Chem 115 Exam 2
α and β versions, 4/8/08

Multiple Choice

α version	
1. D	11. A
2. A	12. B
3. A	13. A
4. B	14. C
5. C	15. D
6. D	16. A
7. D	17. B
8. B	18. E
9. B	19. C
10. D	20. B

β version	
1. A	11. C
2. D	12. D
3. D	13. A
4. C	14. B
5. C	15. A
6. B	16. D
7. B	17. B
8. C	18. B
9. C	19. B
10. E	20. C

Problem 1

	alpha (α) and beta (β) exam versions had the same problem 1
a)	• q has units of Joules (or kilojoules) • m has units of grams (or kilograms) • C has units of $J{\cdot}g^{-1}{\cdot}{}^{o}C^{-1}$ or $J{\cdot}g^{-1}{\cdot}K^{-1}$ • T has units of ºC or K
b)	• volume or mass of the HCl or NaOH solution (since the experiment states that the student is combining equal volumes of these solutions, it is only necessary to record the mass or volume of one of the solutions, then the other one is equal) • initial temperature (T_{initial}) of the HCl or NaOH solution before mixing (since the solutions are at the same temperature before they are combined, it is only necessary to measure the initial temperature of one of them) • final (highest) temperature (T_{final}) of the solution after mixing Note that ΔT is not a measurement, it is a calculation made from the differences between two measurements
c)	i) Since there is mixing of equal volumes of the same concentration <u>and</u> the reaction has 1:1 stoichiometry, moles of H_2O produced = moles of HCl reacted = moles of NaOH reacted. To determine the number of moles of HCl: $(\mathit{volume}\ \text{HCl})\left(\frac{1.0\ \mathit{mol}\ \text{HCl}}{1\ L}\right)\left(\frac{1\ \mathit{mol}\ \text{H}_2\text{O}}{1\ \mathit{mol}\ \text{HCl}}\right) = \mathit{mol}\ \text{H}_2\text{O}$ or $(\mathit{volume}\ \text{NaOH})\left(\frac{1.0\ \mathit{mol}\ \text{NaOH}}{1\ L}\right)\left(\frac{1\ \mathit{mol}\ \text{H}_2\text{O}}{1\ \mathit{mol}\ \text{NaOH}}\right) = \mathit{mol}\ \text{H}_2\text{O}$ or $n_{\text{H}_2\text{O}} = n_{\text{HCl}} = n_{\text{NaOH}} = V_{\text{HCl}} \times 1.0M = V_{\text{NaOH}} \times 1.0M$ ii) Determine the quantity of the heat produced, q, from $q = mC\Delta T$, where m = <u>total</u> mass of solution; divide q by mol H_2O determine in part (c)(i) to determine ΔH_{neut} : $\Delta H_{neut} = \frac{-q}{\mathit{mol}\ \text{H}_2\text{O}}$ or also full credit given for $\Delta H_{neut} = \frac{q}{\mathit{mol}\ \text{H}_2\text{O}}$ Note: since all these moles are equal to each other, due to 1:1 stoichiometry, denominator could be any of them.

d)	i) The ΔT will be greater, so q increases. There are more <u>moles</u> of HCl and NaOH reacting so the final temperature of the mixture will be higher. ii) Both q and mol H_2O increase proportionately. However, when the quotient is determined, there is no change in ΔH_{neut}. Molar enthalpy is defined as <u>per mole</u> of reaction, therefore it will not change when the number of moles is doubled.
e)	Heat lost to the air will produce a smaller ΔT. In the equation $q = mC\Delta T$ a smaller ΔT will produce a smaller value for q (heat released) than it should. In the equation $$\Delta H_{neut} = \frac{-q}{mol\ \mathrm{H_2O}}$$ the smaller magnitude of q and the constant mol H_2O means that ΔH_{neut} will be less negative (smaller magnitude of exothermic change)

Problem 2

alpha (α) exam	$125\ mL \times \frac{1\ L}{1000\ mL} \times \frac{0.0400\ mol\ \mathrm{Na_3PO_4}}{1\ L\ \text{solution}} \times \frac{163.94\ g\ \mathrm{Na_3PO_4}}{1\ mol\ \mathrm{Na_3PO_4}} = 0.8197\ g$ Answer should have 3 sig figs, rounds to 0.820 g
beta (β) exam	$250.\ mL \times \frac{1\ L}{1000\ mL} \times \frac{0.0300\ mol\ \mathrm{Na_3PO_4}}{1\ L\ \text{solution}} \times \frac{163.94\ g\ \mathrm{Na_3PO_4}}{1\ mol\ \mathrm{Na_3PO_4}} = 1.22955\ g$ Answer should have 3 sig figs, rounds to 1.23 g

Problem 3

alpha (α) exam	$\Delta H^o_{rxn} = \sum_{p=products} n_p\left(\Delta H^o_f[p]\right) - \sum_{r=reactants} n_r\left(\Delta H^o_f[r]\right)$ $= \left\{2\left(\Delta H^o_f[\mathrm{H_2O}\ (g)]\right) + \frac{3}{8}\left(\Delta H^o_f[\mathrm{S_8}(s)]\right)\right\} - \left\{1\left(\Delta H^o_f[\mathrm{SO_2}\ (g)]\right) + 2\left(\Delta H^o_f[\mathrm{H_2S}\ (g)]\right)\right\}$ $= \left\{2\ mol\left(-241.8\ {kJ}/{mol}]\right) + \frac{3}{8}(0)\right\} - \left\{1\ mol\left(-296.9\ {kJ}/{mol}\right) + 2\ mol\left(-20.2\ {kJ}/{mol}\right)\right\}$ $= \{-483.6\ kJ\} - \{-337.3\ kJ\}$ $= -146.3\ kJ$ Sig fig rounding is by addition/subtraction rule. Answer should have 1 significant digit after the decimal point
beta (β) exam	$\Delta H^o_{rxn} = \sum_{p=products} n_p\left(\Delta H^o_f[p]\right) - \sum_{r=reactants} n_r\left(\Delta H^o_f[r]\right)$ $= \left\{1\left(\Delta H^o_f[\mathrm{SO_2}\ (g)]\right) + 2\left(\Delta H^o_f[\mathrm{H_2S}\ (g)]\right)\right\} - \left\{2\left(\Delta H^o_f[\mathrm{H_2O}\ (g)]\right) + \frac{3}{8}\left(\Delta H^o_f[\mathrm{S_8}(s)]\right)\right\}$ $= \left\{1\ mol\left(-296.9\ {kJ}/{mol}\right) + 2\ mol\left(-20.2\ {kJ}/{mol}\right)\right\} - \left\{2\ mol\left(-241.8\ {kJ}/{mol}]\right) + \frac{3}{8}(0)\right\}$ $= \{-337.3\ kJ\} - \{-483.6\ kJ\}$ $= +146.3\ kJ$ Sig fig rounding is by addition/subtraction rule. Answer should have 1 significant digit after the decimal point