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A1 6 How many bombs can the ocean hold?

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Abstract

Nuclear bombs, such as hydrogen bombs, are extremely dangerous and are a threat to humanity. We consider a situation where hydrogen bombs explode, and all the water in the ocean absorbs the energy. We calculate that at least 8.6×10^{11} hydrogen bombs would be needed to vaporise all of the water in the ocean at once.

Introduction

The hydrogen bomb is currently a powerful weapon that releases enormous amounts of energy and instantly destroys large areas. Since it is so dangerous, we want to find out the capability of all ocean water to absorb the energy released by hydrogen bombs. Hence, we want to determine how many hydrogen bombs released at once could vaporise all the water in the ocean.

Method

We assume that hydrogen bombs explode in the ocean, where the energy released by the bombs is fully absorbed by the water. The explosion happens as the bomb is dropped into the ocean. We also assume that all the bombs required to vaporise the ocean are detonated in an even distribution across the ocean. The total volume of liquid water in the ocean is 1.355×10^{18} m^3 [1]. As an approximation, we use the ocean temperature averaged across the latitudes from the ocean surface to the bottom of the ocean, which is 4 °C, as the initial ocean temperature before the explosion happens [2].

The energy required to vaporise all the water in the ocean E (J) is calculated by:

$$E = mc\Delta T + ml_v \tag{1}$$

Here, m (kg) is the total mass of water in the ocean, c (J kg^{-1} K^{-1}) is the specific heat capacity of water, ΔT (K) is the rise in temperature and l_v (J kg^{-1}) is the latent heat of vaporisation [3].

Since the volume of water in the ocean is a known value, we can express the mass m as $\rho_{water} \times V$, where ρ_{water} (kg m^{-3}) is the density of water and V (m^3) is the total volume of water in the ocean. Therefore, substituting the expression for mass m into Equation (1), we can write the equation for the energy required to vaporise all the water in the ocean as:

$$E = \rho_{water} V(c\Delta T + l_v) \tag{2}$$

The number of hydrogen bombs n required to vaporise all water in the ocean is calculated with the following equation,

$$n = \frac{E}{E_{bomb}} \tag{3}$$

where E_{bomb} is the energy released by a single hydrogen bomb. The energy released by a single

hydrogen bomb depends on its size; a typical 1 megaton hydrogen bomb releases 4.2×10^{15} J of energy [4].

Substituting Equation (2) into (3) gives an expression for the number of hydrogen bomb n as:

$$n = \frac{\rho_{water} V (c\Delta T + l_v)}{E_{bomb}} \tag{4}$$

Result

By substituting $\rho_{water} = 1000$ kg m^{-3}, $V = 1.355 \times 10^{18}$ m^3, $c = 4200$ J kg^{-1} K^{-1}, $\Delta T = 96$ K, $l_v = 2.26 \times 10^6$ J kg^{-1} [3] ,and $E_{bomb} = 4.2 \times 10^{15}$ J into Equation (4), we estimate that the total number of hydrogen bombs required to vaporise all of the water in the ocean is 8.6×10^{11}.

Discussion

To vaporise all of the liquid water on Earth, a total of 8.6×10^{11} hydrogen bombs is required, with each bomb having a mass of 1 megaton. This would kill all of the creatures in the ocean. However, in reality it might not be possible to release this number of hydrogen bombs at once to vaporise all of the water on Earth at the same time. Also, after all the water has vaporised, they would simply follow the water cycle. Eventually, the vapour would undergo condensation and fall back to Earth as precipitation.

Although it is possible that the Earth's shape would not deform, the Earth would have been polluted with radioactive substances and other toxic chemicals [5]. This, as well as water vapour being a greenhouse gas, changes the climate of Earth, leading to a chaotic environment for humanity to live in [6]. Plus, the atmosphere would be toxic to inhale and could be full of mist [6]. Most food would not be safe for humans to consume, and many people could starve to death [7].

Conclusion

To conclude, roughly 0.9 trillion hydrogen bombs would be required to boil all the water on Earth. This should never happen as it would be a disaster for the planet in several ways. Fortunately, building that many hydrogen bombs would not be feasible for humanity, as it would require significant resources and time. Plus, dropping all the bombs into the ocean at once would be difficult, so we should be safe.

References

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