CHEMISTRY 104
Hour Exam I
Summer 2023

Name _____

Net ID _____

Free Response Questions

GRADING:

MC_____ (60)

21. _____ (6)

22. _____ (6)

23. _____ (7)

24. _____ (7)

25. _____ (9)

26. _____ (5)

27. _____ (13)

28. _____ (7)

Total _____ **120**

For best results please don't leave blanks on the objective or written-out problems.
Please show all steps or logic on the written problems so partial credit can be awarded.

WRITTEN OUT PROBLEMS – Show all work for partial credit.

21. Consider the following reaction at 25°C:

(6 pts.) $N_2O_4(g) \rightleftharpoons 2\ NO_2(g)$

The standard free energy of formations ($\Delta G_f°$) for $N_2O_4(g)$ and $NO_2(g)$ are 98 kJ/mol and 52 kJ/mol, respectively. If at equilibrium, $P_{N_2O_4} = 0.50$ atm, calculate the equilibrium partial pressure of NO_2.

22. White phosphorous exists in two crystalline forms, the α form and the β form. At 1 atmosphere, the β form is stable at temperatures below –76.9°C. Above –76.9°C, the α form is stable. Which statement (a-c) is/are **true** concerning the $P_\beta \rightarrow P_\alpha$ transition? **(6 pts.)**

a. Is the $P_\beta \rightarrow P_\alpha$ transition endothermic or exothermic? Explain.

b. Which is the more disordered crystalline form of phosphorus, the α or the β form? Explain.

23. Given the following data, calculate the normal boiling point for formic acid (HCOOH).

(7 pts.)

	ΔH_f° (kJ/mol)	S° (J/K·mol)
HCOOH(l)	−410.	130.
HCOOH(g)	−363	251

24. K_w is the equilibrium constant for the autoionization of water reaction. The value of K_w depends on temperature. For example, at 25°C, $K_w = 1.0 \times 10^{-14}$ and at 47°C, $K_w = 4.0 \times 10^{-14}$.

(7 pts.)

a. Calculate the pH of neutral water at 47°C.

b. Calculate the pOH of a 0.10 *M* $HClO_4$ solution at 47°C.

25. Consider 0.10 *M* solutions of the following nine substances:
(9 pts.)

$$KF,\ H_2SO_4,\ HONH_2,\ HF,\ HCl,\ RbOH,\ HONH_3NO_3,\ Sr(OH)_2,\ CaBr_2$$

Rank these nine solutions from lowest pH to highest pH. K_a for HF = 7.2×10^{-4} and K_b for $HONH_2$ = 1.1×10^{-8}. Under each substance in your final ranking, label each as either a strong acid (SA), weak acid (WA), strong base (SB), weak base (WB) , or neutral (N) species.

26. Consider the titration of 50.0 mL of 0.10 *M* $Sr(OH)_2$ by 0.10 *M* HNO_3. Sketch a titration curve for this titration and label the axes. On your sketch, indicate the pH at the equivalence point and the volume of $Sr(OH)_2$ required to reach the equivalence point. What are the major species present at the equivalence point after all of the strong base has reacted? **(5 pts.)**

27. The next four questions refer to the titration of 25.0 mL of 0.400 *M* hypochlorous acid (HOCl) by 0.200 *M* KOH. The K_a value for HOCl is 3.5×10^{-8}.
(13 pts.)

A. At what volume of KOH added does $[H^+] = 3.5 \times 10^{-8}$ *M*?

B. Calculate the pH after 40.0 mL of KOH has been added.

C. Calculate the pH at the equivalence point.

D. Calculate the pH after 75.0 mL of KOH has been added.

28. A. Calculate the pH of a solution containing 0.35 *M* $HC_3H_5O_2$ and 0.65 *M* $KC_3H_5O_2$. K_a for $HC_3H_5O_2 = 1.3 \times 10^{-5}$.

(7 pts.)

B. Calculate the pH after 0.30 mol of HCl is added to 2.0 L of a solution containing 0.35 *M* $HC_3H_5O_2$ and 0.65 *M* $KC_3H_5O_2$. Assume no volume change when the HCl is added. K_a for $HC_3H_5O_2 = 1.3 \times 10^{-5}$.