SRI YERRAMILLI NARAYANA MURTHY COLLEGE (AUTONOMOUS)

Re- Accredited by NAAC with A Grade college with CGPA of 3.41

NARASAPUR – 534275, West Godavari District

DEPARTMENT OF CHEMISTRY

A Project work on

APPILICATION OF EQUILIBRIUM RELATIONSHIP BETWEEN DENTAL CAVITIES AND THE USE OF FLUORIDATED TOOTHPASTE AND WATER

For the academic year 2019-2020

Submitted to

Ch. Uday Bhaskar

Department of chemistry

Submitted by

1.T.Rama Krishna

2.K.Satyanarayana

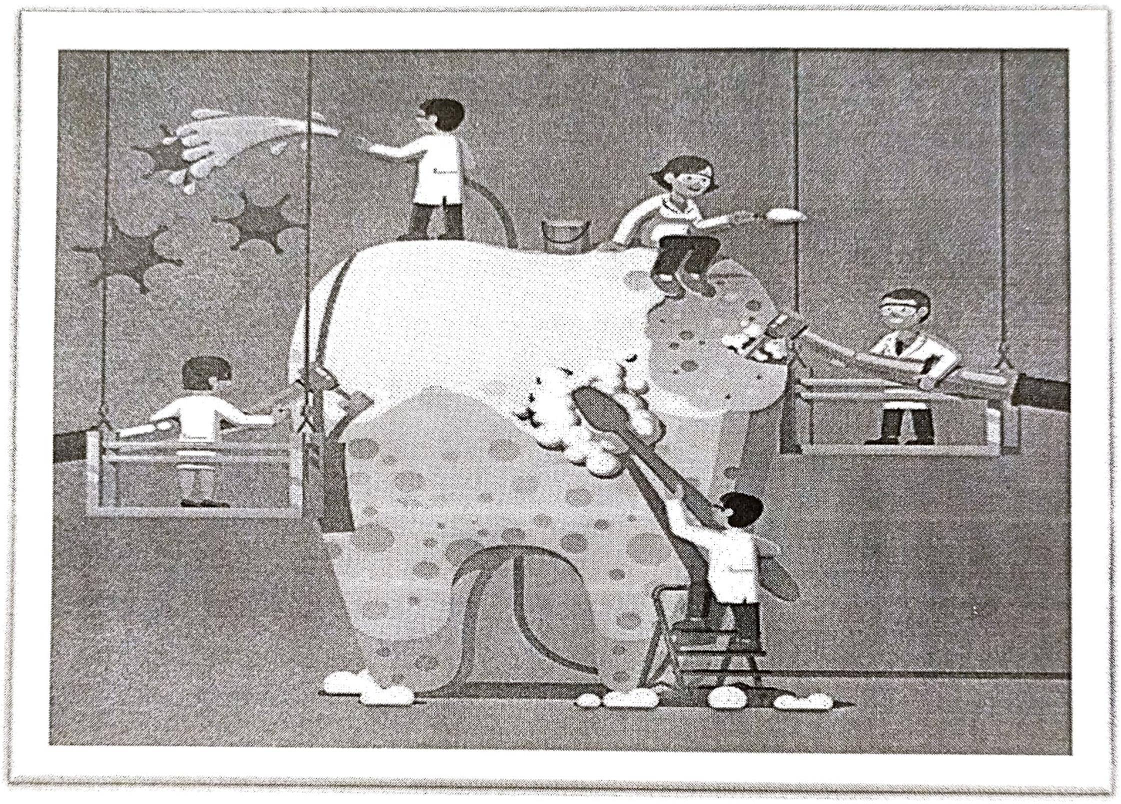
3.T.Lokesh

4.D.Bharghava Narasimha Rao

5.M.Suresh kumar

1.Application of equilibrium to relationship between dental cavities and the use of fluoridated toothpaste and water:

Acids from plaque cause the loss of minerals from the tooth is called demineralization resulting in tooth decay. The formation of small cavities, or carious lesions, can be reversed by remineralization that is, the deposition of minerals into previously damaged areas of tooth.



Fluoride is a naturally occurring element that prevents tooth decay when ingested systemically or applied to teeth topically. The fluoride ion comes from the element fluorine. Fluorine, the 13th most abundant element in the earth's crust, is never encountered in its free state in nature. It exists only in combination with other elements as a fluoride compound. It is found in this form as a constituent of minerals in rocks and soil everywhere. Water passes over rock formations containing fluoride and dissolves these compounds, creating fluoride ions. The result is that small amounts of soluble fluoride ions are present in all water sources, including the oceans.

