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# A3_3: A Pretty Positive Guy

D. Potts, E. Morton, M. Capoccia, R. Hodnett, S. Shingles

*Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH*

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**Abstract**

In this paper we discuss the potential energy associated with a sphere of hydrogen once all of its electrons have been removed, which we have used as an approximation for a person. We calculated this energy to be $4.8\times10^{29}$ J. We compared this value to known processes and it was found to be extremely energetic, billions of times greater than nuclear explosions and of a similar magnitude to the Sun's energy output. We also found that the same process when applied to an approximation of an ant has 1.5 $\times$ the energy of the Tsar bomb.

## Introduction

All matter is comprised of atoms, which are made up of electrons, protons and neutrons. This paper explores the potential energy associated with an object that has had all of its electrons removed instantaneously. Our method takes inspiration from the second solution from [1], but we have used a more appropriate radius and have done a full calculation of the atoms required. Their solution is a very rough estimate made with questionable assumptions, and so our aim is to create a model with more reasonable assumptions, thus obtaining a more relevant value. We have also investigated other creatures of various sizes and masses to demonstrate the potential energy contained within every day beings.

## Theory

If you were to remove all the electrons instantaneously from an object, you would be left with positively charged nuclei in very close proximity. Due to electrostatic forces of repulsion, these tightly packed positive charges would repel each other violently, tearing the entire object apart. By considering the potential energy contained within such a charge distribution using equation (1), we can determine how much energy would be involved with the process.

$$U = \frac{3}{5}\frac{Q^2}{4\pi\epsilon_0 R} \tag{1}$$

Where $U$ is potential energy, $Q$ is charge, $\epsilon_o$ is permittivity of free space and $R$ is radius. The human body is comprised of many different elements with varying sizes and charges, which greatly complicates the application of the physics, as multiple complex equations would be needed. However, since humans are mostly hydrogen (by atomic percentage [2]) we have assumed hydrogen is the only element present.

The second assumption we have made is that the body is perfectly spherical and the charges are uniformally distributed. Therefore, our value will just be a rough estimation, and smaller than the true value for a real person. This is because the heavier elements that make up the human body have larger charges and they would be more tightly packed, as the distribution would not be uniform. This would result in a greater force of repulsion between the positive nuclei, increasing the energy.

| Event | Energy [J] | How Many Events are Equivalent |
|---|---|---|
| Tsar Bomb (Largest detonated H-Bomb) [3] | $2.1\times10^{17}$ | 2.3 Trillion |
| All Detonated Nuclear Bombs Combined [4] | $2.5\times10^{18}$ | 190 Billion |
| World Electricity Consumption (per year)[5] | $7.5\times10^{19}$ | 6.4 Billion |
| Energy released from the Sun (per second)[6] | $3.8\times10^{26}$ | 1270 |

Table 1: Comparison of our value to known high energy processes.

## Results

By taking the weight of the 'positive guy' to be 70 kg, we found the number of hydrogen nuclei required to make up a mass of 70 kg is $4.18\times10^{28}$. We will take the radius of the sphere to be 0.5 m, which is comparable to a grown man in the fetal position. Each hydrogen atom becomes 1 proton once the electrons are removed, and so we have $4.18\times10^{28}$ protons, each with a charge of $1.6\times10^{-19}$ C. By using equation (1) with $Q = 6.69\times10^{9}$ C and $R = 0.5$ m we find an energy of $4.8\times10^{29}$ J. We also performed the same methodology and calculation on some other beings.

| Creature | Energy [J] | Equivalent energy in Tsar Bombs[3] |
|---|---|---|
| Jack Russell | $1.61\times10^{28}$ | $\times$76.8 Billion |
| Guinea Pig | $4.94\times10^{26}$ | $\times$2.4 Billion |
| Ant | $3.16\times10^{17}$ | $\times$1.5 |

Table 2: Calculation for other animals. Lengths and masses estimated as follows. Jack Russel (M=7 kg, R=15 cm), Guinea Pig (M=1 kg, R=10 cm), Ant (M=$4\times10^{-6}$ kg, R=2.5 mm)

## Discussion

To understand the energy associated with removing all the electrons from a 0.5 m sphere of hydrogen, we have put our value in terms of some well known processes. Table 1 shows us that the value is on a stellar scale, equivalent to the energy output of the Sun for 21 minutes and many billions of times more energetic than all the detonated nuclear bombs to date.

The most interesting result from Table 2 is that the energy associated with an approximation of an ant is 1.5 times greater than the Tsar bomb. It allows us to appreciate how much potential energy is stored within the atoms of something so small.

It would be physically impossible to remove all the electrons instantaneously from an object and so this process could never occur, and removing the electrons over a time period would not yield the same result. This is because as you gradually remove electrons, the ions would simply repel each other and the space they occupy would increase, reducing the potential energy. The reason our scenario is so energetic is because it's instantaneous and so the charges are extremely concentrated, making the forces of repulsion extremely strong between the ions.

## Conclusion

We found the energy associated with stripping away all the electrons from a 70 kg, 0.5 m radius ball of hydrogen to be $4.8\times10^{29}$ J. The energy associated with the same process for a human would be even greater, as discussed in the theory. This is an extremely large energy, comparable to the power output of the Sun for 21 minutes. If the process was possible, it would be an extreme energy event for any creature with highly destructive ramifications.

## References


[1] `https://www.quora.com/What-would-happen-to-my-body-if-all-the-electrons-in-it-disappeared` [Accessed 06/09/2019]

[2] `https://en.wikipedia.org/wiki/Composition_of_the_human_body`[Accessed 06/09/2019]

[3] `https://www.atomicheritage.org/history/tsar-bomba`. [Accessed 06/09/2019]

[4] `https://newint.org/features/2008/06/01/nuclear-weapons-facts`. [Accessed 06/09/2019]

[5] `https://en.wikipedia.org/wiki/Electric_energy_consumption`. [Accessed 06/09/2019]

[6] `https://phys.org/news/2015-12-sun-energy.html`. [Accessed 6/09/2019]