Names _____

Buffers Workshop Bonus

1. Provide clear definitions of each the following terms with one or more specific chemical examples that relate to the respective term:

Homeostasis	
Alkalosis	
Acidosis	
Alkalinity	
Salinity	
Dissolved Inorganic Carbon (Oceans)	

2. Sea water has an average of ~35 g dissolved salts /L solution. Provide chemical formulas of 3 ions that do **not** affect acidity-basicity (neutral), case (I), and 3 salts that **do**, case (II). Provide an explanation for your selections.

Salt (I)	Explanation	Salt (II)	Explanation

3. From the following equilibrium reactions write the respective equilibrium expressions for K_1, K_2 , and K_3.

1) $H_2O(l) + CO_2(g) \rightleftharpoons CO_2(aq)$	$K_1 =$
2) $CO_2(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$	$K_2 =$
3) $H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$	$K_3 =$

4. Add the equilibrium reactions 1), 2), and 3) together and write the Net equilibrium reaction for the overall reactants and products. Then provide the mathematical equation for K_{Net} using K_1 , K_2 , and K_3.

Net Eq:	$K_{Net} =$

Human arterial blood having the following values: pCO_2 = 5.3 kPa (40mmHg), pO_2 = 80 torr, pH = 7.40, and $[HCO_3^-]$ = 0.024 M, when measured at +37°C, are within normal ranges for a healthy person. The renal system plays an important role in maintaining this homeostatic balance by regulating the bicarbonate ion concentration through the kidneys and excretion. Diet, exercise, illness and disease will affect these baseline values.

a. *When a person exercises very strenuously, they build up lactic acid in the blood.*
How do the kidneys work to re-establish normal homeostatic baseline conditions in blood after strenuous exercise? (Use K_{Net} in your explanation.)

b. *The urine of heavy red meat eaters is generally more acidic than vegans.*

If urinary excretion of $[HCO_3^-]$ produced a 10 mmol/L decrease in blood $[HCO_3^-]$ what would be the corresponding change in pH? (Assume all other variables remain constant.) Show your calculation.

c. *The kidneys can remove $[HCO_3^-]$ but cannot add it. It must be ingested or infused, or a substitute must be used in its place.*

Explain what criteria would be used to select a substitute and provide the name of a specific compound that would be a suitable replacement for bicarbonate.

The world's oceans unfortunately do not have a renal system to balance pH. It is thought that ocean pH has had an average pH of ~8.1 (within a range of 8.0-8.3) over 20 million years before the present. But, the average pH has been declining in the past 100-200 years; currently it is ~8.0, which corresponds to an atmospheric $CO_2(g)$ = 390 ppm, $[CO_2(aq)] = 1.46 \times 10^{-5}$ mol/L, and $[HCO_3^-(aq)] = 1.89 \times 10^{-3}$ mol/L.

There is one more equilibrium step, (4), in the complete CO_2 /carbonic acid buffer system. It was neglected in humans since it doesn't measurably affect blood pH.

$$(4)\ HCO_3^-(aq) \rightleftharpoons H^+(aq) + CO_3^{-2}(aq)$$

This step is important in the oceans since the carbonate ion is essential to life, as it is used to produce biological structures such as shells, exoskeletons, and coral reefs. These eventually fossilize after the organisms die and ultimately wind up as very poorly soluble $CaCO_3$ or limestone. The current carbonate ion concentration is $[CO_3^{-2}(aq)] = 1.59 \times 10^{-4}$ mol/L.

5. Write the equilibrium expression for step (4) on the left. Using the expression and the values given above, solve for Q on the right.

$K_{(4)}$ =	$Q_{(4)}$ =

a. Explain if you think that the ocean carbon system is currently at equilibrium or not and how you might test your hypothesis using historical data versus Le Chatelier's principle.

b. Worst case models predict that the oceans may have a pH as low as 7.7 by the year 2100. Calculate the $[CO_3^{-2}(aq)]$ for the worst case pH and explain the possible effects on ocean life.