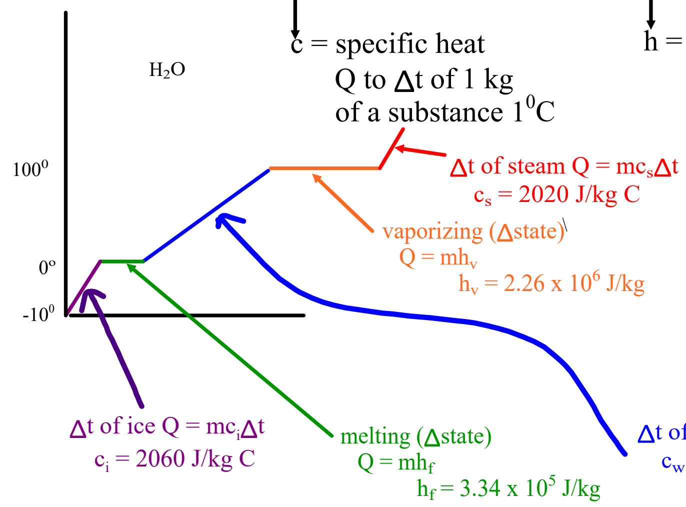
Q will either:

Δt or Δstate (phase)

Δt → Δ KE of particles → $Q = mc\Delta t$ → c = specific heat: Q to Δt of 1 kg of a substance 1^0C

Δstate → Break bonds ΔPE → $Q = mh$ → h = heat of fusion (s⟷l) / vaporization (l⟷g): Q to Δ state of 1kg of a substance



all Q's will be "+" when you gain TE

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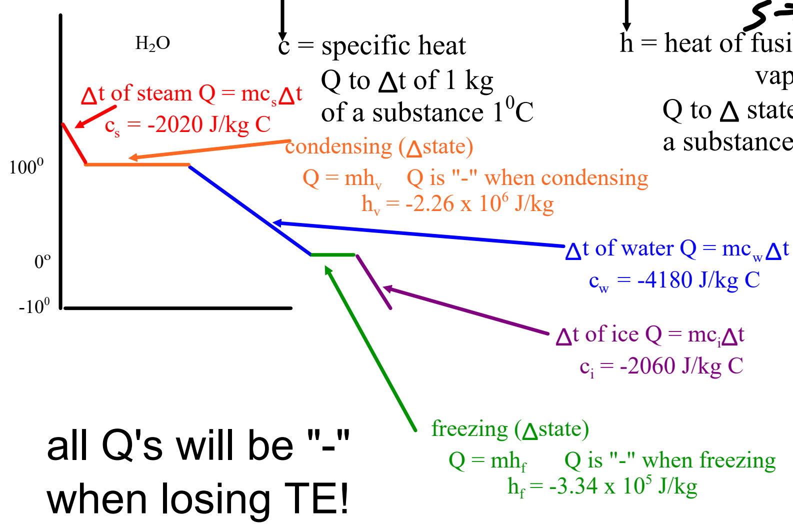
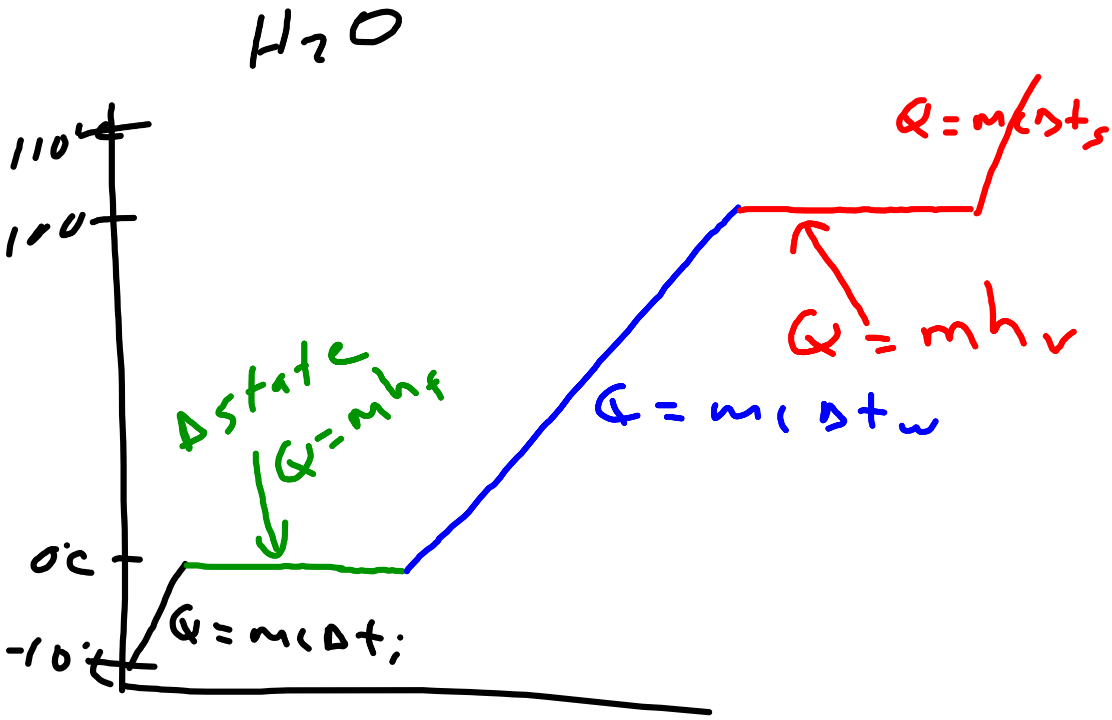