We know that acids dissolve our pearly whites, but where does this acid come from and what chemistry is really going on in our mouths to make this happen? If your mouth hosts biofilms of certain bacteria, especially Streptococcus mutans that are feeding off sugars, the teeth will be in contact with acid. Such bacteria even store polysaccharides and continue to lower the pH of their environment long after food has been swallowed. If this persists, teeth could eventually decay. But are there other sources of acids that could also inflict damage?

Juice, soft drinks and vinegar-rich foods easily come to mind. Gastric juice from either bulimia or a gastro-disorder can also take its toll. Less familiar hazards include professional wine tasting, which involves keeping wine in the mouth for up to a minute, dozens of times a day. Frequent swimming in pools that are not pH-balanced also leads to tooth decay. Stabilizers in chlorine "pucks" are acidic, and the direct application of chlorine forms not only hypochlorite but hydrochloric acid.

All of this begs the question, how exactly does acid damage teeth? And why are there individual variations? This is a perfect application question for a high school chemistry class as it brings together topics, such as pH, Ksp, equilibrium and Le Chatelier's principle.

The first part of the discussion involves what dentists refer to as critical pH. This is the pH of a solution when it is just saturated with respect to one of the minerals in enamel. If the solution's acid-level is above the critical pH, then things are safe for teeth. If the solution is supersaturated relative to that mineral, more of it will tend to precipitate out. The worry is when the solution's pH is below the critical value then the solution is unsaturated and teeth will start to dissolve.

The mineral I've been referring to is calcium hydroxyapatite, one of the enamel's components. In aqueous solution it creates the following equilibrium:

$Ca_{10}(PO_4)_6(OH)_2(s) \rightleftarrows 10\ Ca^{2+}(aq) + 6\ PO4^{3-}\ (aq) + 2\ OH^-(aq)$

Normally, the mineral is highly insoluble; its Ksp is extremely small, on the order of 10-117. But of course, the solubility of the enamel can increase if hydroxide ion is consumed, hampering the reverse reaction and favoring the forward reaction Le Chatelier never rests, not even while you eat! The concentration of phosphate also decreases with lower pH as the presence of H^+ forms H_3PO_4, $H_2PO_4^-$, HPO_4^{2-} in saliva. If phosphate levels decrease, the forward reaction is again favored increasing the solubility of hydroxyapatite. For these two reasons, acidic conditions lead to tooth erosion.

The critical pH is around 5.5 but it's not a fixed value and can vary from one individual to the next.

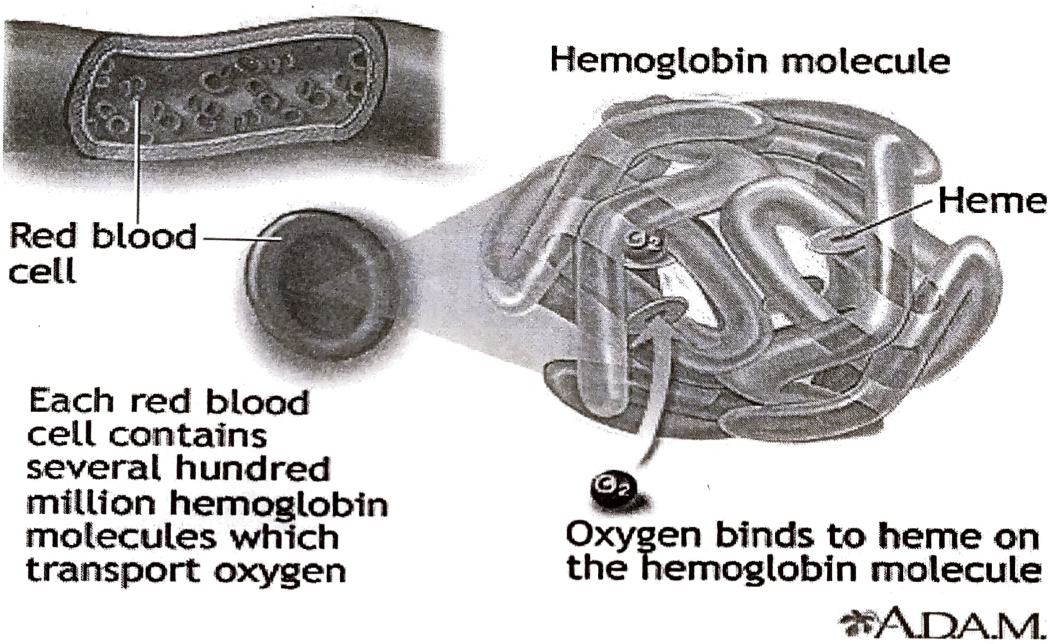
Because the reasons are

1. The amount of fluoroapatite, another mineral present in enamel, reduces the critical pH because fluoroapatite ($Ca_5(PO_4)_3F$) is free of hydroxide. It is less soluble than calcium hydroxyapatite in acidic conditions. Fluoridating teeth protects teeth against acid-erosion by displacing hydroxide with a fluoride ion.

