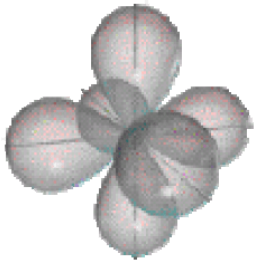
Chem 111 **Summer 2012** **Key III** **Whelan**

Question 1 (6 Points)

Classify each of the following molecules as polar or nonpolar?

1. $BeCl_2$ NONPOLAR
2. IF_3 POLAR
3. NH_2Cl POLAR

Question 2 (5 Points)



There are 6 **hybrid orbitals** represented by the picture on the left. They are composed of* 1 (s) 3 (p) 2 (d) **atomic orbitals**, corresponding to sp^3d^2 **hybridization**. They have the **electron pair geometry** OCTAHEDRON with **bond angles** of 90°.

* - Give the **number** of each of these orbitals that make the hybrid orbital depicted.

Question 3 (6 Points)

A molecule has **sp^3d** hybridization with **2 lone pairs**:

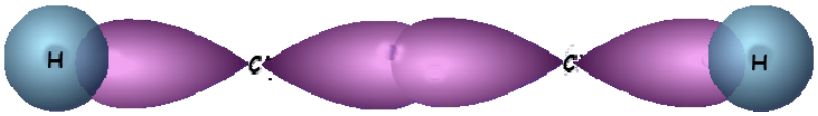
a) The **electron pair geometry** of this molecule is TRIGONAL BIPYRAMID

b) The **geometry** of this molecule is T-SHAPED

c) The **approximate bond angle** in the molecule 120°

Question 4 (6 Points)

Depicted below is the sigma bonds HC≡CH.



1. The **sigma** bond formed between the two carbon atoms is best described as being between the overlap of two sp hybrid orbitals.
2. The **sigma** bond formed between the **hydrogen** and **carbon** is best described as being the overlap of an sp hybrid orbital on carbon with the 1s orbital on hydrogen.
3. If the **pi** bonds were to be depicted one would see 2 pi bond(s).

Question 5 (4 Points)

The compound **iron(II) sulfate** is a strong electrolyte. Write the reaction when iron(II) sulfate is put into **water**:

$FeSO_4(aq)$ = $Fe^{2+} + SO_4^{2-}$

Question 6 (4 Points)

Consider the reaction when aqueous solutions of **aluminum sulfate** and **cobalt(II) nitrate** are combined. The **net ionic equation** for this reaction is:

No = Reaction

Question 7 (4 Points)

Consider the reaction when aqueous solutions of **sodium carbonate** and **ammonium nitrate** are combined. The **net ionic equation** for this reaction is:

No = REACTION

Question 8 (4 Points)

Write a **net ionic equation** for the overall reaction that occurs when aqueous solutions of **potassium hydroxide** and **hydrosulfuric acid** (H_2S) are combined.

$H_2S(aq) + 2OH^- = S^{2-} + 2H_2O(l)$

Question 9 (4 Points)

Write a **net ionic equation** for the reaction that occurs when excess **hydrofluoric acid** (HF) and **calcium carbonate** are combined.

$CaCO_3(s) + 2HF(aq) = Ca^{2+} + 2F^- + CO_2(g) + H_2O(l)$

Question 10 (8 Points)

A **41.2g** sample of copper at **99.8°C** is dropped into a beaker containing **153g** of **water** at **18.5°C**. What is the **final temperature** when thermal equilibrium is reached? *Assume the beaker neither absorbs nor loses heat.*

Heat Capacities: Cu = 0.385 J/g°C H_2O = 4.184 J/g°C

For full credit you must show work.

