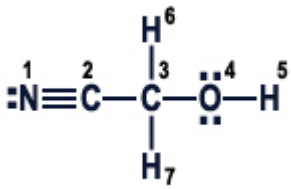
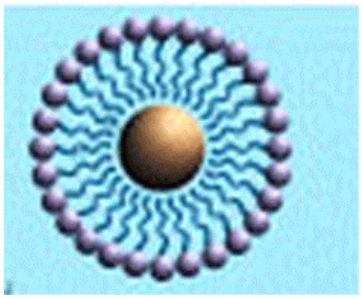
Question 1
18 Points



1. The atoms that form a sigma bond by the overlap of an **sp** and an **sp^3** hybrid orbitals? **C2 & C3**
2. The atoms that form a sigma bond by the overlap of an **sp^3** and an **sp^3** hybrid orbitals? **C3 and O4**
3. The **total** number of **sigma bonds** in this molecule is: **6**
4. The **total** number of **pi bonds** in this molecule is: **2**
5. The hybridization used to describe the bonding around:

   N1 is: **sp** **C2** is: **sp** **C3** is: **sp^3**
6. Orbital used by **H5** to form a sigma bond with the **sp^3** orbital on **O4** : **1s**

Question 2
4 Points



A surfactant molecule with a polar head group and a non-polar tail is depicted on the left.

From this depiction it can be inferred that the solvent that this molecule was placed in is **polar** and that the molecule inside the surfactant molecules is **nonpolar**.

Question 3
6 Points

Give the formula for the precipitate that is formed when each of the following aqueous solutions are mixed.

1. Iron(III) bromide and sodium hydroxide **$Fe(OH)_3$**
2. Calcium chloride and ammonium sulfide **CaS**

Question 4
16 Points

1. Consider the reaction when aqueous solutions of **aluminum nitrate** and **potassium hydroxide** are combined. The net ionic equation for this reaction is:

   $Al^{3+} + 3OH^- = Al(OH)_3(s)$

2. Write a net ionic equation for the reaction that occurs when aqueous solutions of **potassium hydroxide** and **hydrofluoric acid** (HF) are combined.

   $HF(aq) + OH^- = F^- + H_2O(l)$

3. Write a net ionic equation for the reaction that occurs when aqueous solutions of **sodium carbonate** and **hydroiodic acid** are combined.

   $CO_3^{2-} + 2H^+ = CO_2(g) + H_2O(l)$

Question 5
6 Points

A sample of ethylene glycol with a mass of **77.0g** at **4°C** is placed into a perfectly insulated container together with **89.0g** of glass at **56°C**. Calculate the final temperature of the sample when thermal equilibrium is reached?

Heat capacities: Glass = 0.84 J/g°C Ethylene glycol = 2.41 J/g°C

$q_{EG} = 77.0 \times 2.41 \times (T_f - 4) = 185.6T_f - 742.3$
$q_G = 89.0 \times 0.84 \times (T_f - 56) = 74.6T_f - 4186.6$

$185.6T_f - 742.3 + 74.6T_f - 4186.6 = 0$
$260.2T_f = 4928.9$

$T_f = 18.9°C$

Final Temperature: 18.9°C

Question 6
10 Points

19.0g of LiCl are dissolved in **175.0g** of water in a calorimeter the following data was collected:

Initial Temperature: **42.5°C** Final Temperature: **58.5°C**
Heat capacity of the solution = **4.184 J/g°C** Calorimeter constant = **63.9 J/°C**

What is the heat of solution for this compound in **J/mol**?

$q_{SOL} = (19.0 + 175.0) \times 4.184 \times 15 = 12{,}987$ J
$q_{CAL} = 63.9 \times 16 = 1{,}022$ J
$q_{TOTAL} = 14{,}009$ J

$$\frac{19.0 \text{ g LiCl}}{} \left| \frac{1 \text{ mol}}{42.39 \text{ g}} \right. = 0.448 \text{ mol LiCl}$$

$$\frac{14{,}009 \text{ J}}{0.448 \text{ mol}} = 31{,}270 \text{ J/mol}$$

Heat of solution: 31,270 J/mol

Question 7
6 Points

Given the following thermodynamic data:
$\Delta H^0_f MnO_2(s) = -504.0$ kJ/mol $\Delta H^0_f Al_2O_3(s) = -1675.7$ kJ/mol
Determine the enthalpy change associated with the following reaction:

$$4\ Al(s) + 3\ MnO_2(s) = 3\ Mn(s) + 2\ Al_2O_3(s)$$

$\Delta H^0_{rxn} = 3\Delta H^0_f Mn(s) + 2\Delta H^0_f Al_2O_3(s) - 4\Delta H^0_f Al(s) - 3\Delta H^0_f MnO_2(s)$
$\Delta H^0_{rxn} = 3(0) + 2(-1675.7) - (0) - 3(-504.0) =$ **-1839.4 kJ**

Question 8
6 Points

70.0g of water at **60°C** is added to **55.0g** of ice at **0°C**. Some of the ice melts and the water cools to 0°C. When the ice and water mixture are at 0°C, how much ice has melted?

