CO_3
   D) HNO_3, FeS
   E) CH_3COOH, $(NH_4)_2CO_3$

7. In which of the following species is nitrogen in its +1 oxidation state?

I. NO^{-1} (+1)   II. N_2 (0)   III. NCl_3 (+3)

(A) I only
B) II only
C) III only
D) I and III
E) Neither I, II, nor III.

8. A known soluble ionic compound is titrated with another known soluble ionic compound, resulting in a precipitate. The moles of precipitate are then plotted as a function of the moles of the titrant, resulting in a linear trendline. What is the significance of the trendline's slope?

A) it indicates the stoichiometry between the two reacting soluble ionic compounds
(B) it indicates the stoichiometry between the titrant and the product precipitate
C) it indicates the equivalence point of the reaction
D) it indicates the identity of the titrant
E) it indicates that the reaction has gone to completion

Part II. 8-14 points each **SHOW ALL WORK!**

9. You measured 0.2573 g of $KMnO_4$ salt and diluted it to 150.0 mL in a volumetric flask with water. What is the molarity of your $KMnO_4$ solution?

FW ($KMnO_4$) = 158.034 g/mol

$$\frac{0.2573 \text{ g } KMnO_4}{150.0 \text{ mL soln}} \left| \frac{\text{mol } KMnO_4}{158.034 \text{ g } KMnO_4} \right| \frac{1000 \text{ mL soln}}{1 \text{ L soln}} = \boxed{0.01685 \text{ M}}$$

10. A mixture of two gases in a 3:1 molar ratio are placed in an 0.500 L container and the total pressure is measured to be 2.40 atm. The container volume is then increased to 2.00 L. What is the partial pressure of the gas present in the largest quantity?

$P_1 = 2.40$ atm $P_2 = x$ n, R, T const.

$V_1 = 0.500$ L $V_2 = 2.00$ L

$P_1V_1 = P_2V_2$

$$P_2 = \frac{P_1V_1}{V_2} = \frac{(2.40 \text{ atm})(0.500 \text{ L})}{2.00 \text{ L}} = 0.600 \text{ atm}$$

$P_2 = P_A + P_B = 0.600$ atm

$P_B = 3P_A$

$$P_A = \frac{0.600 \text{ atm}}{4} = 0.15 \text{ atm}$$

$\boxed{P_B = 0.450 \text{ atm}}$

11. Balance the following oxidation-reduction reaction that takes place in an acidic solution:

$$Zn + NO_3^{-1} \rightarrow Zn^{+2} + NH_4^{+1}$$

0 +5 +2 -3

oxidized reduced

Oxidation: $4(Zn \longrightarrow Zn^{2+} + 2e^-)$

Reduction: $NO_3^- + 10H^+ + 8e^- \longrightarrow NH_4^+ + 3H_2O$

Overall: $4Zn + NO_3^- + 10H^+ \longrightarrow 4Zn^{2+} + NH_4^+ + 3H_2O$

12. Write a *total ionic equation* for the neutralization of chloric acid by lithium hydroxide.

$HClO_3$ $LiOH$

$$H^+(aq) + ClO_3^-(aq) + Li^+(aq) + OH^-(aq) \longrightarrow Li^+(aq) + ClO_3^-(aq) + H_2O(l)$$

13. The standard enthalpy of formation of gaseous methanol ($CH_4O_{(g)}$) is -201 kJ/mol and the standard enthalpy of vaporization of methanol is +37.4 kJ/mol. What is the standard enthalpy of formation for liquid methanol?

