Name _____ Period _____

A Study in Latent Heat: How "Hungry" is a Hurricane?

Objective

To understand latent heat and its role as an energy source in the atmosphere.

Background

Latent heat is the energy created or used when a substance, such as water, changes phase. For example, in order to boil water (i.e. to make the water evaporate), one must add energy to it. We often add this energy with a stove. The opposite phase change, when water condenses from water vapor to liquid water, releases energy to the environment. We experience this in our daily lives, too. The bathroom heats up during a hot shower, partially due to the energy released from water condensing on the mirror and other surfaces.

In nature, one of the greatest latent heat "engines" is the hurricane. Hurricanes - powerful storms that form in the tropics during the summer - derive much of their energy from warm tropical water, which evaporates, rises, and condenses into cloud droplets and rain. This condensation releases large amounts of latent heat energy. How much? That's what you're about to figure out.

Directions

You are challenged to determine how much energy is added to a hurricane due to latent heat – the condensation of water vapor into clouds and rain. You are given a list of equations that you may recognize from your math and science classes. Using the directions below, choose the appropriate equation at each step to determine how "hungry" a hurricane is. *Pay careful attention to units, and be sure to record them at each step!*

Equations:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{Area} = \pi * R^2$$

$$\text{Energy} = \Delta H_v * \text{mass}$$

For water $\Delta H_v = 540$ cal/g

$$\text{Volume} = \text{Area} * \text{Depth}$$

Step 1: Estimate the area of the hurricane in square meters. Let's say that the hurricane is a perfect circle and that its radius is 665 km (the average radius of a hurricane).

Step 2: Estimate the volume of water evaporated. To do this, you will need to know the depth of the water that is evaporated. Assume that a layer of water 1.5 cm deep is

evaporated. This is equivalent to the average rainfall over an average hurricane's area in one day - an underestimate, because this doesn't include condensation into cloud droplets. (*Note: Be careful of your units!*)

Step 3: Convert this volume of water that you've just calculated to mass. Then, convert this mass from kg to g. *(Hint: The density of water is 1000 kg/m^3.)*

Step 4: Use the latent heat of vaporization and your result in step 3 to find the amount of latent heat energy released, in calories.

Step 5: So that this number makes more sense, convert this to food Calories, which we see everyday on food containers. (1000 calories = 1 Calorie). Then determine how many Big Macs this latent heat energy is equivalent to. You'll get an idea of just how "hungry" a hurricane is in one day! (1 Big Mac = 576 Calories).

Question: We all know that hurricanes don't really eat Big Macs, so how would you explain this result in terms of energy changes that take place during hurricanes?

Challenge Question: Where might all of this energy that is produced in a hurricane go?

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