all Q's will be "-" when losing TE!



100.0 g of ice at -10.0° C is placed in 1.00 kg of water at 90.0° C. What is the final temperature of the mixture?

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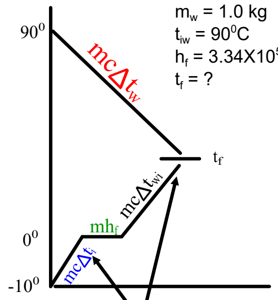
m_i = .10 kg
t_{ii} = -10°C
m_w = 1.0 kg
t_{iw} = 90°C
h_f = 3.34X10^5 J/kg
t_f = ?

$Q_L + Q_g = 0$

$mc\Delta t_w + mc\Delta t_i + mh_f + mc\Delta t_{wi}$



note how the t_f of the ice is different then the t_f of water that came from ice

[0° - (-10°C)]

t_f = 74.1° C

$Q_L = mc\Delta t_w$ = 1kg(4180J/kgC)(74.1° - 90°C) = -66,500J

$Q_g = mc\Delta t_i$ = .1kg(2060J/kgC)[0 - (-10°C)] = +2060J

$Q_g = mh_f$ = .10 kg (3.34X10^5 J/kg) = 33,400)

$Q_g = mc\Delta t_{wi}$ = .1kg(4180J/kgC)(74.1 - 0°C) = +31000J

Q_g = +66,500

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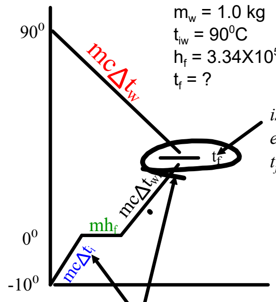

note how the t_f of the ice is different then the t_f of water that came from ice

$Q_L + Q_g = 0$

$mc\Delta t_w + mc\Delta t_i + mh_f + mc\Delta t_{wi} = 0$

move anything that doesn't end at "t_f"

$mc\Delta t_w + mc\Delta t_{wi} = -mc\Delta t_i - mh_f$

expand Δt

$mct_{fw} - mct_{iw} + mct_{fwi} - mct_{iwi} = -mc\Delta t_i - mh_f$

isolate for equilibriium t_f

$mct_{fw} + mct_{fwi} = -mc\Delta t_i - mh_f + mct_{iw} + mct_{iwi}$

$t_f(mc_w + mc_{wi}) = -mc\Delta t_i - mh_f + mct_{iw} + mct_{iwi}$

$$t_f = \frac{-mc\Delta t_i - mh_f + mct_{iw} + mct_{iwi}}{(mc_w + mc_{wi})}$$

+10 0

t_f = - .10 kg(2060 J/kgC)[0-(-10°C)] - .10 kg (3.34X10^5 J/kg) + 1 kg(4180 J/kgC)90.0°C) + .10 kg(4180 J/kgC)0°C / ((1 kg(4180 J/kgC) + .10 kg(4180 J/kgC))

[0° - (-10°C)] =+10C

t_f = 74.1° C

$Q_L = mc\Delta t_w$ = 1kg(4180J/kgC)(74.1° - 90°C) = -66,500J

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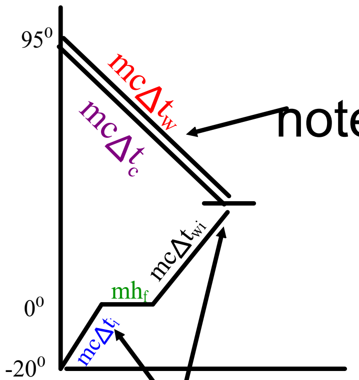
Q_g = +66,500

A 150.0 g block of ice at -20.0°C is placed in 880.0 g of water at 95.0°C.
What is the final temperature of the mixture.