$q_{Cu} = 41.2(0.385)\Delta T$

$= 15.86\Delta T = 15.86(T_f - 99.8) = 15.86T_f - 1583$

$q_{H_2O} = 153(4.184)\Delta T$

$= 640\Delta T = 640(T_f - 18.5) = 640T_f - 11840$

$\Sigma q_{is} = 0$

$15.86T_f - 1583 + 640T_f - 11800 = 0$

$655.86T_f = 13423$

$T_f = \frac{13423}{655.86} =$

20.5 °C

Question 11
5 Points

A sample of solid **silver** is heated with an electrical coil. If **33.6** Joules of energy are added to a **13.0 gram** sample and the final temperature is **35.2°C**, what is the **initial temperature** of the silver? **Heat Capacity**: Ag = 0.237 J/g°C

For full credit you must show work.

$q = m \times C \times \Delta T$

$33.6 = 13 \times 0.237 \times \Delta T$

$\Delta T = \frac{33.6}{13 \times 0.237} = 10.9°C$

$T_i = 35.2 - 10.9 =$

24.3 °C

Question 12
5 Points

The following thermochemical equation is for the reaction of nitrogen(g) with oxygen(g) to form dinitrogen monoxide(g).

$2N_2(g) + O_2(g) = 2N_2O(g) \quad \Delta H = 164$ kJ

How many **grams** of $N_2(g)$ would be made to react if **25.0 kJ** of energy were provided?

For full credit you must show work.

$25.0 \text{ kJ} \left| \frac{2 \text{ mol } N_2}{164 \text{ kJ}} \right. = 0.305 \text{ mol } N_2$

$0.305 \text{ mol } N_2 \left| \frac{28.02 \text{ g}}{1 \text{ mol}} \right. =$

8.54 g N_2

Question 13
5 Points

0.927 grams of benzoic acid is burned completely in a bomb calorimeter. The bomb is surrounded by **1.000 kg** of water. The temperature increases from **25.12** to **29.36** degrees Celsius. If the **heat capacity** of the bomb is **1.60 kJ/°C**, calculate the **heat of combustion** of the benzoic acid **in kJ/gram**. The specific heat of water is **4.184 J/g°C**.

Circle the best answer!

- o -9.2 kJ/gram
- o 21.4 kJ/gram
- o -32.7 kJ/gram
- o 18.9 kJ/gram
- (o) -26.5 kJ/gram

Question 14
4 Points

Given the **standard enthalpy** changes for the following two reactions:

(1) $N_2(g) + 2\ O_2(g) = N_2O_4(g)$ ..... $\Delta H^\circ = 9.2$ kJ

(2) $2\ N_2O(g) = 2\ N_2(g) + O_2(g)$ ..... $\Delta H^\circ = -164.2$ kJ

what is the **standard enthalpy change** for the reaction:

(3) $2\ N_2O(g) + 3\ O_2(g) = 2\ N_2O_4(g)$ ..... $\Delta H^\circ = ?$

For full credit you must show work.

(2) $2NO(g) = 2N_2(g) + O_2(g)$ $\quad \Delta H^\circ = -164.2$

(1)x2 $2N_2(g) + 3O_2(g) = 2N_2O_4(g)$ $\quad \Delta H^\circ = 18.4$

$2NO(g) + 3O_2(g) = 2N_2O_4(g)$

-145.8 kJ

Question 15
4 Points

Using standard **heats of formation** given, calculate the standard **enthalpy change** for the following reaction:

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

[ΔH^0_f: $NH_3(g)$, **-46** kJ/mol $\quad$ $NO(g)$, **90** kJ/mol $\quad$ $H_2O(g)$, **-242** kJ/mol]

For full credit you must show work.

