MEDIUM PACKET 1 Team ID: ________________

1. Is PCl_3 planar or non-planar? Justify your response by drawing the lewis structure.

2. Determine the Ka for carbonic acid (H_2CO_3) given that a 34.0 mL sample of 0.14 M carbonic acid has a pH 3.50 at 25.0˚C.

3. All of the following reactions are examples of redox reactions except for one. Write in the space below which reaction does not follow the rules of redox chemistry.

(i) $Zn + Cu^{2+} \longrightarrow Zn^{2+} + Cu$

(ii) $2\ Fe(s) + O_2(aq) + 2\ H_2O(l) \longrightarrow 2\ FeO \cdot H_2O(s)$

(iii) $AgCl_3 + H_2O \longrightarrow Al(OH)_3 + HCl$

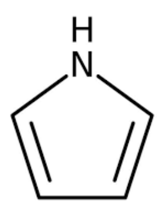
(iii) $IO_3^-(aq) + H^+ + I^-\ (aq) \longrightarrow H_2O(l) + I_3^-(aq)$

MEDIUM PACKET 2 Team ID: ___________________

1. What intermolecular forces are present in a sample of HBr (*l*)?

2. Is $\Delta S^\circ < 0$, $= 0$, or > 0 for the reaction: $2SO_3(g) \rightarrow O_2(g) + 2SO_2(g)$?

3. How many electrons are in resonance in pyrrole?



MEDIUM PACKET 3 Team ID: ________________

1. What is the pH at the equivalence point of a titration between 25.12 g of acetic acid in 100 mL water and 0.1 M NaOH? (K_a of acetic acid = 1.76×10^{-5})

2. The reaction $CO + 3H_2 \rightarrow CH_4 + H_2O$ is entirely in the gas phase. Consider a system at equilibrium. If an inert gas is added to the system, and total pressure is kept constant, which way will equilibrium shift?

3. W, X, Y, Z are four different elements in the first 20 elements of the periodic table. Knowing that:
   i. The common cation of W has the same electron configuration with the anion of Z.
   ii. Y and Z belong to the same group, and they can form 2 common chemical compounds.
   iii. X and Z belong to the same period, and they can form 2 common gaseous compounds.
   iv. W and X can form W_3X_2.

   Identify these four elements:

MEDIUM PACKET 4 Team ID: ________________

1. What do you call a process in which no heat transfer takes place?

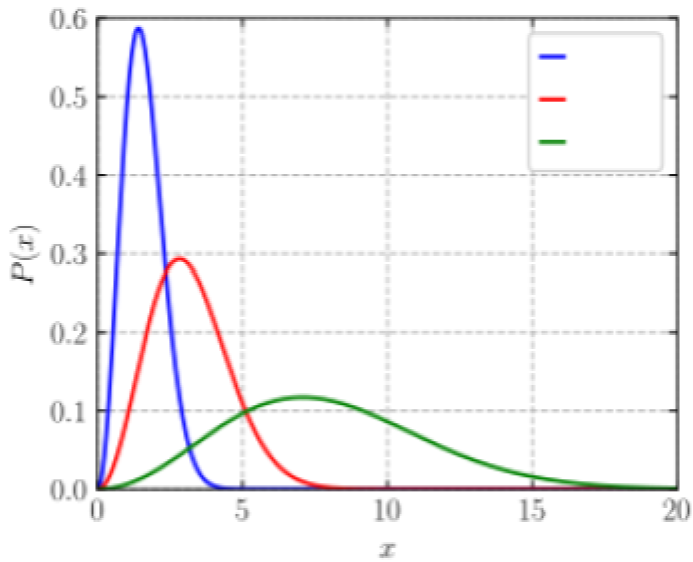
2. Which two phases of matter merge into a single phase at the “critical point” ?

3. Which is not a colligative property: vapor pressure, boiling point, osmolarity, viscosity?

MEDIUM PACKET 5

Team ID: ___________________

For a given sample of ideal gas at a fixed temperature, not all particles (atoms/molecules) are traveling at the same speed. The fraction of particles at each speed is predicted by the Maxwell-Boltzmann distribution equation, which can be plotted as P(x) vs. x. Show below is an example of a Maxwell-Boltzmann distribution plot.



1. If the red line represents Ne gas at 298 K, which color curve (green or blue) could represent Ne gas at 500 K?

2. If the red line represents Ne gas at 298 K, which color curve (green or blue) could represent Ar gas at 298 K?

3. What does the area under the curve between speeds of 0 and 10 represent?

MEDIUM PACKET 6 Team ID: ________________

1. Order the following elements of increasing ionic radius: F^+, O, Cl^-

2. A mixture of gas is contained in a vessel and the equation is given below. The partial pressures of H_2, I_2, and 2 HI are 0.057 atm, 0.035 atm, and 0.022 atm respectively. The Kp value of the reaction at 460 degrees celsius is 49. Determine if the reaction will proceed forward or backward.

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

3. 1.0 mol of HNO_2 was added with 0.30 mol of KOH to 1.0L of water. Assume the volume does not change. Knowing the pKa of HNO_2 is 3.35, what is the pH of the resulting solution?

MEDIUM PACKET 7 Team ID: ___________________

1. Rank the second ionization energy of the following elements: Ne Li C

   (least) ______________ < ______________ < ______________ (most)

2. Calculate the acid dissociation constant, K_a, for a solution containing 0.29M lactic acid with a pOH of 10.21.

3. Given the reaction: $2\ HI\ (g) \rightleftharpoons I_2\ (g) + H_2\ (g)$
   If the volume is reduced by half at a constant temperature, does the reaction shift towards the products, shift towards the reactants, or does nothing happen?

