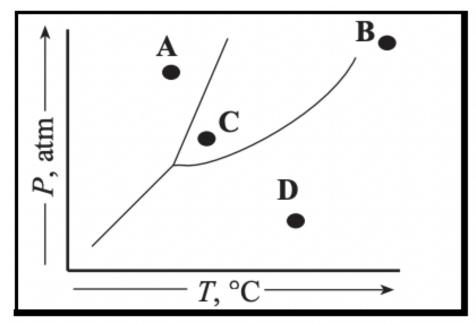
1. Determine the dominant intermolecular force in a pure sample of PH_3 .

2. A gas phase atom with the electron configuration $1s^22s^22p^63s^23p^64s^23d^6$ loses three electrons. What is the electron configuration of the resulting gas phase ion?

- 3. Which substance is most likely to be soluble in a nonpolar solvent?
 - a. Glucose
 - b. Sodium Chloride
 - c. Lithium fluoride
 - d. Sulfur

1. Which point in the phase diagram best represents supercritical conditions?



2. Consider a sample of O_2 gas at 298 K. Calculate the $v_{mp}(in \frac{m}{s})$ for this sample. Given: Ideal gas constant $R = 8.314 J/mol \cdot K$.

3. Water molecules undergo autoionization: $2H_2O \rightleftharpoons H_3O^+ + OH^-$. Similarly, liquid ammonia autoionizes: $2NH_3 \rightleftharpoons NH_4^+ + NH_2^-$. The natural log of the ion product constant for ammonia (pK_{NH_3}) at $-33^{\circ}C$ is 26. 29. What is the concentration of NH_4^+ and NH_2^- in liquid ammonia at 25 degree celsius? (round to 1 decimal place)

Team ID:		

- 1. If at 100 degrees celsius, water has an autoionization constant $K_w = 1.0 \times 10^{-12}$. If an aqueous solution has a pH of 7 at 100 degree celsius, is it acidic, neutral or basic?
 - a. Acidic
 - b. Neutral
 - c. Basic
- 2. Water molecules undergo autoionization: $2H_2O \rightleftharpoons H_3O^+ + OH^-$. Similarly, liquid ammonia autoionizes: $2NH_3 \rightleftharpoons NH_4^+ + NH_2^-$. Guanidine is a weak base in water: $C(NH_2)_2NH + H_2O \rightleftharpoons C(NH_2)_3^+ + OH^-$. Assume it behaves similarly in liquid ammonia, write an equation for its dissociation in ammonia.

- 3. NH_3 is converted to NO_2^- by nitrifying bacteria in natural waters. Is this an oxidation or reduction reaction?
 - a. Oxidation
 - b. Reduction
 - c. Not redox reaction

Team ID:

- 1. Arrange the following substances based on their melting points, from highest to lowest: N_2 , CO, NH_3 .
- 2. Arrange the following covalent compounds based on their melting points, from highest to lowest: SiC, Si_3N_4 , SiO_2
- 3. Which of the substances below cannot participate in hydrogen bonding?

a. Warfarin

$$H_3C$$
 N CH_3

b. Triethylamine

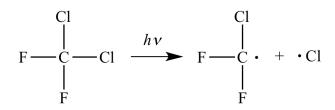
1-naphthalenethiol

c.

d. Sodium dodecyl sulfate

Team ID: _____

1. Shown below is the mechanism of the destruction of the ozone layer by freon. Which species is most likely acting as a catalyst?



$$Cl \cdot + \cdot O \longrightarrow Cl \longrightarrow Cl \longrightarrow - \cdot O \longrightarrow - \cdot$$

$$2 Cl \longrightarrow Cl \longrightarrow Cl \longrightarrow Cl \longrightarrow Cl \longrightarrow Cl$$

- a. *Cl*•
- b. ClO_2
- c. CCl_2F_2
- d. ClO•
- 2. Which of the following groups of species can coexist in an aqueous solution in abundance?
 - a. Ca^{2+} , NO_3^- , I^- , H^+
 - b. OH^{-} , Al^{3+} , Mg^{2+} , Cl^{-}
 - c. ClO^{-} , NH_{4}^{+} , Fe^{3+} , SO_{4}^{2-}
 - d. Na^+ , Br^- , MnO_4^- , H^+
- 3. For the following reaction, $N_2O_4 \rightleftharpoons 2NO_2$, the K_p at 300 K is 0.140 atm. What is the K_p of $4NO_2 \rightleftharpoons 2N_2O_4$?

