

Thermo #1 – Cooking a roast

If you can cook a roast at 320 °F in one hour, does that mean you can cook the same roast at 80 °F in four hours?

Let's examine the misconceptions inherent in this question.

- 1) You can't compare Fahrenheit temperatures like that. If you want to compare the potential for energy transfer at two different temperatures, the readings must be in Kelvins. 320 °F is close to 433 K, while 80 °F is about 300 K. If this were the only consideration, you should be able to cook the roast at 80 °F in less than 1.5 hours. Does this sound reasonable – to cook a roast at 80 °F in less than 1.5 hours?
- 2) In order to cook something, you must break-down molecular bonds in the food. The amount of energy required to do this (the bond energy) has a lower limit. Below this limit, the bonds will remain unbroken, and no cooking will take place at all. No matter how long you expose a roast to 80 °F, you will not apply enough energy to break-down the molecular bonds to make it cook.

What does that have to do with our atmosphere?

Our atmosphere contains many different types of molecules, each with their own molecular break-down energy. As the EM radiation from the sun strikes the earth's upper atmosphere, some of this radiation is absorbed. Certain frequencies (wavelengths) never reach the surface. The energy which does reach the surface is re-radiated back up, but at slightly lower frequencies (longer wavelengths).

Accounting for all of the incoming and outgoing radiation is called the earth's energy balance. Under normal conditions, the amount of energy reaching the surface is equal to the amount that is radiated back into space – the earth is in balance. The effect of a specific compound on the energy balance can be measured as radiative forcing, either warming or cooling the planet. Changes in the composition of the atmosphere, whether natural or man-made, can alter the earth's energy balance.

If more radiation is absorbed or reflected back into space without reaching the ground, the earth would tend to cool off. Scientists have seen this happen when large volcanoes erupt and spew dust into the atmosphere. Man-made pollutants and the clearing of rain forests changes the earth's reflective characteristics (called albedo). These have a cooling effect.

Gases such as Methane (CH₄), Carbon Dioxide (CO₂), Nitrous Oxide (N₂O), and the Chlorofluorocarbons (CFCs), lumped together in a category called long-lived greenhouse gases (LLGHGs), have the opposite effect. These gases allow the sun's EM radiation to penetrate to the surface, but when the earth re-radiates them in longer wavelengths, these gases absorb the radiation, preventing it from returning to space (the greenhouse effect).