ΔH_{fusion} ice = 333 J/g Heat Capacity of water = 4.184 J/g°C

Heat absorbed by ice = 70 x 4.184 x 60 = 17,572.8 J

$$\frac{17{,}572.8\ \text{J}}{333\ \text{J/g}} = \mathbf{52.8\ g}$$

Quantity of **ice** melted: **52.8** g

Question 9
8 Points

How many grams of solid **calcium hydroxide** are needed to exactly neutralize **12.1** mL of a **0.562 M hydrochloric acid** solution? Assume that the volume remains constant.

$Ca(OH)_2 + 2\ HCl = CaCl_2 + 2H_2O$

0.562 x 0.0121 = 0.00680 mol HCl

$$\frac{0.00680\ \text{mol HCl} \mid Ca(OH)_2}{2\ HCl} = 0.00340\text{mol } Ca(OH)_2$$

$$\frac{0.00340\ \text{mol } Ca(OH)_2 \mid 74.1\text{g}}{1\ \text{mol}} = \mathbf{0.252}\text{g } Ca(OH)_2$$

Grams of **barium hydroxide**: **0.252**

Question 10
10 Points

58.8 mL of **0.297 M hydrobromic acid** is added to **39.6** mL of calcium hydroxide, and the resulting solution is found to be acidic.
29.2 mL of **0.126 M barium hydroxide** is required to reach neutrality.
What is the molarity of the original **calcium hydroxide** solution?

0.297 x 0.0588 = 0.0175 mol HBr added

$Ba(OH)_2 + 2\ HBr = BaBr_2 + 2\ H_2O$

0.126 x 0.0292 = 0.00368 mol $Ba(OH)_2$

$$\frac{0.00368\ \text{mol } Ba(OH)_2 \mid 2\ HBr}{Ba(OH)_2} = 0.00736\ \text{mol HBr remaining}$$

0.0175 – 0.00736 = 0.0101 mol HBr that reacted with the $Ca(OH)_2$

$Ca(OH)_2 + 2\ HBr = CaBr_2 + 2\ H_2O$

$$\frac{0.0101\ \text{mol HBr} \mid Ca(OH)_2}{2\ HBr} = 0.00507\ \text{mol } Ca(OH)_2$$

$$\frac{0.00507\ \text{mol}}{0.0396\ \text{L}} = \mathbf{0.128M}$$

Calcium hydroxide concentration: **0.128** M

Question 11
6 Points

Nitrogen monoxide is produced by combustion in an automobile engine. For the following reaction, **0.534** moles of **nitrogen monoxide** are mixed with **0.514** moles of **oxygen** gas.

nitrogen monoxide (g) + oxygen (g) = nitrogen dioxide (g)

What is the **FORMULA** for the limiting reagent?
What is the **maximum amount (in moles)** of **nitrogen dioxide** that can be formed?

$2\ NO(g) + O_2(g) = 2\ NO_2(g)$

$$\frac{0.534 \text{ mol NO}}{} \left| \begin{array}{l} 2\ NO_2 \\ \hline 2\ NO \end{array} \right. = 0.534 \text{ mol } NO_2$$

$$\frac{0.514 \text{ mol } O_2}{} \left| \begin{array}{l} 2\ NO_2 \\ \hline O_2 \end{array} \right. = 1.028 \text{ mol } NO_2$$

Formula for limiting reagent: **NO**

Maximum amount of **nitrogen dioxide** produced: **0.534**

Question 12
4 Points

An observation is that a fixed quantity of a gas occupies a smaller volume as the temperature decreases (under constant pressure). Why is this?

In order to keep the pressure constant with the amount of gas constant to frequency of the collisions with the walls of the container must increase to combat the a lowering of the average kinetic energy, therefore the volume of the container must decrease.

Do Not Write Below This Line

Exam III Score	