A 150.0 g block of ice at -20.0°C is placed in 880.0 g of water at 95.0°C. What is the final temperature of the mixture. Oh no, the water is in a 225 g aluminum cup!

$Q_L + Q_g = 0$



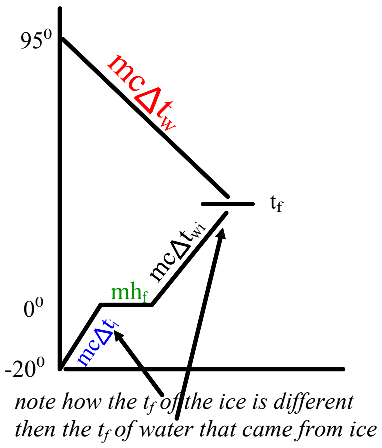
note what changes in our diagram!

two substances (water & cup) lose TE

note how the t_f of the ice is different then the t_f of water that came from ice

A 150.0 g block of ice at -20.0°C is placed in 880.0 g of water at 95.0°C.
What is the final temperature of the mixture.

$$Q_L + Q_g = 0$$



$$mc\Delta t_w + mc\Delta t_i + mh_f + mc\Delta t_{wi} = 0$$

$$mc\Delta t_w + mc\Delta t_{wi} = -mc\Delta t_i - mh_f$$

$$mct_{fw} - mct_{iw} + mct_{fwi} - mct_{iwi} = -mc\Delta t_i - mh_f$$

$$mct_{fw} + mct_{fwi} = -mc\Delta t_i - mh_f + mct_{iw} + mct_{iwi}$$

$$t_f(mc_w + mc_{wi}) = -mc\Delta t_i - mh_f + mct_{iw} + mct_{iwi}$$

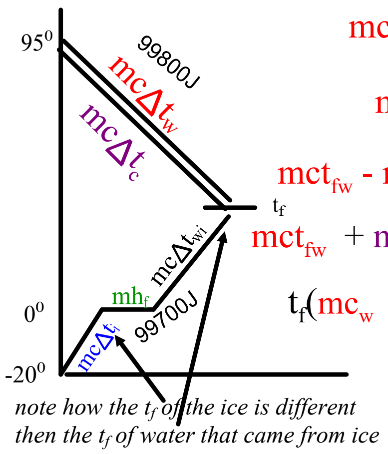
$$t_f = \frac{-mc\Delta t_i - mh_f + mct_{iw} + mct_{iwi}}{(mc_w + mc_{wi})}$$

$$t_f = \frac{-\,.15\text{ kg}(2060\text{ J/kgC})20^\circ\text{C} - .15\text{ kg}(3.34\times10^5\text{ J/kg}) + .88\text{ kg}(4180\text{ J/kgC})95^\circ\text{C}) + .15\text{ kg}(4180\text{ J/kgC})0^\circ\text{C}}{((.88\text{ kg}(4180\text{ J/kgC}) + .15\text{ kg}(4180\text{ J/kgC}))}$$

$$t_f = 68.1^\circ\text{ C}$$

A 150.0 g block of ice at -20.0°C is placed in 880.0 g of water at 95.0°C. What is the final temperature of the mixture. Oh no, the water is in a 225 g aluminum cup!

$$Q_L + Q_g = 0$$



$$mc\Delta t_w + mc\Delta t_c + mc\Delta t_i + mh_f + mc\Delta t_{wi} = 0$$

$$mc\Delta t_w + mc\Delta t_c + mc\Delta t_{wi} = -mc\Delta t_i - mh_f$$

$$mct_{fw} - mct_{iw} + mct_{fc} - mct_{ic} + mct_{fwi} - mct_{iwi} = -mc\Delta t_i - mh_f$$

$$mct_{fw} + mct_{fc} + mct_{fwi} = -mc\Delta t_i - mh_f + mct_{iw} + mct_{ic}\ mct_{iwi}$$

