EXAM IV – November 25, 2019

Answers to Calculation-Based Problems

2. (16 pts) Sulfuric acid, H_2SO_4, is arguably the most commonly used chemical in the world, with myriad applications. Among them, you may know that it is the "battery acid" in most car batteries.

   Suppose that a mechanic keeps a solution of lye (more formally known as sodium hydroxide, NaOH) on hand to neutralize any H_2SO_4 that happens to leak from used car batteries.

   a. What is the pH of a 6.0 M solution of NaOH?

Answer: pH = 13.22

4. (18 pts) Radioactive iodine, ^{131}I, is used to treat hyperthyroidism (overactive thyroid) by shrinking the thyroid gland. It decays according to first-order kinetics. $ln\frac{[A]_t}{[A]_0} = -kt$

   b. The half-life of ^{131}I is 8.021 days. Calculate the rate constant for its decay.

Answer: k = 0.864 days^{-1}

   c. How much time must pass after administration of ^{131}I before its concentration has decayed to 5.0% of its initial value?

Answer: t = 35 days

5. (12 pts) The hemoglobin in our blood (abbreviated Hb) readily binds to carbon monoxide. (This is a key factor in CO poisoning, as the CO displaces oxygen.) The rate of this binding reaction was studied at 20 °C. [1 μM = 1 × 10^{-6} M = 1 μmol/L]

$$Hb + CO \rightarrow Hb—CO$$

$[Hb]_0$ (μM)	$[CO]_0$ (μM)	Initial Rate (μM/s)
2.21	1.00	0.619
4.42	1.00	1.24
4.42	3.00	3.71

   b. Calculate the rate constant.

Answer: k = 0.280 μM^{-1} s^{-1}

7. (17 pts) Uric acid ($C_5H_4N_4O_3$, $K_a = 1.29 \times 10^{-4}$) can collect in joints, giving rise to a medical condition known as gout. What is the pH of a 0.0650 M solution of uric acid? [**Hint:** Find the equilibrium concentration of H_3O^+.]

$$C_5H_4N_4O_3\ (aq) + H_2O\ (l) \rightleftharpoons C_5H_3N_4O_3^-\ (aq) + H_3O^+\ (aq) \qquad K_a = 1.29 \times 10^{-4}$$

Answer: pH = 2.548 (using quadratic formula)

OR

pH = 2.538 (using the shortcut, assuming x << 0.0650 M)