

## 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  $5 \times 10^{-10}$  M solution of  $\text{Ca}(\text{OH})_2$  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  $1.00 \times 10^{-3}$  M HCl mixed with 25.00 mL of  $6.00 \times 10^{-4}$  M  $\text{Mg}(\text{OH})_2$ .

4) **[9 marks total]** Calculate the pH (at 25°C) of the following solutions, all made with propionic acid ( $\text{HC}_3\text{H}_5\text{O}_2$ ) 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<sub>3</sub>)<sub>3</sub>N) 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<sub>4</sub>

b) **[2 marks]** A solution that has  $[\text{trimethylamine}] = 0.215 \text{ M}$  and  $[\text{trimethylammonium perchlorate}] = 0.139 \text{ M}$

c) **[3 marks]** A solution that has  $[\text{trimethylammonium perchlorate}] = 0.65 \text{ M}$

6) **[6 marks total]** Phosphoric acid ( $\text{H}_3\text{PO}_4$ ) is a weak triprotic acid with  $\text{pK}_{\text{a}1} = 2.12$ ,  $\text{pK}_{\text{a}2} = 7.21$ , and  $\text{pK}_{\text{a}3} = 12.32$ . Calculate (at  $25^\circ\text{C}$ ) the pH of the following solutions, all made using phosphoric acid and/or its salts.

a) **[4 marks]** 10 mL of 1 M  $\text{H}_3\text{PO}_4$  mixed with 15 mL of 1 M KOH

b) **[2 marks]** A solution containing only  $\text{NaH}_2\text{PO}_4$ .

7) **[5 marks total]** A 10-mL aliquot of  $1.0 \times 10^{-3}$  M HCl is titrated with  $8.0 \times 10^{-4}$  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:

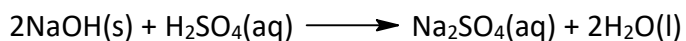
NaNO<sub>2</sub>      acid          base          neither

NH<sub>4</sub>Cl      acid          base          neither

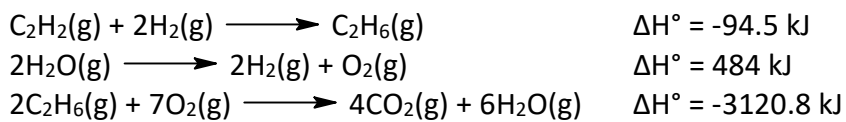
KF          acid          base          neither

KI          acid          base          neither

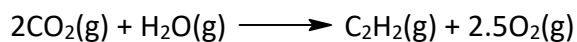
9) **[4 marks]** When 1.63 grams of NaOH (40.0 g/mol) was mixed with 100.0 mL of 0.300 M H<sub>2</sub>SO<sub>4</sub> (S = 4.184 J/g·°C, D = 1.00 g/mL) at 22.20°C, the temperature of the resulting solution rose to 29.06°C. Given that the H<sub>2</sub>SO<sub>4</sub> was contained in a calorimeter with C = 50 J/°C, calculate ΔH° for the reaction:



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

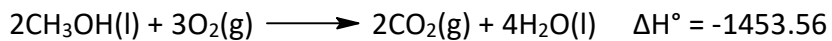


a) [2 marks] Calculate  $\Delta\text{H}^\circ$  for the reaction



b) [1 mark] What is the enthalpy of formation of  $\text{H}_2\text{O}(\text{g})$ ? Give your answer in kJ/mol.

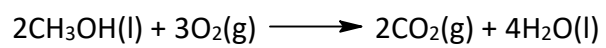
11) [2 marks] Given the reaction



And that the molar enthalpies of formation of  $\text{CO}_2$  and  $\text{H}_2\text{O}$  are  $-393.52 \text{ kJ}$  and  $-285.83 \text{ kJ}$  respectively, calculate the molar enthalpy of formation of  $\text{CH}_3\text{OH}(\text{l})$ .



12) [4 marks] When 324.4 mg of  $\text{CH}_3\text{OH}(\text{l})$  (32.04 g/mol) is burned in a bomb calorimeter with  $C = 10.0 \text{ kJ}/^\circ\text{C}$ , the temperature of the calorimeter increases from  $25.0000^\circ\text{C}$  to  $25.7346^\circ\text{C}$ . Calculate  $\Delta H^\circ$  for the reaction



**[BONUS – 4 marks]** It takes 5.0144 g of  $\text{FeX}_n$  to lower the freezing point of 100 g of water ( $K_f = 1.86^\circ\text{C/molal}$ ) by  $2.3^\circ\text{C}$ . It takes 6.4125 g of  $\text{RuX}_n$  (same X, same n) to lower the freezing point of 100 g of water by  $2.3^\circ\text{C}$ . What are the element X and the value of n? You may assume that both  $\text{FeX}_n$  and  $\text{RuX}_n$  ionize completely in water.