Chemistry 1154 R10 Fall 2007 Test 3

Thursday, November 22, 2007 Time: 1 hour 50 minutes

Name: _____ Student Number: _____

*This exam consists of **seven** pages of questions, a periodic table, and the formula sheet. Please ensure that you have a complete paper and, if you do not, obtain one from me immediately. There are **36** marks available. Good luck!*

1) **[3 marks]** A 0.10 M weak base (B) is 0.10% ionized in solution. Calculate the pH of this solution and the ionization constant (K_b) for this weak base. **[pH = 10, $K_b = 1 \times 10^{-7}$]**

2) **[3 marks]** The triprotic acid H_3X has the following pK_a values:

$pK_{a1} = 2.00$, $pK_{a2} = 6.00$ and $pK_{a3} = 11.00$

If you were given the following four solutions:

0.200 M H_3X; 0.100 M NaH_2X; 0.300 M Na_2HX and 0.400 M Na_3X

How would you prepare 500 mL of a buffer solution with a pH = 6.30?
[mix 200 mL of Na_2HX with 300 mL of NaH_2X]

3) **[9 marks total]** The triprotic acid H_3X has the following pK_a values:

$pK_{a1} = 2.00$, $pK_{a2} = 6.00$ and $pK_{a3} = 11.00$

You are given 20.00 mL of 0.100 M H_3X to titrate with a 0.200 M KOH solution.

a) **[2 marks]** Calculate the pH after 5.00 mL of the KOH solution has been added. **[2.0]**

b) **[2 marks]** Calculate the pH after a total of 12.50 mL of the KOH solution has been added. **[5.52]**

c) **[2 marks]** Would an indicator with a $pK_{Ind} = 6.00$ be useful in determining the first equivalence point? How do you know? **[No – pHs at eq. pts. are 4 and 8.5, not 6]**

d) **[2 marks]** Calculate the pH after a total of 20.00 mL of KOH solution has been added. **[8.5]**

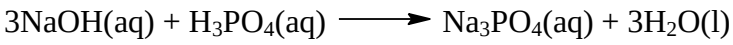
e) **[1 mark]** What is the principal species of the triprotic acid present in solution at the second equivalence point? **[HX^{-2}]**

4) **[5 marks total]** A 20-mL aliquot of a 0.11 M solution of a weak base B ($K_b = 1.0 \times 10^{-5}$) is titrated with 0.20 M HCl. An indicator with a $pK_{In} = 8.00$ is used.

a) **[4 marks]** How many mL of HCl will it take to reach the end point of the titration? **[10]**

b) **[1 mark]** Is the indicator used a suitable one? How do you know? **[No – you'll reach the end point 1 mL before you reach the equivalence point.]**

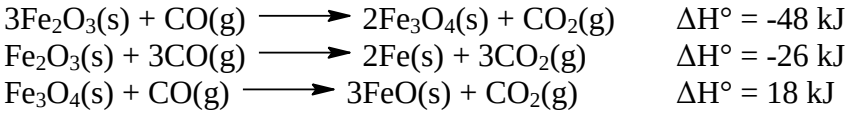
5) **[3 marks]** In one experiment, 60.0 mL of 1.00 M NaOH at a temperature of 21.6°C was mixed with 50.0 mL of 0.500 M H_3PO_4 at 22.6°C:



$$3NaOH(aq) + H_3PO_4(aq) \longrightarrow Na_3PO_4(aq) + 3H_2O(l)$$

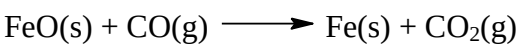
The final temperature of the solution was found to be 28.6°C. Determine ΔH for the reaction above. You may assume that all solutions have a specific heat capacity of 4.184 J/g-°C and a density of 1.00 g/mL. **[-150 kJ]**

6) **[2 marks]** Given the following:



$$3Fe_2O_3(s) + CO(g) \longrightarrow 2Fe_3O_4(s) + CO_2(g) \qquad \Delta H° = -48 \text{ kJ}$$
$$Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(s) + 3CO_2(g) \qquad \Delta H° = -26 \text{ kJ}$$
$$Fe_3O_4(s) + CO(g) \longrightarrow 3FeO(s) + CO_2(g) \qquad \Delta H° = 18 \text{ kJ}$$

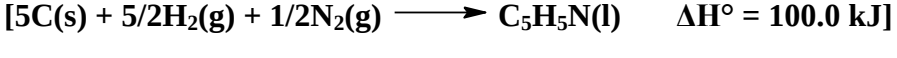
` Calculate ΔH° for the reaction:



$$FeO(s) + CO(g) \longrightarrow Fe(s) + CO_2(g)$$

[-11 kJ]

7) **[1 mark]** Write the thermochemical equation for the enthalpy of formation of pyridine, $C_5H_5N(l)$, for which $\Delta H°_f = 100.0$ kJ.



$[5C(s) + 5/2H_2(g) + 1/2N_2(g) \longrightarrow C_5H_5N(l) \qquad \Delta H° = 100.0 \text{ kJ}]$

8) **[2 marks]** The molar enthalpy of formation of $H_2O(l)$ is roughly four times that of $CH_4(g)$, and the molar enthalpy of formation of $CO_2(g)$ is roughly five times that of $CH_4(g)$. Given this information, and that $\Delta H°$ for the reaction

$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$$

is roughly -900 kJ/mol, estimate the enthalpies of formation of $CH_4(g)$, $H_2O(l)$, and $CO_2(g)$. **[CH_4: -75 kJ/mol; H_2O: -300 kJ/mol; CO_2: -375 kJ/mol]**

9) **[3 marks]** Given the following reaction:

$$B(s) + \tfrac{3}{4}\,O_2(g) \longrightarrow \tfrac{1}{2}B_2O_3(s) \qquad \Delta H° = -637 \text{ kJ}$$

How many kilojoules of heat would you predict to be liberated by the reaction of 21.62 grams of B(s) with 64.00 grams of $O_2(g)$? **[1274 kJ]**

10) **[3 marks]** A 1.081-gram sample of solid boron was burned in a bomb calorimeter that had C = 10.0 kJ/°C:

$4B(s) + 3O_2(g) \longrightarrow 2B_2O_3(s)$

The temperature of the calorimeter and contents increased by 6.345°C. Calculate ΔH for the reaction above at 25°C. **[-2546 kJ]**

11) **[2 marks total]** A balloon is contracted from an initial volume of 7.0 litres to a final volume of 5.0 litres against a constant external pressure of 2.00 atm. In the process, the balloon is made to evolve 1.50 kJ of heat to its surroundings.

a) **[0.5 marks]** Calculate q and ΔH for the process. **[both are -1.5 kJ]**

b) **[1 mark]** Calculate w for the process. **[400 J]**

c) **[0.5 marks]** Calculate ΔE for the process. **[-1100 J]**