Name Key Date ______________ Period ______

Take Home FRQ - Buffers

1. The major buffer in blood is composed of the weak acid carbonic acid (H_2CO_3) and its conjugate base, bicarbonate ion (HCO_3^-). The normal pH of blood is 7.2-7.4, which is very far removed from the pK_a value. The pH is kept in check by the lungs, which remove CO_2 via exhalation, and by the kidneys, which excrete acid (H_3O^+) in the urine. The blood buffering system is based on the following chemical equation:

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow HCO_3^- + H^+$$

a. People with impaired lung function are not able to exchange carbon dioxide efficiently between the lungs and air. The result is an increase in the amount of CO_2 dissolved in the blood. According to Le Chatelier's Principle, how does this affect the concentration of other components in the blood buffering system? (1 point)

* Increasing the amount of CO_2 in the blood will shift the equilibrium to the right, causing the blood pH to decrease. due to increased H_2CO_3. +½ +½

b. Which term, respiratory acidosis or respiratory alkalosis, would better describe the resulting condition? (1 point)

* The blood pH will decrease this is acidosis +1

2. Many soft drinks contain phosphate buffers.

a. Calculate the volume (in mL) of an 8.0 oz. soft drink. There are 29.6 mL per ounce. (1 point)

$8.0 \text{ oz} \times \frac{29.6 \text{ mL}}{1 \text{ oz}} = \boxed{240 \text{ mL}}$ +1 (-½ sig figs, -½ units)

b. An 8 oz. soft drink contains 4.4 g of sodium dihydrogen phosphate (formula weight = 120 g/mole) and 5.4 g of sodium hydrogen phosphate (formula weight = 142 g/mole). Find the molar concentrations of both $H_2PO_4^-$ and HPO_4^{2-}. (2 points)

$H_2PO_4^-$: $4.4 \text{ g} \times \frac{1 \text{ mol}}{120 \text{ g}} = 0.037 \text{ mol}$ $\quad \frac{0.037 \text{ mol}}{0.24 \text{ L}} = \boxed{0.15 \text{ M } H_2PO_4^-}$ +1

HPO_4^{2-}: $5.4 \text{ g} \times \frac{1 \text{ mol}}{142 \text{ g}} = 0.038 \text{ mol}$ $\quad \frac{0.038 \text{ mol}}{0.24 \text{ L}} = \boxed{0.16 \text{ M } HPO_4^{2-}}$ +1 (-½ sig figs, -½ units)

c. Use the Henderson-Hasselbalch equation to calculate the pH of this solution. (2 points)

$pH = pK_a + \log\left(\frac{[HPO_4^{2-}]}{[H_2PO_4^-]}\right)$ $\quad pK_a = 7.2$

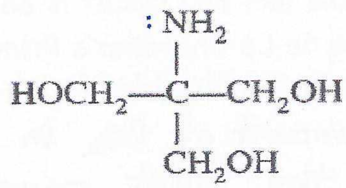
$pH = 7.2 + \log\left(\frac{0.16}{0.15}\right)$ $\quad \boxed{pH = 7.2}$ +1

3. Explain why a mixture of the strong acid HCl and its conjugate base NaCl does not provide buffering action. (2 points)

+1 The conjugate base of the HCl is chloride ion (Cl^-), which is neutral and cannot neutralize any excess acid added to the solution.

+1 ↳ A buffer has an acid component to neutralize excess base and a basic component to neutralize acid)

4. Forensic analysis of DNA by electrophoresis requires the use of a pH 8.3 buffer to ensure that the DNA phosphate groups remain negatively charged. The major constituent of electrophoresis buffers is called TRIS, which stands for tris(hydroxymethyl)aminomethane. Its structure is shown below.

TRIS 

a. Identify the functional group in TRIS that is a Lewis base, and can be protonated to give a weak acid. (1 point)

+1 $:NH_2$ is a Lewis base (e^- pair donor)

b. Explain why this functional group is considered a Lewis base. (1 point)

+1 There is a lone pair of e^- on the nitrogen atom that can be donated. (This is analogous to the weak base ammonia, NH_3)

c. Draw the protonated form of TRIS that is weak acid. (1 point)

+1