1. A 2-L container contains 0.400 mol of O_2 gas and 0.200 mol of H_2 gas. At 100°C, what is the total pressure, in atm, of the gasses?

2. For the following reaction, $Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$, assuming it goes to completion, how many moles of H_2 gas would be produced if 3.45 g Zn reacts with 10.0 mL of 6 M HCl?

3. Write the equilibrium expression for the following decomposition reaction, $NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$.

1. What is the molar mass of CH_3COOH ?

2. Draw the preferred Lewis structures for NO_3^- . Indicate any equivalent resonance structures if necessary.

3. What is the formal charge, if any, on the nitrogen atom in NO_2 ?

1. Using your knowledge of intermolecular interactions, predict which molecule would have the highest boiling point: C_4H_8 , CH_3CH_2OH , or CH_3CH_2COOH ?

2. Which molecule has a trigonal pyramidal molecular geometry: NH_3 , NH_4 ⁺, BCl_3 ?

3. The pK_a of benzene sulfonic acid, $C_6H_5SO_3$ at 25°C is 0.70. Calculate the K_a of this acid at 25°C.

Team ID:

1. What is the conjugate base of H_2SO_4 ?

- 2. A solution made up of a strong base and a weak acid is most likely to have a pH:
 - a. Greater than 7
 - b. Around 7
 - c. Less than 7

3. Calculate the molality of a solution made by adding $0.10~g~BaCl_2$ to 25.00~mL of water. Assume the density of water is 1.00~g/mL.

1. A dilution is prepared by adding 1 mL of a 6 M HCl solution to 100 mL of water. What is the HCl concentration of the new solution?

2. What is the electron configuration for a +1 arsenic cation? (noble gas configuration is acceptable)

3. True/False: The following set of quantum numbers (given as n, l, m) could describe an electron in the 3d sublevel : (3, 3, -1).

1. How many electrons are found in the 5^{th} energy level?

2. How many unbonded electrons are present in formaldehyde, H_2CO , given that C is the central atom?

3. True/False: Methane (CH₄) is able to undergo hydrogen bonding with hydrofluoric acid (HF).

Team ID:

- 1. What direction does the dipole moment lie in CH_3Cl ?
 - a. Towards the the carbon
 - b. Towards the hydrogens
 - c. Towards the chlorine
 - d. There is no dipole moment in the molecule

- 2. The auto-ionization of water, given by the equation $2H_2O \rightleftharpoons H_3O^+ + OH^-$, is known to be an endothermic process. If the temperature of the reaction was lowered, which way would the reaction proceed?
 - a. To the right
 - b. To the left
 - c. The reaction would not shift as it would still remain in equilibrium

- 3. The reaction between water and formic acid, HCOOH, has a K_a of 1. 77 × 10⁻⁴. When formic acid is titrated with sodium hydroxide, NaOH, which of the following listed indicators would be best used to detect the equivalence point?
 - a. Thymol blue: pH range 1.2-2.8
 - b. Methyl orange: pH range 3.2-4.4
 - c. Bromothymol blue: pH range 6.0-7.6
 - d. Phenolphthalein: pH range 8.2-10.0

Team ID: ____

1. A 10 g ice cube (specific heat = $2.09 \frac{J}{g \cdot C}$, enthalpy of fusion = 334 J/g) at -15°C is added to 25 g of water (specific heat = $4.184 \frac{J}{g \cdot C}$) at 37°C. What is the final temperature of the water?

2. Estimate the enthalpy of formation of 1 mol of HBr for the following reaction: $H_2 + Br_2 \rightarrow 2HBr$, given the following average bond dissociation energies: H-H = 436 kJ/mol, Br-Br = 193 kJ/mol, and H-Br = 366 kJ/mol.

3. Consider the following balanced, heterogeneous chemical reaction:

$$BaO_2(s) + 4HCl(g) \rightleftharpoons BaCl_2(s) + 2H_2O(g) + Cl_2(g)$$

Using the Law of Mass Action, write the expression for the equilibrium constant, K, for this reaction.

1. Consider the following radial wavefunction for the H atom:

Rn,
$$\ell = \frac{1}{2\sqrt{6}} \left[\frac{Z}{a_0} \right] \sigma$$
 where $\sigma = \frac{Zr}{a_0}$

Determine if there are any radial nodes. If there are, please indicate where they are.

