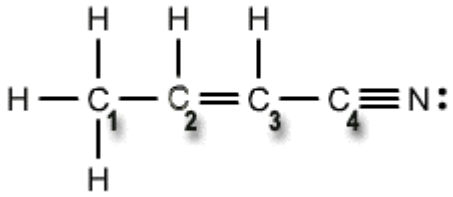
Question 1
16 Points

The following questions relate to the molecule depicted:



1. The **total** number of **sigma bonds** in this molecule is: **9**
2. The **total** number of **pi bonds** in this molecule is: **3**
3. The hybridization used to describe the bonding around:

   C1 is: sp^3 **C2** is: sp^2 **C4** is: **sp**
4. The sigma bond formed between **C3** and **C4** is best describe as the overlap of a(n) sp^2 orbital on **C3** with a(n) **sp** orbital on **C4**.
5. The **pi** bonds in this molecule are best described as being formed from the overlap of **p** orbitals.

Question 2
6 Points

1. What is the **driving force** in the following reaction? **Gas/Water formation**

   $2\ HNO_3(aq) + CoCO_3(s) = Co(NO_3)_2(aq) + H_2O(l) + CO_2(g)$
2. Give the **net ionic equation** for this reaction?

   $2H^+ + CoCO_3(s) = Co^{2+} + H_2O(l) + CO_2(g)$

Question 3
6 Points

When a solution **nickel(II) chloride** and **ammonium sulfide** are mixed a precipitate is formed.

1. Write the balanced chemical equation for this reaction:

   $NiCl_2(aq) + (NH_4)_2S(aq) = NiS(s) + 2NH_4Cl(aq)$
2. Write the net ionic equation for this reaction:

   $Ni^{2+} + S^{2-} = NiS(s)$

Question 4
4 Points

HNO_2 is a **weak acid** that reacts with $CoCO_3(s)$ to form $Co(NO_2)_2(aq)$, $H_2O(l)$ and $CO_2(g)$.

Write the **net ionic equation** for this reaction:

$$2HNO_2(aq) + CoCO_3(aq) = Co^{2+} + 2NO_2^- + H_2O(l) + CO_2(g)$$

Question 5
4 Points

What reaction, if any, will occur when a solution of **potassium chloride** is mixed with an aqueous solution of **iron(II) nitrate**. **Circle** the correct answer.

1. An acid base reaction
2. A gas forming reaction
3. A precipitation reaction
4. **No reaction**

Question 6
6 Points

What quantity of heat (**in joules**) is required to raise the temperature of **52.8 mL** of **water** from **24.9°C** to **28.1°C**. The **density of water** at this temperature is **0.997 g/mL**. The specific **heat capacity** of water is **4.184 J/g°C**.

$$\frac{52.8\text{mL} \mid 0.997\text{g}}{\quad \mid 1\text{mL}} = \mathbf{52.6g\ H_2O}$$

$$\Delta T = 28.1 - 24.9 = \mathbf{3.2^0C}$$

$$q = m \times C \times \Delta T = 52.6g \times 4.184J/g^0C \times 3.2^0C = \mathbf{705\ J}$$

Answer: 705 J

Question 7
6 Points

What quantity of heat (**in joules**) must be absorbed by **CH_3Cl** to convert **91.6g** of **liquid** to a **vapor** at its boiling point, **-24.09°C?** The **heat of vaporization** of CH_3Cl is **21.40 kJ/mol**.

CH_3Cl: 12.01 + 3(1.01) + 35.45 = **50.49g/mol**

$$\frac{91.6g\ CH_3Cl \mid 1\ mol}{\quad \mid 50.49g} = \mathbf{1.81\ mol\ CH_3Cl}$$

$$q = 1.81\ mol \times 21.40kJ/mol = 38.82kJ = \mathbf{38,820J}$$

Answer: 38,820J

Question 8
9 Points

If **0.61g** of C is burned in excess $O_2(g)$ in a calorimeter which contains **775g** of water, the calorimeter temperature increases from **25.0°C** to **28.0°C**. The **heat capacity of water** is **4.184 J/g°C**, the **calorimeter constant** is **893 J/°C**. What quantity of heat is evolved **per mole** of carbon?

