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Degrees Of Undercooling In Snow Formation And Ice Particles

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ABSTRACT:- In the calculation for v, the velocity for small undercooling, from Hillig and Turnbull (1956) $0.01 < \Delta T < 10$ Kelvin, where ΔT is the degrees of undercooling and they say that $v = (D \Delta S \Delta T) / (l R T)$, that is, according to simple rate theory by Wilson (1900) and Frenkel (1932). To estimate ΔT, I reason you have to take the geometric mean, GM, of 0.01 and 10. That is $GM = (0.01 \times 10)^{1/2} = (0.1)^{1/2} = 0.316$. In my snow point paper, Jennings (2023), I had said $\Delta T < 0.5$ Kelvin, so that was correct in the first place. In Hillig (1958), p. 351, there is the comment that larger undercoolings are 0.5 Kelvin. In Jennings (2023) the author gets $T = D (7.15 \times 10^7) / (k a n_s \Delta T^{0.69})$ for T, the snow point for formation of ice from water. The expression for T, the snow point, comes from homogeneous nucleation theory as employed by Fletcher (1970). $\Delta T = To - T$, is the underooling for formation of ice in the cloud.
To is the melting temperature Kelvin of ice. The reason there is an undercooling is because it is applied as measured in a thermostat bath. It is an assumption that this applies to clouds, as said by Jennings (2023). The process of using the bath will be explained in this paper.

KEY WORDS:- undercooling "snow point" "homogeneous nucleation theory" "geometric mean"

I. INTRODUCTION

We now look at Hillig (1958) where a bath is used to produce frozen ice and measure the kinetics. The author here is interested in clouds where water droplets will become ice particles leading to snow.
The assumption is that the two are related. Since this is a theoretical paper, the experimantalist has to establish whether the assumption is correct.

II. RESULTS

Jennings (2023) derived an expression for T, the point at which snow forms. Briefly, that will be summarized. (2) is from Fletcher (1970), (6) is using equations from Fletcher (1970) and (7) comes from Hillig and Turnbull (1956). We use $\Delta T = 0.316$ Kelvin, so $1.13 - 0.004 \times 0.316 = 1.1287$ and $1.1287 / 0.158 = 7.14$.

$$<\Delta Sv> \approx (1.13 - 0.004 \Delta T) \times 10^7 \text{ erg/cc-deg} \quad (2)$$

$$T = (D \Delta S_V \Delta T) / (k v n_s a) \text{ Kelvin} \quad (6)$$

$$v = (0.158 \pm 0.009) \times \Delta T^{(1.69 \pm 0.03)} \text{ cm/sec} \quad (7)$$

Next, (2), (6) and (7) are combined to give (8). These equation numbers are from Jennings (2023) givng a revised formula to the ABSTRACT with the geometric mean for ΔT in (2).

$$T = D (7.14 \times 10^7) / (k n_s a \Delta T^{0.69}) \text{ Kelvin} \quad (8)$$

III. DISCUSSION

This whole mathematical process is a try at seeing if the undercooling in the bath corresponds to supercooling in a cloud that produces snow. To get the value for the pressure and temperature dependence of self-diffusion in water, consult Krynicki, et al (1978).

NOMENCLATURE

a atomic spacing of ice (cm)

D self-diffusion coefficient of water (m^2 /sec)

k Boltzmann constant (Joules/Kelvin)

l jump distance across the interface (cm)

n_s number density of ice (molecules/cc)

R universal gas constant (Joules/Kelvin-mole)

ΔS molar entropy of fusion (erg/Kelvin)

$<\Delta S_V>$ average entropy of fusion over the supercooling range (erg/Kelvin)

$\Delta T = To - T$ Kelvin

T temperature Kelvin of the bath or supercooling limit in the cloud

To melting temperature Kelvin of ice

v growth velocity of ice-water interface (cm/sec)

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God has all knowledge from eternity to eternity. One time, Nebuchadnezar, the head of gold, in the Book of Daniel, said, I, with my great strength, built Babylon the great! Then Nebuchadnezzar said he built it for his spendor and majesty. Immediately God put the King into madness for seven years and his nails grew like the claws of a bird. Then, when the seven years were over, his reason was restored and Nebuchadnezzar praised the King of heaven, knowing God is able to humble the proud. The United States has a Christian President, Donald Trump, and there is a new Pope Leo XIV, born in the United States, who are going to lead us into the Kingdom of God. (See Daniel 2:44)

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