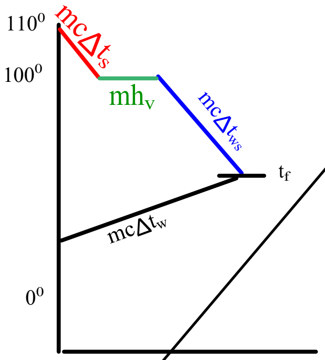
$$t_f(mc_w + mc_c + mc_{wi}) = -mc\Delta t_i - mh_f + mct_{iw} + mct_{ic} + mct_{iwi}$$

$$t_f = -mc\Delta t_i \frac{- mh_f + mct_{iw} + mct_{ic} + mct_{iwi}}{(mc_w + mc_c + mc_{wi})}$$

$$t_f = \frac{-\,.15\text{ kg}(2060\text{ J/kgC})20^\circ\text{C} - .15\text{ kg}(3.34\times10^5\text{ J/kg}) + .88\text{ kg}(4180\text{ J/kgC})95^\circ\text{C}) + .225\text{kg}(903\text{ J/kgC})95\text{C}\ .15\text{ kg}(4180\text{ J/kgC})0^\circ\text{C}}{((.88\text{ kg}(4180\text{ J/kgC}) + .225\text{ kg}(903\text{ J/kgC}) + .15\text{ kg}(4180\text{ J/kgC}))}$$

$$t_f = 69.3^\circ\text{ C}$$

What is the final temperature if you add 50.0 g of steam at 110 degrees C to 455 ml of water at 27.0 degrees C? (note that the heat of vaporization is negative- this is because the TE is lost! Any time heat is lost the "h" will be negative)



$$mc\Delta t_s + mh_v + mc\Delta t_{ws} + mc\Delta t_w = 0$$

$$mc\Delta t_{ws} + mc\Delta t_w = -mh_v - mc\Delta t_s$$

$$mc(t_f - t_i)_{ws} + mc(t_f - t_i)_w = -mh_v - mc\Delta t_s$$

$$mct_{fws} - mct_{iws} + mct_{fw} - mct_{iw} = -mh_v - mc\Delta t_s$$

$$mct_{fws} + mct_{fw} = -mh_v - mc\Delta t_s + mct_{iws} + mct_{iw}$$

$$t_f = \frac{-mh_v - mc\Delta t_s + mct_{iws} + mct_{iw}}{(mc_{ws} + mc_w)}$$

$$t_f = \frac{-.05\text{ kg}(-2.26\times10^6\text{ J/kg}) - .05\text{ kg}(2020\text{ J/kgC})\text{-}10^{o}\text{C} + .05\text{ kg}(4180\text{ J/kgC})100^{o}\text{C} + .455\text{ kg}(4180\text{ J/kgC})27^{o}\text{C}}{((.05\text{ kg}(4180\text{ J/kgC}) + .455\text{ kg}(4180\text{ J/kgC}))}$$

$t_f = 88^0$ C

T E needed to change 1 kg water from 0°C → 100°C

$$Q = mc\Delta t$$

$$Q = mc(t_f - t_i)$$

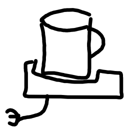
$$Q = 1\,kg\,(4180\,J/kg\,°C)(100°C - 0°C)$$

$$Q = 1\,kg\,(4180\,J/kg\,°C)\,100°C$$

$$Q = 418{,}000\,J$$

$$P = \frac{Q}{t} \qquad t = \frac{Q}{P} = \frac{mc\Delta t_c}{P}$$

$t_i = 19°C$



$t_f = 40°C$

$P = 25\,W$

$t = ?$

$c_c = 3870\,J/kg\,°C$

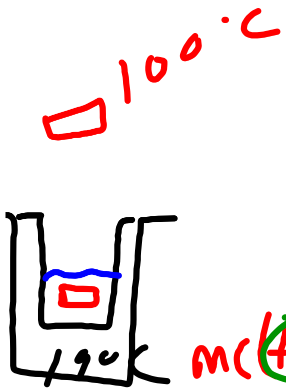
m = 175 mL → 175 g

1 g = 1 cm³ = 1 mL

$$t = \frac{.175\,kg\,(3870\,J/kg\,°C)\,21}{25\,W}$$

$$t = 569\,s$$

→ 9.48 min



$$Q_L + Q_g = 0$$

$$mc\Delta t_m + mc\Delta t_w + mc\Delta t_c = 0$$

$$mc(t_f - t_i)_m + mc(t_f - t_i)_w + mc(t_f - t_i)_c$$

t_i: 100 (m), 9 (w), 9 (c)