```
$UnitSystem SI J Pa K mass deg

"Parameters"
T_0 = ConvertTemp(C, K, 25[C])          "Starting Temperature"
T_f = ConvertTemp(C, K, 2[C])           "Goal Temperature"
T_f_ice = ConvertTemp(C, K, 0[C])       "Ice's melting Temperature"
T_0_ice = ConvertTemp(C, K, -5[C])      "Ice's starting Temperature"
DELTAT = T_f - T_0                      "Delta T"
DELTAT_ice = T_f_ice - T_0_ice          "Ice's delta T"
h = Enthalpy_Fusion(Ice)                "Enthalpy of Fusion of Ice"
c_ice = SpecHeat(Ice, T = T_0_ice, P = 101325[Pa])        "Ice specific heat"
rho_ice = Density(Ice, P = 101325[Pa], T = T_f_ice)       "Ice density"
V[1] = 30[L]*Convert(L,m^3)             "Air volume"
V[2] = 7[L]*Convert(L,m^3)              "Water volume"
V[3] = 5[L]*Convert(L,m^3)              "Ethanol volume"
rho[1] = Density(Air, P = 101325[Pa], T = T_0)"Air Density"
rho[2] = Density(Water, P = 101325[Pa], T = T_0)          "Water Density"
rho[3] = Density(Ethanol, P = 101325[Pa], T = T_0)        "Ethanol Density"
m[1] = rho[1]*V[1]        "Air mass"
m[2] = rho[2]*V[2]        "Water mass"
m[3] = rho[3]*V[3]        "Ethanol mass"
c[1] = SpecHeat(Air, T = T_0)           "Air specific heat"
c[2] = SpecHeat(Water, P = 101325[Pa], T = T_0)           "Water specific heat"
c[3] = SpecHeat(Ethanol, P = 101325[Pa], T = T_0)         "Ethanol specific heat"

"Energy needed"
E[1] = m[1]*c[1]*DELTAT
E[2] = m[2]*c[2]*DELTAT
E[3] = m[3]*c[3]*DELTAT
E_net = E[1]+E[2]+E[3]

"Mass of ice needed"
eta = 0.75                "Underestimated Efficiency"
E_ice*eta = -E_net        "Conservation of Energy"
E_ice = m_ice*(h + c_ice*DELTAT_ice)    "Energy needed to change the state of ice, plus get it colder"

"Volume of ice for design"
n = 1.5                   "Volume FOS"
rho_ice = m_ice/V_i       "Density formula"
V_ice = n*V_i
```

Parameters

T_0 = **ConvertTemp** (C, K 25 [C]) Starting Temperature

T_f = **ConvertTemp** (C, K 2 [C]) Goal Temperature

$T_{f,ice}$ = **ConvertTemp** (C, K not defined [C]) Ice's melting Temperature

$T_{0,ice}$ = **ConvertTemp** (C, K −5 [C]) Ice's starting Temperature

$\Delta T = T_f - T_0$ Delta T

$\Delta T_{ice} = T_{f,ice} - T_{0,ice}$ Ice's delta T

h = **Enthalpy**$_{fusion}$ (Ice) Enthalpy of Fusion of Ice

$c_{ice} = \mathbf{Cp}(\text{Ice}, T = T_{0,ice}, P = 101325\ [Pa])$ Ice specific heat

$\rho_{ice} = \rho(\text{Ice}, P = 101325\ [Pa], T = T_{f,ice})$ Ice density

$V_1 = 30\ [L] \cdot \left| 0.001 \cdot \frac{m^3}{L} \right|$ Air volume

$V_2 = 7\ [L] \cdot \left| 0.001 \cdot \frac{m^3}{L} \right|$ Water volume

$V_3 = 5\ [L] \cdot \left| 0.001 \cdot \frac{m^3}{L} \right|$ Ethanol volume

$\rho_1 = \rho(\text{Air}, P = 101325\ [Pa], T = T_0)$ Air Density

$\rho_2 = \rho(\text{Water}, P = 101325\ [Pa], T = T_0)$ Water Density

$\rho_3 = \rho(\text{Ethanol}, P = 101325\ [Pa], T = T_0)$ Ethanol Density

$m_1 = \rho_1 \cdot V_1$ Air mass

$m_2 = \rho_2 \cdot V_2$ Water mass

$m_3 = \rho_3 \cdot V_3$ Ethanol mass

$c_1 = \mathbf{Cp}(\text{Air}, T = T_0)$ Air specific heat

$c_2 = \mathbf{Cp}(\text{Water}, P = 101325\ [Pa], T = T_0)$ Water specific heat

$c_3 = \mathbf{Cp}(\text{Ethanol}, P = 101325\ [Pa], T = T_0)$ Ethanol specific heat

Energy needed

$E_1 = m_1 \cdot c_1 \cdot \Delta T$

$E_2 = m_2 \cdot c_2 \cdot \Delta T$

$E_3 = m_3 \cdot c_3 \cdot \Delta T$

$E_{net} = E_1 + E_2 + E_3$

Mass of ice needed

$\eta = 0.75$ Underestimated Efficiency

$E_{ice} \cdot \eta = -E_{net}$ Conservation of Energy

$E_{ice} = m_{ice} \cdot (h + c_{ice} \cdot \Delta T_{ice})$ Energy needed to change the state of ice, plus get it colder

Volume of ice for design

$n = 1.5$ Volume FOS

$\rho_{ice} = \frac{m_{ice}}{V_i}$ Density formula

$V_{ice} = n \cdot V_i$

SOLUTION

Unit Settings: SI K Pa J mass deg

c_{ice} = 2069 [J/kg-K]
ΔT = -23 [K]
ΔT_{ice} = 5 [K]
η = 0.75 [-]
E_{ice} = 1.189E+06 [J]
E_{net} = -891835 [J]
h = 333606 [J/kg]
m_{ice} = 3.457 [kg]
n = 1.5
ρ_{ice} = 916.7
T_0 = 298.1 [K]
$T_{0,ice}$ = 268.1 [K]
T_f = 275.1 [K]
$T_{f,ice}$ = 273.1 [K]
V_i = 0.003771
V_{ice} = 0.005657 [m^3] {5.657 [L]}

3 potential unit problems were detected.

KEY VARIABLES

m_{ice} = 3.457 [kg] *Mass of ice needed*
V_{ice} = 0.005657 [m^3] {5.657 [L]} *Volume for ice needed*

Arrays Table: Main

	ρ_i [kg/m^3]	V_i [m^3]	m_i [kg]	c_i [J/kg-K]	E_i [J]
1	1.184	0.03	0.03552	1005	-820.7
2	997	0.007	6.979	4181	-671204
3	785.1	0.005	3.926	2434	-219810