Journal of Interdisciplinary Science Topics

Human Body Vaporisation

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19/02/2013

Abstract
Hypothetically, how much energy would be required to completely vaporise the human body? This would be the amount of energy that would completely dissociate the chemical bonds of the body. In this paper, we focus on the energy that would be required to dissociate the human skeleton. For simplicity, we determine this by considering only the bond energy of bonds that make up the bone mineral, calcium hydroxyapatite, assuming it makes up 100% of the bone. The energy obtained was $89.8GJ$ for a person with a mass of 78kg.

Introduction

The idea of completely vaporising a person, such that there is no trace of the person left, is quite common in futuristic sci-fi movies where there are weapons with the capability to achieve this feat. This vaporisation process would be the dissociation of the body into its constituent atoms so that nothing is left visible. To achieve this, the weapon must release sufficient energy to dissociate the chemical bonds of the constituents of the body.

The human body is composed of several constituents that make up the various tissues and organs. These include; water – which makes up about 70% of an adult human body, proteins, lipids, sugars and inorganic minerals. In order for a human to be completely vaporised, the water which makes up most of the body would have be dissociated. In addition to this, the tissues remaining, which consists of organic molecules and inorganic minerals, would be vaporised. One of these tissues would be the bone tissue which makes up the skeleton [1].

For the purpose of this paper, we would only be focusing on the vaporisation of an adult human skeleton. Thus the vaporisation energy required would be sufficient to completely dissociate the whole skeleton to its atoms.

Bones composition

Bones are the hardest and strongest tissues of the human body. The bones are made up of 20% water, 10% Type 1 collagen fibres and 70% of an inorganic mineral known as calcium hydroxyapatite (CHA). This mineral consists of three phosphate molecules with ionic interaction between four calcium ions. We will assume that, since calcium hydroxyapatite makes up the majority of the bone, the energy required to dissociate the mineral would be sufficient to completely dissociate the other components of the bone [2].

Dissociation Energy Calculation

Calcium hydroxyapatite has the chemical formula $Ca_{10}(PO_4)_6(OH)_2$ [3]. Based on its molecular structure, it has the given bonds shown in Table 1. The bond energy per mole of the chemical bonds is given.

Chemical Bond	Bond Energy (kJ/mol)	No of bonds per mol CHA	Type of Bond
Ca-O	487	4	Ionic
P=O	502	3	Covalent
P-O	418	9	Covalent
O-H	460	1	covalent

Table 1: Chemical bonds and their energies in calcium hydroxyapatite [4]

If we assume that the person to be vaporised has a mass of 78kg and the weight proportion of the skeleton is 15% of the body, the total mass of the skeleton would 11.7kg. The mass of calcium hydroxyapatite is 70% of the bone mass, however we will take it as being 100% of the bone mass.

Thus, the amount of the mineral in the person, with a mass of 78kg, can be determined by first calculating the molar mass of $Ca_{10}(PO_4)_6(OH)_2$ by the summation of its constituent elements;

$$Molar\ Mass\ of\ CHA = (Ca \times 10) + (P \times 6) + (O \times 26) + (H \times 2)$$

$$= (40 \times 10) + (31 \times 6) + (16 \times 26) + (1 \times 2)$$

$$= 1004\ gmol^{-1} \approx 1.0\ kgmol^{-1}$$

The amount of CHA in the skeleton would then be;

$$No\ of\ \ moles = \frac{mass}{molar\ mass} = \frac{11.70kg}{1.00\ kgmol^{-1}} = 11.70mol$$

Given that;

1 mol $Ca_{10}(PO_4)_6(OH)_2$ ⟶ 4 moles Ca-O
1 mol $Ca_{10}(PO_4)_6(OH)_2$ ⟶ 3 moles P=O
1 mol $Ca_{10}(PO_4)_6(OH)_2$ ⟶ 9 moles P-O
1 mol $Ca_{10}(PO_4)_6(OH)_2$ ⟶ 1 mol O-H

11.70 mol of $Ca_{10}(PO_4)_6(OH)_2$ will have;

46.80 mol of Ca-O
35.10 mol of P=O
105.30 mol of P-O
11.70 mol of O-H

Therefore, the energy required to break the bonds in the calcium hydroxyapatite can be calculated based on the bond energy of each bond from Table 1. The result of this is given in Table 2;

Chemical Bond	No. of moles in 11.70 mol CHA	Bond energy (kJ)	Bond energy in 11.70 mol CHA (kJ)
Ca-O	46.80	487	22.79×10^3
P=O	35.10	502	17.62×10^3
P-O	105.30	418	44.02×10^3
O-H	11.70	460	5.38×10^3

Table 2: Energies required in break the constituent bonds of CHA in a 78kg person [6]

Based on this result, the total energy required to completely dissociate the calcium hydroxyapatite (CHA), and hence the whole skeleton (given previous assumptions), in a 78kg person would be the sum of the bond energies of the constituents bonds of CHA in the subject. This is calculated to be;

$$E_{tot} = 89.81 \times 10^3\ kJ$$

This energy is equivalent to approximately eight days worth of the recommended calorific intake of an average male at 2500kcal per day [5]. This brings to light the fact that in order for vaporisation to take place, such energy must be applied in a very short time.

Conclusion

We were able to determine the approximate amount of energy required to completely vaporise the skeleton of a person. This value was approximately 90 million joules. However, for such an amount of energy to completely vaporise the skeleton, the energy must be applied in a very short frame of time, that is, with a very high power.

To completely dissociate a whole human body, the energies required dissociating the water content and other constituents of such tissues like the muscles must also be determined. This can be determined in future papers. Also, the power needed to cause the dissociation must also be determined.

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