2. Impurities in enamel such as carbonate and fluoride affect enamel solubility and those ions vary in different people. If concentrations of phosphate and calcium ions in an individual's saliva are unusually low, the critical pH may increase by a factor of 10 to a pH of 6.5.

2. Application of Equilibrium to chemistry of blood (Hemoglobin and oxygen equilibrium):

Hemoglobin is a critical component of red blood cells that is composed of protein known as "heme" which aids in the transportation of oxygen throughout the body. From the lungs, hemoglobin binds oxygen to itself and carries it to the tissue where it is released. The cycle occurs again once hemoglobin travels back to the lungs



This is a form of biological equilibrium. When hemoglobin reacts with oxygen, oxyhemoglobin is formed. The oxygenation of blood is an equilibrium reaction. This is a form of dynamic equilibrium since it establishes balance with the movement of hemoglobin. Therefore the synthesis of oxyhemoglobin (foreword reaction) and the decomposition of oxyhemoglobin (reverse reaction)

Chemical equation

$$\mathbf{Hb}\ (aq) + 4O_2\ (g) \leftrightharpoons \mathbf{Hb(O_2)_4}\ (aq)$$

Note: Hb stands for hemoglobin

Le Chatlier's principle and External forces that control hemoglobin and oxygen equilibrium

PRESSURE

Both high and low altitudes control this equilibrium system. The air pressure directly correlates with the amount of oxygen needed for survival.

Decrease in gas pressure at high altitudes:

- Results in a shift to the sides with more gas molecules. In this case, it would be a shift to the left since, as pressure decreases, volume will increase and to re-establish equilibrium more gas molecules of hemoglobin and oxygen have to be present.
- Low air pressure results in less oxyhemoglobin needed for survival and more hemoglobin and oxygen to be present

Increase in gas pressure at low altitudes:

- Results in a shift to the side with the fewest gas molecules as volume will inversely decrease. To re-establish equilibrium a shift to the right will occur so that fewer gas molecules are present.

- High air pressure results in more oxyhemoglobin needed for survival.

CONCENTRATION OF OXYGEN

In the lungs:

- The concentration of oxygen increases and therefore a shift to the right will occur in order to counteract the increasing concentration of oxygen by producing more oxyhemoglobin.

In the tissue:

- The concentration of oxygen decreases and thus to re-establish equilibrium a shift to the left occurs by decomposing oxyhemoglobin to increase the concentration of oxygen.

TEMPERATURE

High increase or decrease in temperature:

- This causes protein denaturation for oxyhemoglobin which results in an increase within the concentration of hemoglobin and oxygen. In order to re-establish equilibrium a shift occurs in the right to increase the production of oxyhemoglobin.

References:

1. Scientific American, a Division of Springer Nature America (Oct 21 1999)How does the fluoride in toothpaste prevent cavities?

2. Horst, J. A., Tanzer, J. M., & Milgrom, P. M. (2018) Fluorides and Other Preventive Strategies for Tooth Decay. Dental clinics of North America,

3. Sananda Dey, BiplabGiri, (December 24 2015) Fluoride Fact on Human Health and Health Problems: A Review. Med Clin Rev.

4. Lamberg M, Hausen H, Vartiainen T (August 1997)"Symptoms experienced during periods of actual and supposed water fluoridation". Community Dentistry and Oral Epidemiology.

5. Pizzo G, Piscopo MR, Pizzo I, Giuliana G (September 2007). "Community water fluoridation and caries prevention". Clinical Oral Investigations.

6. Chemistry 104, Bryn Mawr College. (May 2013) Equilibrium and Breathing,

7. Hemoglobin: Medline plus Medical Encyclopedia Image. Retrieved

(May 7, 2013), National Library of Medicine – National Institutes of Health.

9. Metal Complex in the Blood. Department of Chemistry

(may 2013)|Washington University in St. Louis.