MEDIUM PACKET 8 Team ID: ________________

1. Which molecule has the highest bond order and which has the lowest: SO_2 NO_3^- XeF

   Highest:________ Lowest:_________

2. A solution containing 0.12 M of HCl is titrated with a solution of NaOH with a molarity of 0.76 M. Calculate the pH of the titration solution before any titrant is added.

3. A first-order reaction has a half-life of 15 minutes, how much time is required for this reaction to 63% complete.

MEDIUM PACKET 9 Team ID: ________________

1. In the reaction, $[A] + [B] \rightarrow [C] + [D]$, the rate law looks like: $Rate = k[A]^m[B]^n$, where k is some constant. Given the following experimental data where $[B]$ is held constant, what is the value of n?

	[A] (in M)	
Experiment	Time = 0 s	Time = 10 s
1	0.10	0.9
2	0.20	0.19
3	0.30	0.29

2. $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l) + CO_2(g)$

There are 3.5 g of $CaCO_3$ in a closed 2L container. 60 mL of 1M HCl solution is added to the container. Assume that the CO_2 produced behaves like an ideal gas. Calculate its pressure (3 significant digits). (Temperature: 298K, R=0.08206 $L \cdot atm \cdot mol^{-1} \cdot K^{-1}$)

3. There is great current interest in developing fuel cells based on the reaction:

$$2\ CH_3OH_{(l)} + 3\ O_{2\,(g)} \rightarrow 2\ CO_{2\,(g)} + 4\ H_2O_{(l)}.$$

Write a balanced equation for the half-reaction that occurs in acid solution for such a fuel cell at the anode and cathode.

MEDIUM PACKET 10 Team ID: ________________

1. $CH_4(g) + CO_2(g) \rightarrow 2H_2(g) + 2CO(g)$

   The reaction takes place in a closed container with a volume of 3L. The total pressure at the beginning of the reaction is 3.6 atm. The partial pressure of CH_4 is 2.6 atm, H_2 is 0.4 atm, CO is 0.6 atm. Knowing that K for this reaction is 4.8×10^2, calculate the equilibrium partial pressure for CO_2 (3 sig figs).

2. A hot metal cube 1cc (cubic centimeter) in volume was placed into a cup of water. The water was previously 23°C but increased in temperature to 32°C. Before removing the cube, the volume of the system in the cup was measured to be 34cc. The heat capacity of water is 4.186J/g°C. What was the change in heat of the system?

3. Consider the reaction: $[A] + [B] \leftrightarrow [C]$ at 400°K. The forward reaction rate constant is 11min^{-1}, and the arrhenius constant, A, is $5 \cdot 10^7$min^{-1}. A catalyst is added and the activation energy of the forward reaction, E_a, is reduced by 5 kJ/mol. What is the new rate constant of the forward reaction?

MEDIUM PACKET 11 Team ID: ________________

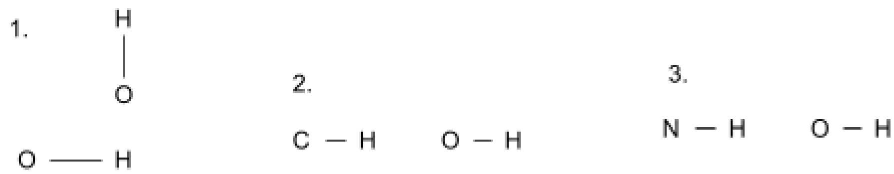
1. Write out the name of the following compound: $Mn_2(SO_3)_3$

2. Rank the following compounds from smallest number of oxygens to most:
   Bromic acid, perchloric acid, iodous acid, dihydrogen monoxide

3. What's the bond order of an O-O bond in ozone (O_3)?

MEDIUM PACKET 12 Team ID: ________________

1. Determine if hydrogen bonds can exist in the structures below. If they do exist, draw dashed lines of where the bond would occur



2. The density of gaseous form of sulfur is 2.857 g/L under standard conditions. What is the molecular formula of sulfur in this case?

3. Solution A has a pH of 10. Solution B has a pH of 5. How many times more acidic is Solution B than Solution A?

MEDIUM PACKET 13 Team ID: ________________

1. Under standard conditions, a glass jar filled with air has a mass of 152.34 g. When it is filled with oxygen, it has a mass of 152.37 g. What is its mass when it is filled with nitrogen? (M(air) $\simeq$ $28.97\ g/mol$)

2. Determine if a 20 mL solution of 0.03M $AgNO_3$ and 50 mL of 0.1 M K_2SO_4 will form a precipitate. (Given: K_{sp} for $Ag_2SO_4 = 1.2 \times 10^{-5}$)

3. A 5 L vessel holds a reaction where in the forward direction, the system is exothermic. A stress is applied to the system and where the temperature is increased but the moles of mixture and the volume remain constant. Will the reaction proceed forwards, backwards, or is more information needed?

MEDIUM PACKET 14 Team ID: ___________________

1. The term used to describe the concentration of the enzyme-substrate complex in a single-substrate, single-product reaction: __________

2. Consider the following reaction: $\mathbf{3C(s) + 4H_2(g) \rightarrow C_3H_8(g)}$

If you have 2.3g of C(s) and 5L of H_2(g) at STP, what is the limiting reagent and how much product (in grams) will be formed? Assume there are 22.4 L/mol of gas at STP.

3. What do you call the slowest step in a chemical reaction that determines the overall rate of chemical reaction?