Friday Worksheet **Name: ……………….**

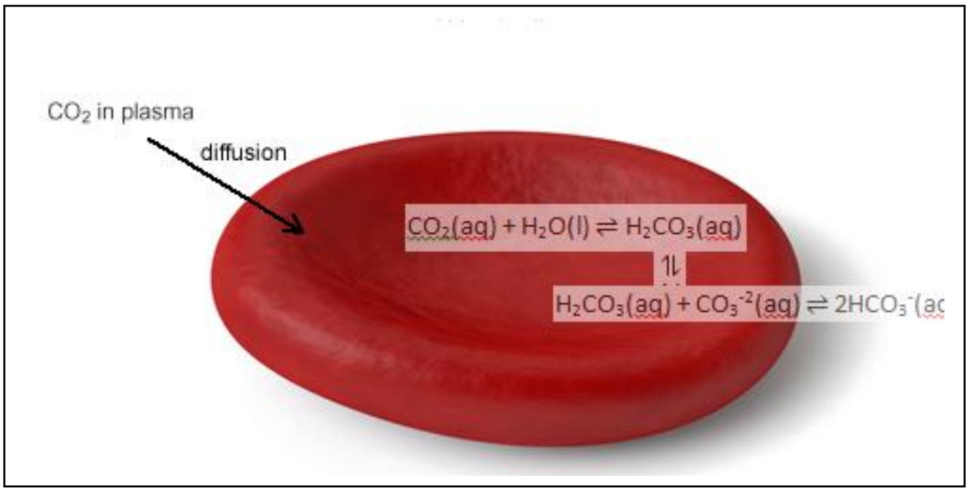
Chemical equilibrium worksheet 5

1) Below are two reactions that Are part of htr bicarbonate system in the blood.

$CO_2(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$ -------------------------- 1)

$H_2CO_3(aq) + H_2O\ (l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$ ------------------ 2)

CO_2 is a product of cellular respiration. It diffuses out of the cell's membrane and accumulates in the fluid surrounding the cell. CO_2 reacts with water to produce carbonic acid, reaction 1) above. This reaction is catalysed by an enzyme called carbonic anhydrase. Carbonic acid is a weak acid that if allowed to accumulate can disrupt vital cellular functions.



a) The bicarbonate system can be summarised below.

$CO_2(aq) + 2H_2O(l) \rightleftharpoons H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$

People who hyperventilate, during a moment of crisis, are often advised to breath into a paper bag.

Using Le Chatelier's principle explain:

the effect on blood pH of hyperventilating,

Hyperventilating causes blood CO_2 levels to decrease. This would drive the equilibrium below to the left thus decreasing $[H_3O^+]$ and increasing the pH.

$CO_2(aq) + 2H_2O(l) \rightleftharpoons H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$

- the effect on blood pH of breathing into a paper bag.

Breathing into a bag increases the amount of CO_2 in the blood and pushes the equilibrium, shown below to the right thus increasing $[H_3O^+]$ and decreasing the pH

$CO_2(aq) + 2H_2O(l) \rightleftharpoons H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$

b) The concentration of carbon dioxide in the lungs is very low, how does this affect the:

- equilibrium position of the following reaction $CO_2(g) \rightleftharpoons CO_2(aq)$

The equilibrium is pushed to the left thus expelling CO_2 from the blood.

- the pH of the blood leaving the lungs as compared to the pH coming into the lungs.

The blood coming to the lungs is reach in CO_2 thus having a low pH but blood leaving the lungs has a relative low concentration of CO_2 and so the pH is relatively high

2) It is proposed to indirectly determine the concentration of Fe^{3+} ions in a solution by using UV-visible spectroscopy to measure the concentration of red coloured $FeSCN^{2+}$ ions generated by the equilibrium reaction.

$Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons FeSCN^{2+}(aq)$ ΔH = positive

Tick the conditions that this procedure must be conducted under, that would provide the most accurate estimate of Fe^{3+} ions in the original solution.

Conditions that will drive the eqyilibrium to the right and produce maximum yield. This way we can exact all of the Fe^{3+} in the solution.

Equilibrium constant	High	✓
	Low	
Temperature	High	✓
	Low	
Concentration of SCN^{-}	Excess	✓
	Limiting	

3) The equation below shows the steam reforming reaction for the industrial production of hydrogen gas using a Ni catalyst, high temperature and pressure.

$CH_4(g) + H_2O(g) \Rightarrow CO(g) + 3H_2(g)$ ΔH = +207 kJ mol^{-1}

a) Write an equilibrium expression for the steam reforming reaction.

$$\boxed{\frac{[CO][H_2]^3}{[CH_4]\,[H_2O]} = K}$$

Water must be included in the equilibrium expression as all the species in the reaction are in the gaseous phase.

b) According to Le Chatelier's principle what are the ideal conditions for maximum yield for this reaction?

Low pressure, high emperature

c) Suggest one reason why high pressure is used in the industrial process described above.

To increase the rate of the reaction.

d) At 1500 °C the concentrations of the gases in a particular equilibrium mixture were found to be $[CH_4]$ = 0.200 M, [CO] = 0.580 M, $[H_2O]$ = 0.038 M
If K = 5.70 M^2 at 1500 °C for the reaction. Calculate the molar concentration of H_2 in the equilibrium mixture.

$$\frac{[0.580][H_2]^3}{[0.200][0.0380]} = 5.70$$

⇨ **$[H_2]$ = 0.421 M**