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A4_2 Vaporising the Earth

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Abstract
In this paper we explore the energies needed to completely vaporise the Earth. Taking into account the relative abundances of elements in the Earth and their latent heats of fusion and vaporisation, it is found that 7.58×10^{31} J of energy (the equivalent of 9.25×10^{17} Kg of fissionable uranium)is needed to achieve this. It is found that this is not possible with modern day technologies, but may be possible in the future.

Introduction
Many science fiction stories have plots which involve decimation of a planet via vaporisation. An example of this is the very start of Douglas Adams' *The Hitchhiker's Guide to the Galaxy*, in which a race of aliens, known as the Vogons, vaporise the Earth [1]. In this paper we look at how much energy is needed in order to heat the Earth enough to cause it to vaporise, to see if it is at all possible, or will at all be possible for an alien race to vaporise the Earth.

Vaporising the Earth
Let's assume that the Earth is a perfect solid sphere consisting of, by mass, 50% nickel and 50% silicon, two of the most common elements found with in the Earth's crust, mantle and core respectively [2]. The calculations are to find how much energy is needed to vaporise both of these elements completely, ignoring effects of gravity and pressure gradients throughout the Earth's composition. We first needed the specific heat of the two elements. The following equation was used:

$$C = \frac{3R}{M}. \tag{1}$$

Where C is specific heat, R is the gas constant and M is the atomic weight in kg mol^{-1} [3]. The atomic weight of nickel is 59 (0.059 kg mol^{-1}) and silicon is 28 (0.028 kg mol^{-1}) giving specific heat values of 423 Jkg^{-1}K^{-1} and 890 Jkg^{-1}K^{-1} for Nickel and Silicon respectively [4]. This equation is a good approximation for both the solid and liquid phases of nickel and silicon. To find the energy needed to heat up Nickel and Silicon from a solid state to vaporisation, ignoring latent heat of fusion and vaporisation for now, we used the following equation:

$$\Delta H = C\Delta T. \tag{2}$$

Where ΔH is the change in energy needed to heat up 1kg of an element by a change in temperature ΔT, measured in kelvin (K). ΔT was assumed to be 3000 K (as this approximately covers both nickel and silicon melting and heating up enough to the point where they vaporise). C is the specific heat. With the addition of the latent heats of fusion and vaporisation, the total amount of energy taken to heat up a solid and for it to melt can be found. Multiplying this by the mass of each element gives the total energy to vaporise the Earth.

$$TE = \frac{M_E}{2}([L_{FN} + L_{VN} + \Delta H_N] + [L_{FS} + L_{VS} + \Delta H_S]) \tag{3}$$

Where TE is total energy, M_E is the mass of the Earth, ΔH_N and ΔH_S are the energies needed to heat 1 kg of nickel and silicon by 3000 K respectively and L_{FN}, L_{VN}, L_{FS} and L_{VS} are the latent heat energies (fusion and vaporisation) for both nickel and silicon respectively and measured in Jkg^{-1} [5].

Thus, the amount of energy required to vaporise the Earth was calculated to be 7.58×10^{31} J.

How Much Energy is That?
To put this into perspective, the amount of fissionable uranium required was calculated. The following

equation represents a typical nuclear fission reaction [6].

$$\mathrm{n} +^{235}_{92} \mathrm{U} \rightarrow^{144}_{56} \mathrm{Ba} +^{90}_{36} \mathrm{Kr} + 2\mathrm{n} + 200 \text{ MeV} \tag{4}$$

Where the left hand side of the equation represents the uranium-235 nuclei and a neutron and the right hand side represents the daughter nuclei produced along with 2 neutrons and some energy. Each reaction produces 200 MeV of energy (equivalent to 3.2 x 10^{-11} J). To find mass of uranium needed (in kg), the equation shown below was used:

$$\frac{7.58 \times 10^{31} \times 0.235}{3.2 \times 10^{-11} \times N_A} = 9.25 \times 10^{17} \text{ kg} \tag{5}$$

Where N_A is Avogadro's number (6.02×10^{23}) and 0.235 is the weight in kg per mol of uranium. Eqn(6) shows that 9.25×10^{17} kg of uranium would be needed to vaporise Earth. In 2013 approximately 7×10^7 kg of uranium was mined which is 10 orders of magnitudes lower than is required [7].

Conclusion

It was found that the amount of energy required to vaporise the Earth is approximately 7.58×10^{31} J. This was found to be equivalent to using 9.25×10^{17} kg of uranium in nuclear fission reactions. As this number is approximately 10 orders of magnitude greater than the uranium mined yearly, it is not likely that this could be achieved in the near future.

References

[1] Adams, Douglas. *The Hitchhiker's Guide to the Galaxy* DavCom.
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