Chemistry 1210 Spring 2023 Test 3

Wednesday, March 29, 2023 Time: 1 hour 50 minutes

Name: _____ Student #: _____

*This test consists of **ten** pages of questions, the formula sheet, and a periodic table. Please ensure that you have a complete test and, if you do not, obtain one from me **immediately**. There are **51** marks (and four bonus marks) available. Good luck!*

1) **[2 marks]** A solution has a pH of 7.1. This solution is:

   a) Acidic
   b) Neutral
   c) Basic
   d) There is not enough information to answer this question.

2) **[2 marks]** At 25°C, the pH of a 5×10^{-10} M solution of $Ca(OH)_2$ should be:

   a) 4.70
   b) 5.00
   c) 9.00
   d) 9.30
   e) None of these

3) **[4 marks]** Calculate the pH (at 25°C) of 15.00 mL of 1.00×10^{-3} M HCl mixed with 25.00 mL of 6.00×10^{-4} M $Mg(OH)_2$.

4) **[9 marks total]** Calculate the pH (at 25°C) of the following solutions, all made with propionic acid ($HC_3H_5O_2$) and/or its salts. Propionic acid is a weak acid with a $K_a = 1.34 \times 10^{-5}$.

a) **[2 marks]** 0.0746 M propionic acid

b) **[4 marks]** 10.00 mL of 1.00 M propionic acid mixed with 15.00 mL of 0.620 M NaOH

c) **[3 marks]** 0.134 M sodium propionate

5) **[8 marks total]** Calculate the pH (at 25°C) of the following solutions, all made with trimethylamine ($(CH_3)_3N$) and/or its salts. Trimethylamine is a weak base with a $K_b = 6.5 \times 10^{-5}$.

a) **[3 marks]** 10 mL of 0.5 M trimethylamine mixed with 15 mL of 0.289 M $HClO_4$

b) **[2 marks]** A solution that has [trimethylamine] = 0.215 M and [trimethylammonium perchlorate] = 0.139 M

c) **[3 marks]** A solution that has [trimethylammonium perchlorate] = 0.65 M

6) **[6 marks total]** Phosphoric acid (H_3PO_4) is a weak triprotic acid with $pK_{a1} = 2.12$, $pK_{a2} = 7.21$, and $pK_{a3} = 12.32$. Calculate (at 25°C) the pH of the following solutions, all made using phosphoric acid and/or its salts.

a) **[4 marks]** 10 mL of 1 M H_3PO_4 mixed with 15 mL of 1 M KOH

b) **[2 marks]** A solution containing only NaH_2PO_4.

7) **[5 marks total]** A 10-mL aliquot of 1.0×10^{-3} M HCl is titrated with 8.0×10^{-4} M NaOH. An indicator with $pK_{in} = 4.00$ is used.

a) **[4 marks]** At what added volume of NaOH will the end point be reached?

b) **[1 mark]** Is the indicator a suitable one for the titration? How do you know? (No marks for guessing. ☺)

8) **[2 marks]** Indicate whether each of the following salts acts as an acid, as a base, or neither in aqueous solution. Circle your choice:

$NaNO_2$	acid	base	neither
NH_4Cl	acid	base	neither
KF	acid	base	neither
KI	acid	base	neither

9) **[4 marks]** When 1.63 grams of NaOH (40.0 g/mol) was mixed with 100.0 mL of 0.300 M H_2SO_4 (S = 4.184 J/g·°C, D = 1.00 g/mL) at 22.20°C, the temperature of the resulting solution rose to 29.06°C. Given that the H_2SO_4 was contained in a calorimeter with C = 50 J/°C, calculate ΔH° for the reaction:

$$2NaOH(s) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O(l)$$

10) **[3 marks total]** Given the following reactions:

$C_2H_2(g) + 2H_2(g) \longrightarrow C_2H_6(g)$ $\Delta H° = -94.5$ kJ
$2H_2O(g) \longrightarrow 2H_2(g) + O_2(g)$ $\Delta H° = 484$ kJ
$2C_2H_6(g) + 7O_2(g) \longrightarrow 4CO_2(g) + 6H_2O(g)$ $\Delta H° = -3120.8$ kJ

a) **[2 marks]** Calculate $\Delta H°$ for the reaction

$2CO_2(g) + H_2O(g) \longrightarrow C_2H_2(g) + 2.5O_2(g)$

b) **[1 mark]** What is the enthalpy of formation of $H_2O(g)$? Give your answer in kJ/mol.

11) **[2 marks]** Given the reaction

$2CH_3OH(l) + 3O_2(g) \longrightarrow 2CO_2(g) + 4H_2O(l)$ $\Delta H° = -1453.56$

And that the molar enthalpies of formation of CO_2 and H_2O are -393.52 kJ and -285.83 kJ respectively, calculate the molar enthalpy of formation of $CH_3OH(l)$.

12) **[4 marks]** When 324.4 mg of $CH_3OH(l)$ (32.04 g/mol) is burned in a bomb calorimeter with C = 10.0 kJ/°C, the temperature of the calorimeter increases from 25.0000°C to 25.7346°C. Calculate ΔH° for the reaction

$$2CH_3OH(l) + 3O_2(g) \longrightarrow 2CO_2(g) + 4H_2O(l)$$

[BONUS – 4 marks] It takes 5.0144 g of FeX_n to lower the freezing point of 100 g of water (K_f = 1.86°C/molal) by 2.3°C. It takes 6.4125 g of RuX_n (same X, same n) to lower the freezing point of 100 g of water by 2.3°C. What are the element X and the value of n? You may assume that both FeX_n and RuX_n ionize completely in water.