(1) $C(graphite) + 2H_2(g) + \frac{1}{2}O_2(g) \longrightarrow CH_4O(g) \quad \Delta H_f^\circ = -201\ kJ/mol$

(2) $CH_4O(l) \longrightarrow CH_4O(g) \quad \Delta H_{vap}^\circ = +37.4\ kJ/mol$

reverse rxn(2): $CH_4O(g) \longrightarrow CH_4O(l) \quad \Delta H^\circ = -37.4\ kJ/mol$

add rxn(1) and (3): $C(graphite) + 2H_2(g) + \frac{1}{2}O_2(g) \longrightarrow CH_4O(l) \quad \Delta H_f^\circ = -238\ kJ/mol$

14. In a coffee-cup calorimeter, 0.6076 g of $Mg_{(s)}$ are oxidized in excess acid at an initial temperature of 23.20 °C. Upon completion of the reaction, the temperature of the calorimeter increases to 27.36 °C. The (experimentally determined) heat capacity of the calorimeter is 2775 J/°C. *Note: assume an isolated system as you answer the following.*

a) Write a balanced chemical equation for the oxidation of 1 mol of magnesium metal in excess acid to yield $Mg^{2+}_{(aq)}$ and $H_{2\,(g)}$.

b) Using the calorimetry data, calculate the molar enthalpy of reaction for the oxidation of $Mg_{(s)}$ (the same reaction that you determined in part (a)).

(a) $Mg(s) + 2H^+(aq) \longrightarrow Mg^{2+}(aq) + H_2(g)$

(b) $0.6076\ g\ Mg \times \frac{1\ mol}{24.305\ g\ Mg} = 0.0250\ mol\ Mg$ reacted

$\Delta T = 27.36^\circ C - 23.20^\circ C = 4.16^\circ C$

$\Delta H_{rxn} = q_{rxn} = -C_{cal}\Delta T = -(2775\ J/^\circ C)(4.16^\circ C)$

$= -11500\ J$

On a per mole basis

$\Delta H_{rxn} = \frac{-11500\ J}{0.0250\ mol} = -460\ kJ/mol$

15. Dichlorodimethylsilane ($(CH_3)_2SiCl_2$) is made by the reaction below (which, industrially, is carried out at high temperature and in the presence of a catalyst).

$$Si_{(s)} + 2\ CH_3Cl_{(g)} \rightarrow (CH_3)_2SiCl_{2\,(g)} \quad \text{(balanced)}$$

A 16.5 L flask is filled with gaseous CH_3Cl to a pressure of 885 mmHg at 175 °C. You place 0.200 mole of solid silicon in the flask and initiate the reaction. What is the *total* pressure in the flask (also at 175 °C) upon completion of the reaction?

Initial moles of CH_3Cl:

$$n = \frac{PV}{RT} = \frac{(885\ \text{mmHg}/760\ \text{mmHg/atm})(16.5\ \text{L})}{(0.08206\ \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}})(448\ \text{K})}$$

$= 0.523$ mol CH_3Cl

Since we have 0.200 moles of Si, Si is limiting (and need 0.400 mol CH_3Cl to react)

$$0.200\ \text{mol Si} \times \frac{2\ \text{mol}\ CH_3Cl}{1\ \text{mol Si}} = 0.400\ \text{mol}\ CH_3Cl\ \text{reacted}$$

$$\underset{\text{available}}{0.523\ \text{mol}\ CH_3Cl} - \underset{\text{reacted}}{0.400\ \text{mol}} = \underset{\text{remaining}}{0.123\ \text{mol}\ CH_3Cl}$$

$$0.400\ \text{mol}\ CH_3Cl \times \frac{1\ \text{mol}\ (CH_3)_2SiCl_2}{2\ \text{mol}\ CH_3Cl} = 0.200\ \text{mol}\ (CH_3)_2SiCl_2\ \text{produced}$$

Total moles of gas after reaction:

$$\underset{CH_3Cl}{0.123\ \text{mol}} + \underset{(CH_3)_2SiCl_2}{0.200\ \text{mol}} = \underset{\text{total gas}}{0.323\ \text{mol}}$$

$$P = \frac{nRT}{V} = \frac{(0.323\ \text{mol})(0.08206\ \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}})(448\ \text{K})}{16.5\ \text{L}}$$

$P = 0.720$ atm