Phase diagram

Note:

1) In the same phase, heat will increase the temperature. There is a temperature change. No phase change

2) Specific heat (c) for solid is different than the specific heat of liquid and different from the specific heat or gas.

3) Is there a phase change? If the answer is “No”, then use the formula:

Heat = q = m c ΔT = m c (T final - T initial).

4) Is there a phase change? If the answer is “Yes”. then use the formula:

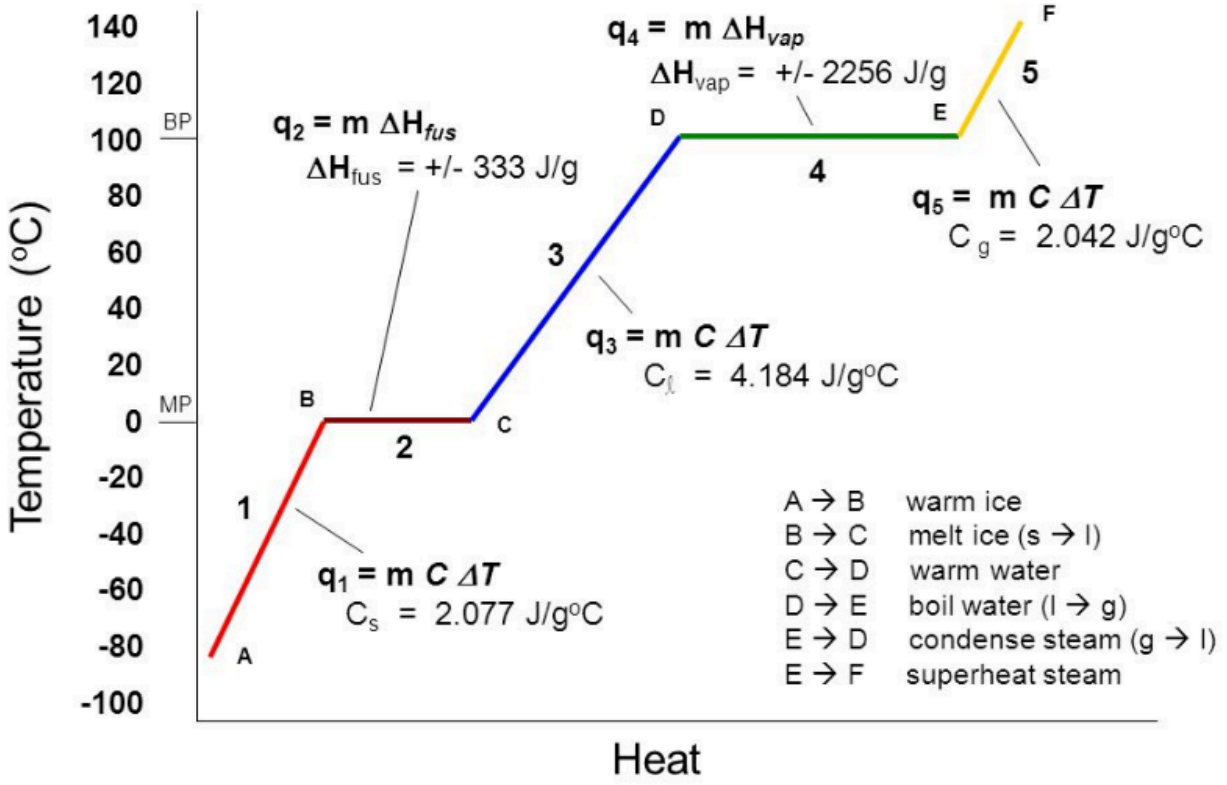
From solid to liquid: q = hf x m. (hf: heat of fusion)

From liquid to gas: q = hv x m (hv: heat of vaporization)

During phase change. The temperature stays the same.

Heating Curve for Water

(Phase Diagram)



Case Study

Use the heating curve and calculate the total amount of energy to raise the temperature of 200 g of of ice (-10 ^{o}C) water to vapor at 110 ^{0}C).

The specific heat of water in the three states:
Solid: C_s = 2.05 J/g.k
Liquid: C_l = 4.178 J/g.k
Vapor: C_g = 1.89 J/g.k

The heat of fusion of water from solid to liquid is: ΔH_{fusion} = 333.55 J/g
The heat of vaporization from liquid to vapor is : $\Delta H_{vaporization}$ = 2257 J/g

1) A-B: Ice water from -10 ^{0}C to 0 ^{0}C:

There is no phase change. There a temperature change in the same solid phase. Water is ice solid, so the specific heat is 2.05 J/g.k

$q_1 = m\ C_s\ \Delta T = m\ C_s$ (T final - T initial) = 2.05 x 200 x 10 = 4100 Joules

2) B-C: 0 ^{0}C ice to 0 ^{0}C water.

There is a phase change and the temperature is constant (heat of fusion of water ΔH_{fusion} = 333.55 J/g)

$q_2 = m \times \Delta H_{fusion} = 333.55 \times 200 = 67110$ Joules

3) C-D: 0 ^{0}C water to 100 ^{0}C liquid water .

There is no phase change. There is a temperature change in the same liquid phase. The specific heat for liquid water: C_l = 4.178 J/g.k

$q_3 = m\ C_l\ \Delta T = m\ C_l\ (T_{final} - T_{initial}) = 4.178 \times 200 \times 100 = 83560$ Joules

4) D-E: 100 ^{0}C liquid to 100 ^{0}C vapor

There is a phase change and the temperature is constant (heat of vaporization of water $\Delta H_{vaporization}$ = 2257 J/g)

$q_4 = m \times \Delta H_{vaporization} = 2257 \times 200 = 451400$ Joules.

5) E-F) 100 ^{0}C vapor at 110 ^{0}C vapor:

There is no phase change. There a temperature change in the same gaseous phase. The specific heat for water in the vapor or gaseous form is C_g = 1.89 J/g.K

$q_5 = m\ C_g\ \Delta T = m\ C_g\ (T_{final} - T_{initial}) = 200 \times 1.89 \times 10 = 3780$ Joules