Gateway General Chemistry 125/126/130
Exam 2
October 31, 2006 (8:00-10:00pm)

Name_____KEY_____

Section (*circle one*): 601 (Colin)　　602 (Brannon)　　603 (Mali)　　604 (Xiaomu)

The exam has at total of 9 pages including the cover, and a table of heats of formation and a periodic table both of which you may remove. You do not need to turn the table of heats of formation or the periodic table in with your exam. Please neatly show all of your work.

Page	Questions	Possible points	Score
2	1-5	5	
3	6	8	
4	7-8	8	
5	9-11	12	
6	12-14	6	
7	15-16	6	

Total　　　　　　　　　　　_____/45

Q1-5 *(1 point each) Please place the correct letter in the box*

1) Which of the following represents a non-polar covalent bond ?
   a. O-O
   b. C-O
   c. NaCl
   d. C-N
   e. C=O

1)
A

2) Which statement concerning the interaction between two atoms is **<u>incorrect</u>**?
   a. If two atoms are widely separated, there is very little attraction between them.
   b. When two atoms are one bond length apart, the valence electrons on one atom
      are attracted to the nucleus of the other atom.
   c. When two atoms are very close to one another (0.5 Å apart), repulsion occurs.
   d. A covalent bond occurs when electrons are shared between two nuclei.
   e. As atoms get closer together, their electrons attract each other.

2)
E

3) Which statement about the reaction below is incorrect?

   $$H_2O_{(l)} \rightarrow H_2O_{(g)} \qquad \Delta H° = +44.0 \text{ kJ}$$

   a. The same quantity of heat is needed for the solid to liquid transformation
   b. The liquid must absorb heat from the surroundings to evaporate.
   c. The reaction is endothermic.
   d. The heat of vaporization is shown.
   e. The ΔH for the gas to liquid transformation has the opposite sign.

3)
A

4) If you need 300.0 mL of 0.500 M $K_2Cr_2O_7$, which method would you use to prepare this
   solution?
      a) Dilute 250.0 mL of 0.600 M $K_2Cr_2O_7$ to 300.0 mL.
      b) Add 50.0 mL of water to 250.0 mL of 0.250 M $K_2Cr_2O_7$
      c) Dilute 125.0 mL of 1.00 M $K_2Cr_2O_7$ to 300.0 mL
      d) Add 30.0 mL of 1.50 M $K_2Cr_2O_7$ to 270.0 mL of water
      e) Dilute 150.0 mL of 0.250 M $K_2Cr_2O_7$ to 300.0 mL

4)
A

5) You prepared a NaCl solution by adding 58.44 g of NaCl to a 1-L volumetric flask and then
adding water to dissolve it. When you were finished, the final volume in your flask looked like
this:

fill line
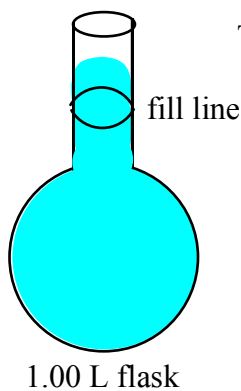
The solution you prepare is:
      a) Greater than 1M because you added more solvent than necessary.
      b) Less than 1M because you added less solvent than necessary
      c) Greater than 1 M because you added less solvent than necessary
      d) Less than 1 M because you added more solvent than necessary.
      e) 1M because the amount of solute, not solvent determines the
      concentration

1.00 L flask

5)
D

6) (*8 points*) The following is an excerpt from a question written into Car and Driver Magazine (May 2006, p20). "…you claim a 12mpg vehicle produces 20,000 pounds of cabon dioxide every 12,000 miles. How do 6200 pounds (1000 gallons at 6.2 pounds per gallon) of fuel excrete 20,000 pounds of pollutant? …."

Let's first rephrase the question to make it clearer. A car that gets 12 mpg (miles per gallon) drives 12,000 miles and thus uses 1000 gallons of gasoline. Gasoline weighs 6.2 pounds per gallon, so the car consumed 6200 pounds of gasoline. How did the consumption of 6200 pounds of gasoline result in the creation of 20,000 pounds of pollutant?

a) Write the balanced chemical equation for the burning of gasoline assuming that it is pure octane (C_8H_{18}).

$C_8H_{18(l)} + 25/2\ O_{2(g)} \rightarrow 8\ CO_{2(g)} + 9\ H_2O_{(g)}$

b) What is the ΔH of the reaction you wrote in a) assuming that all products are gases. (A table of heats of formations is available at the end of the exam.)

