

Chemistry 1210 Fall 2008 Test 3

Friday, November 21, 2008

Time: 1 hour 50 minutes

Name: _____

Student Number: _____

*This exam consists of **nine** pages of questions, a periodic table, and the formula sheets. Please ensure that you have a complete paper and, if you do not, obtain one from me **immediately**. There are **44** marks available. Good luck!*

- 1) **[7 marks total]** A certain weak triprotic acid (H_3A) has $\text{pK}_{\text{a}1} = 3.0$, $\text{pK}_{\text{a}2} = 7.0$, and $\text{pK}_{\text{a}3} = 10.0$. Calculate the pH of the following solutions made using this weak triprotic acid. You may assume the measurements were made at 25°C .
- a) **[3 marks]** 15.0 mL of 1.0 M weak acid mixed with 15.0 mL of 1.0 M NaOH **[5]**

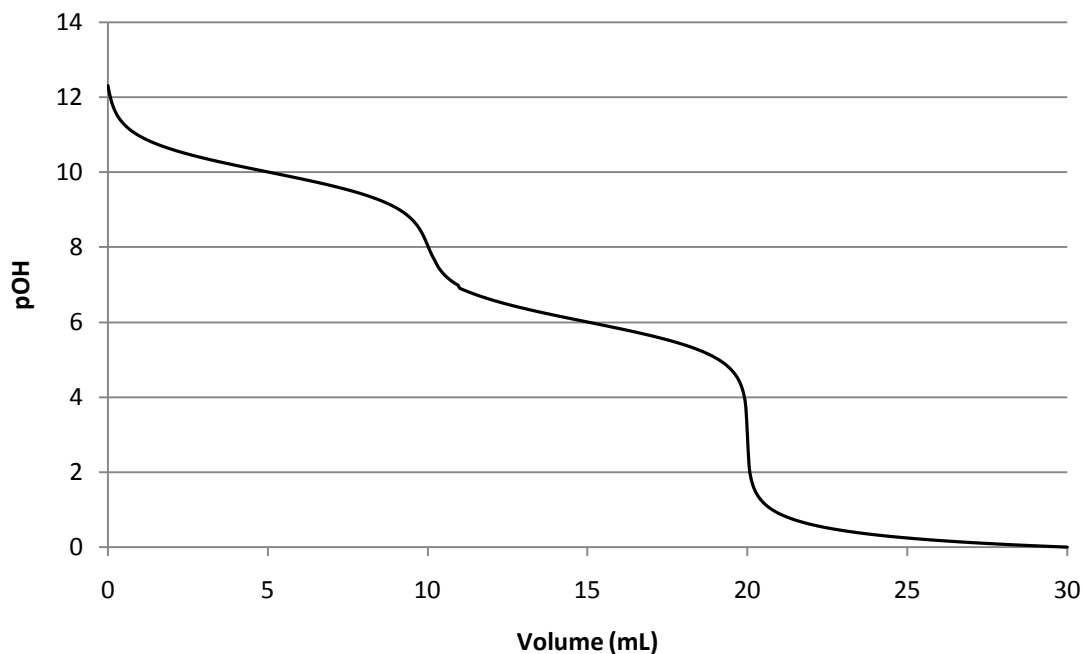
b) **[4 marks]** 15.0 mL of 1.0 M weak acid mixed with 45.0 mL of 1.0 M NaOH **[11.7]**

2) **[4 marks total]** A titration was carried out at elevated temperatures, where $K_w = 1.0 \times 10^{-13}$. For this titration, a 10.0 mL aliquot of 1.0×10^{-3} M HCl was titrated with 1.1×10^{-3} M NaOH, and an indicator having $pK_{in} = 8.70$ was used.

a) **[3 marks]** At what volume of added NaOH will the end point be reached? Give your answer in mL. **[10]**

b) **[1 mark]** Is this a good indicator to use for the titration? How do you know? **[No – wrong by +0.9 mL or about 10%]**

3) [3 marks] A titration was performed at 25°C, and the graph shown below is the result:



Assuming the complete titration curve is shown above:

- a) What general class of compound is being titrated?
[weak diprotic acid]
- b) Identify all the relevant ionization constants of the compound being titrated.
[$pK_{a1} = 4$, $pK_{a2} = 8$]
- c) Place a (c) on the graph above at the point or points where the pH is governed by only one ion but is independent of the concentration of that ion.
[at 10 mL of added NaOH]

