

## Chemistry 1154 R25 Fall 2023 Test 3

Friday, November 24, 2023

Time: 1 hour 50 minutes

Name: \_\_\_\_\_

Student #: \_\_\_\_\_

*This test consists of **eleven** 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 **45** marks (and three bonus marks) available. Good luck!*

- 1) **[13 marks total]** Calculate the pH (at 25°C) of the following solutions. Trimethylamine ((CH<sub>3</sub>)<sub>3</sub>N) is a weak base with  $K_b = 6.3 \times 10^{-5}$ .
  - a) **[3 marks]** 1.59 M (CH<sub>3</sub>)<sub>3</sub>N

b) **[3 marks]** 10 mL of 3.975 M  $(\text{CH}_3)_3\text{N}$  mixed with 15 mL of 1.67 M  $(\text{CH}_3)_3\text{NHBr}$

c) **[4 marks]** 10 mL of 2.5 M  $(\text{CH}_3)_3\text{N}$  mixed with 15 mL of 1.0 M HBr

d) **[3 marks]** 0.63 M  $(\text{CH}_3)_3\text{NHBr}$

2) **[6 marks]** Calculate the pH (at 25°C) of the following solutions. Benzoic acid ( $\text{HC}_6\text{H}_5\text{CO}_2$ ) is a weak acid with  $K_a = 6.3 \times 10^{-5}$ .

a) 15 mL of 1.0 M  $\text{HC}_6\text{H}_5\text{CO}_2$  mixed with 10 mL of 0.75 M KOH

b) 0.63 M  $\text{NaC}_6\text{H}_5\text{CO}_2$

3) **[9 marks total]** Calculate the pH (at 25°C) of the following solutions. Fumaric acid ( $\text{H}_2\text{C}_4\text{H}_2\text{O}_4$ ) is a polyprotic acid with  $K_{a1} = 0.015$  and  $K_{a2} = 2.6 \times 10^{-7}$ .

a) **[2 marks]** 2.00 M  $\text{KHC}_4\text{H}_2\text{O}_4$

b) **[3 marks]** 10 mL of 2.00 M  $\text{H}_2\text{C}_4\text{H}_2\text{O}_4$  mixed with 20 mL of 1.50 M KOH

- c) **[4 marks]** Sketch (not necessarily to scale) the complete titration curve you would expect to see for Fumaric acid when titrated with a strong base. On your sketch, indicate:
- i) Any buffer regions and the acid species present there
  - ii) Any equivalence points and the acid species present there
  - iii) Where the pH is controlled by excess base
  - iv) Where the end point of the titration would be observed. Assume you are using an indicator with a  $pK_a$  of 4

4) **[5 marks total]** A 10 mL aliquot of 0.012 M  $\text{HNO}_3$  is titrated with 0.01 M KOH. An indicator with a  $\text{pK}_a = 3.00$  is used for the titration.

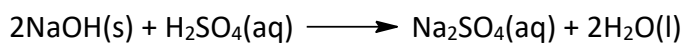
a) **[4 marks]** At what added volume of KOH will the end point be reached?

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

5) [2 marks] Complete the following table:

Acid	Conjugate Base
$\text{HPO}_4^{2-}$	
	$\text{OH}^-$
$\text{NH}_2^-$	
	$\text{CH}_3^-$

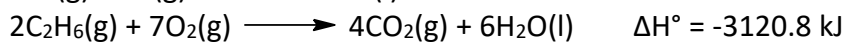
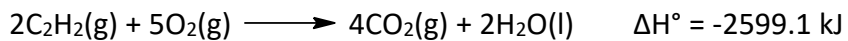
6) [4 marks] When 1.99 g of NaOH (40.0 g/mol) is mixed with 100.0 mL of 0.500 M  $\text{H}_2\text{SO}_4$  ( $S = 4.184 \text{ J/g}\cdot^\circ\text{C}$ ,  $D = 1.00 \text{ g/mL}$ ) at  $22.68^\circ\text{C}$ , the temperature of the resulting solution increases to  $32.01^\circ\text{C}$ . Calculate  $\Delta H$  for the reaction:



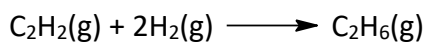
Give your answer in kJ.



7) **[3 marks]** Given the following reactions:

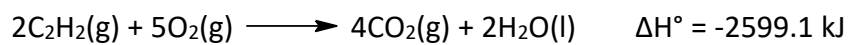


Calculate  $\Delta\text{H}^\circ$  for the reaction



8) **[1 mark]** Write the thermochemical equation for the formation of  $\text{C}_2\text{H}_6(\text{g})$ , for which  $\Delta\text{H}^\circ_{\text{f}} = -84 \text{ kJ/mol}$ .

- 9) **[2 marks]** Given that the enthalpy of formation of  $\text{CO}_2(\text{g})$  is  $-393.5 \text{ kJ/mol}$ , and of  $\text{H}_2\text{O}(\text{l})$  is  $-285.8 \text{ kJ/mol}$ , and given the reaction



calculate  $\Delta H^\circ_f$  for  $\text{C}_2\text{H}_2(\text{g})$ . Give your answer in  $\text{kJ/mol}$

**[BONUS – 3 marks]**

The first ionization of  $\text{H}_2\text{SO}_4$  is complete, and  $K_{a2} = 0.011$ . Calculate the pH of a 0.01 M solution of  $\text{H}_2\text{SO}_4$ .