$\Delta H_{rxn} = \sum n\Delta H^o_f$ products - $\sum n\Delta H^o_f$ reactants

$\quad = [8\ \text{mol}\ CO_2(-393.5kJ/mol) + 9\text{mol}\ H_2O(-241.8kJ/mol)] - [1\text{mol}\ C_8H_{18}(-249.95kJ/mol) + 0]$

$\quad = [-3148\ kJ + (-2176.2kJ)] - [-249.95kJ]$

$\quad = -5074.25\ kJ$

c) The pollutant referred to is CO_2. How much carbon dioxide in pounds is produced when 6200 pounds of gasoline is burned? (1 lb = 453.59 g)

| 6200 lb C_8H_{18}	453.59g C_8H_{18}	1 mol C_8H_{18}	8mol CO_2	44g CO_2	1 lb CO_2
	1 lb C_8H_{18}	114 g C_8H_{18}	1 mol C_8H_{18}	1 mol CO_2	453.59g CO_2

=19143.85 lb CO_2 = 19000 lb CO_2

d) How much energy is given off when 6200 pounds of fuel are burned?

6200 lb C_8H_{18}	453.59g C_8H_{18}	1 mol C_8H_{18}	5074.25 kJ
	1 lb C_8H_{18}	114 g C_8H_{18}	1 mol C_8H_{18}

= 1.3×10^8 kJ

7) (*2 points*) One of the reagents that you used to determine the nitrate concentration of the Muskov's well water was naphthylamine hydrochloride. Naphthylamine is not soluble in water. Hydrochloric acid is added to naphthylamine to form naphthylamine hydrochloride (as shown in Figure 1) which is soluble in water.

Figure 1: Naphthylamine to naphthylamine hydrochloride

naphthylamine   naphthylamine hydrochloride
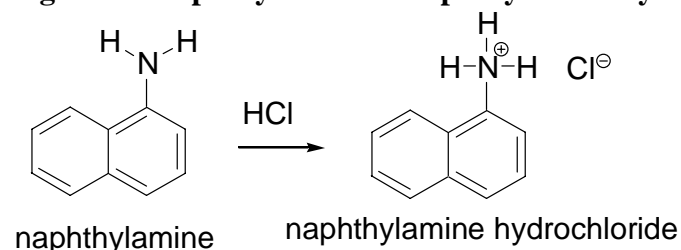
Explain why HCl must be added to naphthylamine in order for it to dissolve in water.

Naphthylamine contains mostly nonpolar covalent bonds, the exceptions being three polar covalent bonds: C-N bond and 2 N-H (both capable of hydrogen bonding.) Naphthylamine hydrochloride differs from naphthylamine in that it has an additional polar covalent bond (N-H) and an ionic bond which is even more polar than a polar covalent bond. The hydrochloride's increased polarity creates more favorable interaction with the polar solvent water allowing the molecule to overcome the unfavorable nonpolar/polar interactions which dominate the naphthylamine. (The dissolution of the hydrochloride is energetically favored.)

8) (*6 points*)The structure of aspartame is shown below.
   a. Circle five of the most polar bonds.
   b. But a box ☐ around any hydrogen atom that can participate in hydrogen bonding.
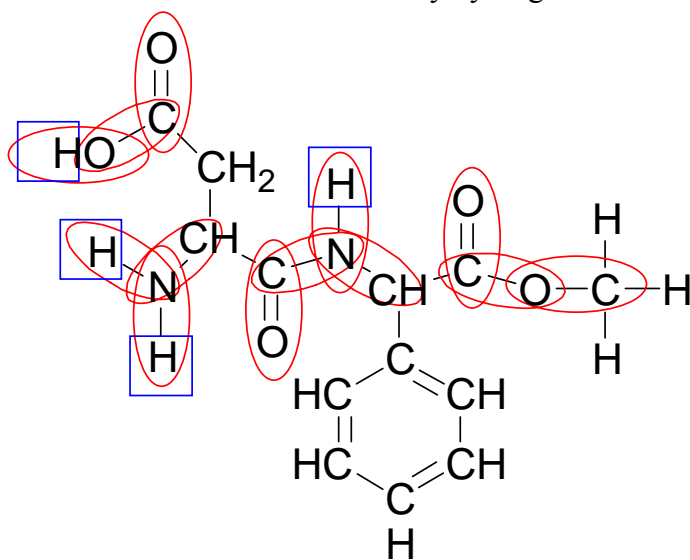

Aspartame

c) Would you predict aspartame to be soluble in water or oil? Explain

Water. It has over a dozen polar covalent bonds (C=O, C-O, C-N, O-H, and N-H) and four hydrogen atoms capable of hydrogen bonding. The nonpolar covalent bonds (C-C, C=C, and C-H) are limited. Water is polar so there will be numerous desirable interactions to dissolve aspartame in water