4) **[7 marks total]** Calculate the molar solubility of compound AB_2 ($K_{sp} 4 \times 10^{-9}$) in the following solutions (AB_2 ionizes into A^{+2} cations and B^{-1} anions):

a) **[2 marks]** water **[$1 \times 10^{-3} \text{ M}$]**

b) **[2 marks]** $0.10 \text{ M } B^{-1}$ **[$4 \times 10^{-7} \text{ M}$]**

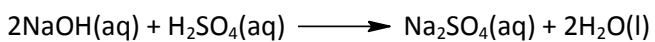
c) **[3 marks]** $1 \text{ M } L^{-2}$ if $K_f \text{ for } AL_2^{-2} = 1 \times 10^3$ **[0.01 M]**

5) **[4 marks]** A solution has $[\text{CrO}_4^{2-}] = 1.2 \times 10^{-6} \text{ M}$ and $[\text{Cl}^{-}] = 1.8 \times 10^{-5} \text{ M}$. Solid AgNO_3 is slowly added to the solution. The K_{sp} s of Ag_2CrO_4 and AgCl are 1.2×10^{-12} and 1.8×10^{-10} respectively.

a) Which species will precipitate first? **[1]**

b) At the point of maximum separation, what percentage of the first species to precipitate will remain in solution? **[1.0]**

6) **[4 marks]** A calorimeter with $C = 100 \text{ J/}^\circ\text{C}$ held 100 mL of 1.0 M NaOH ($S=4 \text{ J/g-}^\circ\text{C}$, $D=1.00 \text{ g/mL}$) at 22.0°C . To that was added 100 mL of 1.0 M H_2SO_4 ($S=4 \text{ J/g-}^\circ\text{C}$, $D=1.00 \text{ g/mL}$) at 25.0°C . The temperature of the calorimeter and contents rose to 30.0°C . Calculate ΔH° for the reaction



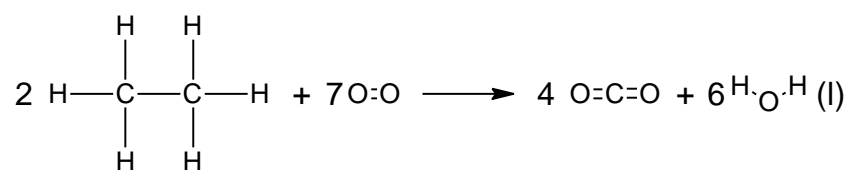
[-120 kJ]

7) [2 marks] Given the following data:

Bond	Bond strength (kJ/mol)
C-H	400
C-C	350
O=O	500
C=O	800
H-O	450

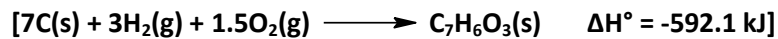
$$\Delta H^\circ_{\text{vap}}(\text{H}_2\text{O}(\text{l})) = 44 \text{ kJ/mol}$$

Calculate ΔH for the reaction

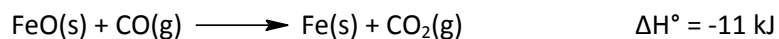


[-3064 kJ]

8) [1 mark] Write the thermochemical equation that corresponds to the enthalpy of formation of solid salicylic acid, $\text{C}_7\text{H}_6\text{O}_3$, for which $\Delta H^\circ_f = -592.1 \text{ kJ/mol}$.

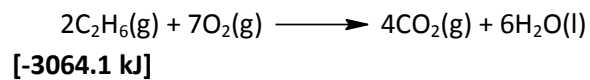


9) **[1 mark]** Given the reaction:



and that ΔH°_f for CO(g) is -110 kJ/mol, and for CO₂(g) is -395 kJ/mol, what is ΔH°_f for FeO(s)?
[-274 kJ/mol]

10) **[3 marks]** A 3.007-gram sample of C₂H₆(g) (30.07 g/mol) was burned in a bomb calorimeter that had C = 10.0 kJ/°C. The temperature of the calorimeter and contents rose from 20.000°C to 35.258°C. Calculate ΔH° at 300 K for the reaction:



11) **[5 marks total]** A balloon contracts from 3 L to 1 L against a constant external pressure of 2.0 atm, and at 300 K. In the process, it evolves 3.6 kJ of heat. Given that $\Delta S_{\text{sys}} = -9 \text{ J/K}$ for the process:

a) **[3 marks]** calculate q , w , ΔE , ΔH , ΔS_{surr} , and ΔS_{univ} for the process.

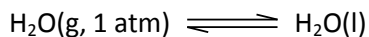
[-3600 J, 400 J, -3200 J, -3600 J, 12 J/K, 3 J/K]

b) **[2 marks]** At what temperature (if any) will the process not occur?

[400 K]

12) **[3 marks]** Complete the following table. Your choices are "+" (greater than zero), "-" (less than zero), or "0".

The reaction:



T(°C)	ΔH°	ΔS°	ΔG°
75	-	-	-
100	-	-	0
125	-	-	+