$$q_{water} = 775g \times 4.184J/g^0C \times 3^0C = \mathbf{9728J}$$
$$q_{calorimeter} = 893J/^0C \times 3^0C = \mathbf{2679J}$$
$$q_{total} = 9728J + 2670J = \mathbf{12,407J}$$

$$\frac{0.61g\ C \mid 1\ mol}{\quad \mid 12.01g} = \mathbf{0.05mol\ C}$$

$$q_{evolved} = (12398J/0.05\ mol) = \mathbf{248,136J/mol}$$

Answer: 248,136J

Question 9
6 Points

The first step in the production of nitric acid is given below:

$$\mathbf{4NH_3(g) + 5O_2(g) = 4NO(g) + 6H_2O(g)}$$

What quantity of heat is evolved or absorbed in the production of **1** mole of **NO**?

ΔH^0_f's in kJ/mol: NO(g) = 90.29 NH_3(g) = -45.90 H_2O(g) = -241.83

$$\Delta H^0_{rxn} = 4\Delta H^0_f NO(g) + 6\Delta H^0_f H_2O(g) - 4\Delta H^0_f NH_3(g)$$

$$\Delta H^0_{rxn} = 4(90.29) + 6(-241.83) - 4(-45.90) = \mathbf{-906.22kJ} \text{ per 4 moles of NO}$$

$$\Delta H^0_{rxn} = \mathbf{-226.6kJ} \text{ per mole of NO}$$

Answer: **-226.6kJ**

Question 10
10 Points

1. Two vessels, **A** and **B**, contained equal molar quantities of the same gas; both vessels are at the **same temperature**. However the **pressure** of vessel **B** is **twice** that of vessel **A**. If vessel A has a volume of 4L what is the volume of vessel B?

   Volume of vessel B: **2L**

2. Briefly, without any calculations, justify your answer.

   With T and n constant the only thing that could effect a change in pressure in the two vessels is the frequency of the collisions. With T constant this can only be caused by a different volume. In order for the pressure in B to be twice that of A the volume of B must be $\frac{1}{2}$ that of A.

3. What assumption (if any) did you have to make in determining the volume of B

   a) Average KE is proportional to T

   b) Total elastic collisions between the gas molecules (no IMF's)

   c) Volume of gas molecules negliable in comparison to volume of the container.

Question 11
9 Points

How many grams of solid **calcium hydroxide** are needed to exactly neutralize **24.9 mL** of a **0.351M monoprotic** acid solution? Assume that the volume remains constant. **Show All Work.**

$Ca(OH)_2$: 40.08 + 2(1.01) + 2(16.00) = 74.10g/mol

#mol of Acid = 0.351 x 0.0249 = 8.74×10^{-3} mol Acid

$$\frac{8.74\times10^{-3}\text{ mol Acid}}{\dfrac{1\ Ca(OH)_2}{2\ \text{Acid}}} = 4.37\times10^{-3}\text{ mol } Ca(OH)_2$$

$$\frac{4.37\times10^{-3}\text{ mol } Ca(OH)_2}{\dfrac{74.10g}{1\text{ mol}}} = 0.324g\ Ca(OH)_2$$

Answer: 0.324g

Question 12
8 Points

In the laboratory you dissolve **16.9g** of **iron(III) sulfate** in a volumetric flask and add water to a total volume of **100mL**.

1. What is the **molarity** of the solution? **0.423M**
2. What is the **concentration** of the **iron(III) cation**? **0.846M**
3. What is the **concentration** of the **sulfate anion**? **1.269M**

Question 13
10 Points

For the following reaction, **23.0 grams** of **hydrochloric acid** are allowed to react with **64.4 grams** of **barium hydroxide** to produce **barium chloride** and **water**.

1. Balanced **chemical equation**: $2HCl + Ba(OH)_2 = BaCl_2 + 2H_2O$
2. What is the **formula** of the **limiting reagent**? **HCl**
3. The **maximum** amount (**in grams**) of **barium chloride** formed? **65.7g**

Do Not Write Below This Line

Exam III Score		