9) (*5 points*) For the molecule SCO: | a) count the number of valence electrons: 16

b) Draw the Lewis structure; include any formal charges or resonance structures:
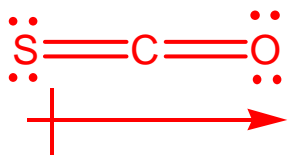
$$\ddot{S}=C=\ddot{O}$$

c) Draw an arrow indicating the net polarity of the molecule if any.
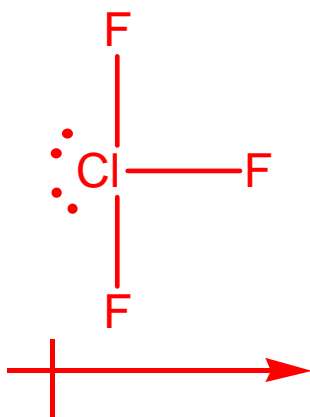
d) Name the electron pair geometry:
linear

e) Name the molecular geometry:
linear

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10) (*5 points*) For the molecule ClF_3: | a) count the number of valence electrons: 28

b) Draw the Lewis structure; include any formal charges or resonance structures:

F
|
:Cl——F
|
F

c) Draw an arrow indicating the net polarity of the molecule if any.

d) Name the electron pair geometry:
trigonal bipyramidal

e) Name the molecular geometry:
T-shaped

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11) (*2 points*) Write out the chemical reaction illustrating the heat of formation of ClF_3. What is the ΔH of this reaction?

½ $Cl_{2(g)}$ + 3/2 $F_{2(g)}$ → ClF_3 ΔH_{rxn} = -163.2 kJ

12 (*4 points*) a) 50.0 mL of ethanol at 5.0°C was mixed with 50.0 mL of water at 75°C. What is the final temperature of the mixture?
Specific heat capacities: ethanol = 2.46 J/g°C; water = 4.184 J/g°C
Densities: ethanol: 0.789 g/mL; water 1.00 g/mL

$$q_{eth} = -q_{water}$$
$$mC\Delta T = -mC\Delta T$$

50.0 mL	0.789 g	2.46 J	T_f – 5.0°C	=	-50.0 mL	1 g	4.184 J	(T_f-75°C)
	mL	g°C				mL	g°C	

$$97.047 \ T_f - 485.235 = -209.2 \ T_f + 15690$$
$$306.2 \ T_f = 16175.25$$
$$T_f = 52.8 \ °C = 53°C$$

$T_f = 53 \ °C$

b) Which liquid underwent a greater temperature change? Why?

Ethanol-it has a lower heat capacity (it takes less heat to increase its temperature by a degree than water.)

13 (*1 point*) Write out the chemical formulas for the following compounds:

a) sodium phosphate Na_3PO_4

b) magnesium chlorate $Mg(ClO_3)_2$

14) (*1 point*) A typical mug (250 mL) of coffee contains 125 mg of caffeine ($C_8H_{10}N_4O_2$). What is the molarity of caffeine in this solution?

125 mg $C_8H_{10}N_4O_2$	1 g	1 mol $C_8H_{10}N_4O_2$	
	1000 mg	194 g $C_8H_{10}N_4O_2$	0.250L

$$2.577 \times 10^{-3} \ M = 2.6 \times 10^{-3} \ M$$

15) (*4 points*) How many grams of salt (sodium chloride) are in your chicken soup? A student added excess $AgNO_{3(aq)}$ to a 1-cup (250 mL) serving of regular chicken soup and got 5.55 g of AgCl precipitate.

a) Write the net ionic equation for the reaction that took place. Include (s), (l), (g), (aq).

$$Cl^-_{(aq)} + Ag^+_{(aq)} \rightarrow AgCl_{(s)}$$
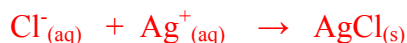
b) What was the concentration of chloride ions in the soup in ppm. You may assume that the soup has a density of 1.00 g/mL?

5.55 g AgCl	35.453 g Cl
	143.3212 g AgCl

= 1.37 g Cl

250 mL	1.00 g	1 kg
	mL	1000g

= 0.25 kg

1.37 g Cl	10000 mg
0.25 kg solution	1 g

= 5488 ppm = 5500 ppm

16) (*2 points*) Nitrogen makes up 78.08% of the atmosphere on earth. It is often liquefied and used as a coolant. How much energy does it take to heat 100.0 mL of liquid nitrogen from its boiling point of -195.9°C to 20.0°C. Nitrogen has a heat of fusion of 0.721 kJ/mol, a heat of vaporization of 5.56 kJ/mol, and a gaseous molar heat capacity of 0.02 kJ/mol°C. The density of nitrogen is 0.807 g/mL.

100 mL N_2	0.807 g	1 mol N_2
	mL	28 g N_2

2.88 mol N_2

$q = n\Delta H_{vap} + nC\Delta T$

= 5.56 kJ/mol(2.88 mol) + 2.88 mol N_2(0.02 kJ/mol°C) [20.0°C - (-195.9°C)]
= 16. 02 kJ　　　　　　　+ 12.436 kJ
= 28.5 kJ
Sig fig 30 kJ