Ex 1.

$$SW_{IN} = 600 \ W/m^2 \qquad\qquad W = 1 \ J/s$$

$$SW_{OUT} = SW_{IN} \cdot \alpha = 600 \times 0.2 = 120 \ W/m^2$$

$$LW_{IN} = 200 \ W/m^2$$

$$LW_{OUT} = \varepsilon \sigma T^4 = 366 \ W/m^2$$

$$T = 18°C = 273.15 + 18 \ k = 291.15 \ k$$

$$\sigma = 5.67 \times 10^{-8} \ W/m^2/k$$

$$\varepsilon = 0.9$$

$$R_n = SW_{IN} - SW_{OUT} + LW_{IN} - LW_{OUT}$$

$$= 600 - 120 + 200 - 366$$

$$= 314 \quad W/m^2 \qquad\qquad +ve \sim so \ warming!$$

Ex 2. $\qquad$ Conduction $\qquad j_c = -k \cdot \dfrac{dT}{dx} \qquad$ Fourier's law.

$$j_c = k \frac{(T_1 - T_2)}{L}$$

$$j_c = k \cdot \frac{(80-20)}{0.5} = 120 \ k$$

1) $k = 0.66 \ W/m/k \implies j_c = 79.2 \ W/m^2 \quad$ Water

2) $k = 2.2 \qquad\qquad \implies j_c = 264 \ W/m^2 \quad$ Ice

3) $k = 0.025 \ W/m/k \implies j_c = 3 \ W/m^2 \quad$ Air

Ex 3.
$$q = -k \cdot \frac{dh}{dx}$$
$$j_a = c_p \cdot \rho \cdot q \cdot (T_2 - T_1)$$

$h_1 = 20$

$h_2 = 15$

$T_1 = 20°C$

$T_2 = 19°C$

$k = 0.1 \ m/d$

$L = 100 \ m$

$c_p = 4180 \ J/kg/k$

$\rho = 1000 \ kg/m^3$

$$q = k \cdot \frac{(20-15)}{100} = 0.005 \ m/d$$

$$j_a = \cancel{\frac{W}{m^2}} = \frac{J}{\cancel{kg \cdot k}} \cdot \frac{\cancel{kg}}{m^3} \cdot \frac{\cancel{k}}{d} \cancel{k}$$

$$= J/m^2/d$$

$$= 4180 \times 1000 \times 0.005 \times 1$$

$$= 20\,900 \ J/m^2/d$$

$$= \frac{20900}{86400} \ J/m^2/s$$

$$j_a = 0.242 \ W/m^2$$

Ex 4.

$m = 1kg \qquad T = 5°C \qquad U = c_p \cdot m \cdot T$

$c_p = 4180 \ J/kg/k = 4180 \ J/kg/°C$

$$U = 4180 \times 1 \times 5 = 20900 \ J$$

$$\Delta U = c_p (\Delta m \, T) = 4180 \times 0.5 \times 5 = 10450 \ J$$

$$U_{FINAL} = 20900 + 10450 = 31350 \ J$$

$$T = \frac{U}{c_p \cdot m} = \frac{31350}{4180 \times 1.5} = \underline{\underline{5°C}}$$

$$\Delta U = 4180 \times 0.5 \times 20 = 41800 \text{ J}$$

$$U_{FINAL} = 31350 + 41800 = 73150 \text{ J}$$

$$m = 1.5 + 0.5 = 2 \text{ kg}$$

$$T = \frac{73150}{4180 \times 2} = \underline{\underline{8.75 \text{ °C}}}$$

Ex 5.

$m = 1 \text{ kg}$ $T = 5°C$ $U_{INI} = 4180 \times 1 \times 5$
$$= 20900 \text{ J}$$

$+ \; 0.5 \text{ kg}$ $0°C$ $U_{ADD} = 4180 \times 0.5 \times 0$
$$= \underline{0 \text{ J}}$$

$m = 1.5 \text{ kg}$ $U_{FINAL} = 20900 \text{ J}$

$$T = \frac{20900}{4180 \times 1.5} = \underline{\underline{3.3 \text{ °C}}}$$

Ex 6.   Isolated system $\rightarrow$ no heat or mass
exchge w/ surroundigs.

$T_1 = 0°C$ $T_2 = 0°C$

In equilibrium.   Nothing happens.
½ kg ice & ½ kg water
coexist.

Ex7. $m_I = 0.5$ kg $m_L = 0.5$ kg
        $T_I = -4°C$ $T_L = +1°C$

        $m_T = 1$ kg.

Assume liquid cools to 0°C. $\Delta U = c_p . \Delta(Tm)$
                                       $= 4180 \times 1 \times 0.5$
                                       $= 2090$ J

$\Delta T = \dfrac{\Delta U}{c_{p_i} m} = \dfrac{2090}{2100 \times 0.5} \cong 2°C$

$\underline{T_I = -2°C \qquad m_I = 0.5 kg \qquad T_L = 0°C \qquad m_L = 0.5}$

                                                $\Delta m = \dfrac{\Delta U}{\lambda} = \dfrac{2100}{334000}$

$\Delta U = \lambda . \Delta m$

$\Delta U = c_p . \Delta T . m = 2100 \times 2 \times 0.5 = 2100$ J

$\Delta m = 0.006 kg = 6$ g

Final state $\rightarrow$ $m_I = 0.506$ kg $T_I = 0°C$
                             $m_L = 0.494$ kg $T_L = 0°C$

Ex 8. $m_I = 10$ kg $T_I = -10°C$

                $m_L = 0.5$ kg $T_L = 0°C$

$\Delta U = \lambda \Delta m = 334000 \times 0.5$

                        $= 167000$ J ←

$\Delta U = C_p.m.T = 2100 \times 10 \times 10 = \underline{210000}$ J

$T = \dfrac{U}{C_p.m} = \dfrac{167000}{2100 \times 10} = 0.8$ °C

$m_L = 0$ $m_I = 10.5$ $T = -9.2°C$

Ex 9. $m_I = 0.5$ kg $T_I = -1°C$

                $m_L = 10$ kg $T_L = 20°C$

$U = 2100 \times 0.5 \times 1 = 1050$ J

$T = \dfrac{U}{C_p.m} = \dfrac{1050}{4180 \times 10} = 0.025°C$

$T_L = 19.975$ °C $T_I = 0°C$

$$U = \lambda m = 334000 \times 0.5 = 167000 \text{ J}$$

$$T_L = \frac{167000}{4180 \times 10} = 4 \text{ °C}$$

$$\boxed{T_L = 15.975 \text{ °C} \qquad m_L = 10.5 \text{ kg} \quad m_I = 0 \text{ kg}}$$