$\Delta H^\circ_{RXN} = 4\Delta H^\circ_f NO(g) + 6\Delta H^\circ_f H_2O(g) - 4\Delta H^\circ_f NH_3(g) - 5\Delta H^\circ_f O_2(g)$

$= 4(90) + 6(-242) - 4(-46) - 5(0)$

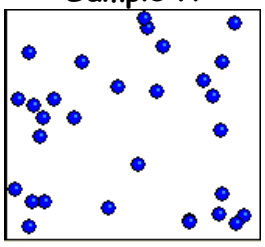
$= 360 - 1452 + 184 =$

-908 kJ

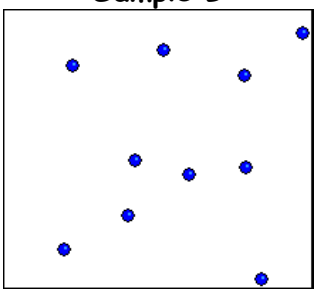
Question 16
4 Points

In the following 2-D illustrations, **assume that the gas molecules are in motion** and that if there is a **larger box it indicates a larger volume** for the container holding the molecules.

Sample A



Sample B



o A and B are at the **same temperature**.
o B has the **highest temperature**.

o A has the **highest temperature**.
o A has a **smaller average kinetic energy**.

Question 17
8 Points

0.758 moles of **hydrochloric acid** are allowed to react with **0.416** moles of **barium hydroxide**.

hydrochloric acid (aq) + barium hydroxide (aq) = barium chloride (aq) + water (l)

What is the maximum amount in **grams** of **barium chloride** that can be formed?
For full credit you must show work.

$2\,HCl(aq) + Ba(OH)_2 = BaCl_2(aq) + 2H_2O(l)$
0.758 0.416

$0.758\ mol\ HCl \left| \frac{1\ BaCl_2}{2\ HCl} \right. = 0.379\ mol\ BaCl_2$ ✓

$0.416\ mol\ Ba(OH)_2 \left| \frac{1\ BaCl_2}{1\ Ba(OH)_2} \right. = 0.416\ mol\ BaCl_2$

$BaCl_2: 137.33 + 2(35.45) = 208.23\ g.mol^{-1}$

$0.379\ mol\ BaCl_2 \left| \frac{208.23\ g}{1\ mol} \right. = 78.9\ g$

78.9 g of barium chloride

Question 18
7 Points

For the following reaction, **5.03** grams of water are mixed with excess **sulfur dioxide**. The reaction yields **20.2** grams of **sulfurous acid** (H_2SO_3).

sulfur dioxide (g) + water (l) = sulfurous acid (H_2SO_3) (g)

What is the percent yield for this reaction?
For full credit you must show work.

$SO_2(g) + H_2O(l) = H_2SO_3$
5.03 g

$5.03\ g\ H_2O \left| \frac{1\ mol}{18.02\ g} \right. = 0.279\ mol\ H_2O$

$0.279\ mol\ H_2O \left| \frac{1\ H_2SO_3}{1\ H_2O} \right. = 0.279\ mol\ H_2SO_3$

$H_2SO_3: 2(1.01) + 32.07 + 3(16.00) = 82.09\ g.mol^{-1}$

$0.279\ mol\ H_2SO_3 \left| \frac{82.09\ g}{1\ mol} \right. = 22.9\ g$

$\left(\frac{20.2\ g}{22.9\ g}\right)100 = 88.2\%$

88.2 %

Question 19
7 Points

How many grams of solid **calcium hydroxide** are needed to exactly neutralize **28.2 mL** of a **0.714 M nitric acid** solution ? Assume that the volume remains constant.

For full credit you must show work.

$2\,HNO_3(aq) + Ca(OH)_2 = Ca(NO_3)_2(aq) + 2\,H_2O(l)$

28.2 mL
0.714 M

$\#\,mol\ HNO_3 = 0.0282(0.714) = 0.0201$

$$0.0201\ mol\ HNO_3 \left| \frac{1\ Ca(OH)_2}{2\ HNO_3} \right. = 0.0101\ mol\ Ca(OH)_2$$

$Ca(OH)_2$: $40.08 + 2(16.00 + 1.01) = 74.10\ g \cdot mol^{-1}$

$$0.0101\ mol\ Ca(OH)_2 \left| \frac{74.10\ g}{1\ mol} \right. = 0.746\ g$$

0.746 g of calcium hydroxide

Do Not Write Below This

Exam III Score