2. Consider the following radial wavefunction for the H atom:

Rn,
$$\ell = \frac{1}{2\sqrt{6}} \left[\frac{Z}{a_0} \right] \sigma$$
 where $\sigma = \frac{Zr}{a_0}$

If the radial wavefunction given describes an electron in a hydrogen atom that has a total energy equal to -3.4 eV, identify the quantum numbers n and ℓ associated with this function. Hint: you can simplify using Bohr's model.

3. Write the balanced chemical equation for the combustion of liquid pentane (C_5H_{12}) .

1. Consider the balanced reaction shown below to answer the following questions.

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$$
 at 245 K, K = 2.25.

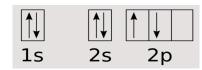
Determine if each of the initial conditions below will result in the reaction as written to proceed to the right in order to reach equilibrium.

a.
$$P(N_2) = 1.0$$
 atm; $P(O_2) = 1.5$ atm; $P(NO) = 1.5$ atm

b. The partial pressure of each gas is 0.45 atm

c. $P(N_2) = 0.20$ atm; $P(O_2) = 0.20$ atm; P(NO) = 0.50 atm

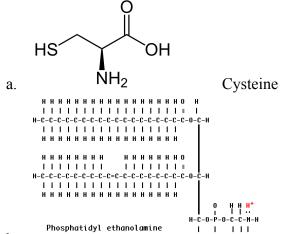
1. Which rule does the following configuration (of a ground state atom) violate?



2. Balance the reaction below:

$$S + HNO_3 \rightleftharpoons H_2SO_4 + NO_2 + H_2O$$

3. Which of the following compounds **cannot** act as a hydrogen bond donor but **can** act as a hydrogen bond acceptor?



b. Phospholipid

$$H_3C$$
 CH_3
 $Chloroxylenol$

d. H₃C O CH₃ Diethylether

c.

1. Write the net ionic reduction half-reaction for the following redox reaction. Be sure to include phases.

$$Fe_2O_{3(s)} + 2Al_{(s)} \rightarrow Al_2O_{3(s)} + 2Fe_{(l)}$$

2. Write the net ionic oxidation half-reaction for the following redox reaction. Be sure to include phases.

$$Fe_{2}O_{3(s)} + 2Al_{(s)} \rightarrow Al_{2}O_{3(s)} + 2Fe_{(l)}$$

3. For the following situations, determine if the reaction will shift left, shift right, or more information is needed.

$$Zn(s) + 2H_30^+(aq) -> Zn^{2+}(aq) + H_2(g) + H_20(l)$$

Note: this reaction is exothermic.

- a. Increasing the pH
- b. Increasing the temperature

1. $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

You combine 20 g of C_2H_6 and 30 g of O_2 . Identify the limiting reagent of this reaction.

2. A sample of 1.23 mol of an ideal gas occupies a container volume of $0.04~\rm{m}^3$. Calculate the pressure in the container.

3. True or False:

 ${\it CO}_2$ contains bonds that are longer than those in ${\it O}_3$.

1. Draw the Lewis dot diagram for SO_4^{2-} . Write the formal charges on the four oxygen atoms. The order you write them in does not matter

- 2. Here is a list of elements: lithium, nitrogen, oxygen, fluorine, beryllium
 - a. Which one has the highest electronegativity?
 - b. Which one has the largest second ionization energy?
 - c. In the ground state, which element has only 1 electron in each of the three p orbitals?

3. What is the name of the VSEPR geometry of phosphorus pentafluoride?

1. In a solution, the $[H^{+}] = 10^{-3}$. What is the pH, the $[OH^{-}]$, and the pOH?

- 2. At pressures above the critical point, what is the expected phase of a substance?
- 3. Consider the following reaction: $CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COO_{(aq)}^- + H_3O_{(aq)}^+$. Given $\Delta G_{rxn}^o = 27.2 \, kJ/mol$, calculate the equilibrium constant (K_a) at 25°C.

Team ID:

1. Consider the following reaction: $CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COO_{(aq)}^- + H_3O_{(aq)}^+$. Given $\Delta H_{rxn}^o = -0.3 \, kJ/mol$ for the reaction shown above, calculate the equilibrium constant (K_a) at 90°C. You may assume that ΔH_{rxn}^o and ΔS_{rxn}^o are temperature independent over this temperature range.

2. What is the name of the process in which solid is converted directly into gas?

3. The pH of pure water at 50°C is 6.85. What is the value of K_w at 50°C? Report your answer to the nearest 3 significant figures.