Lecture 9
April 20, 2012

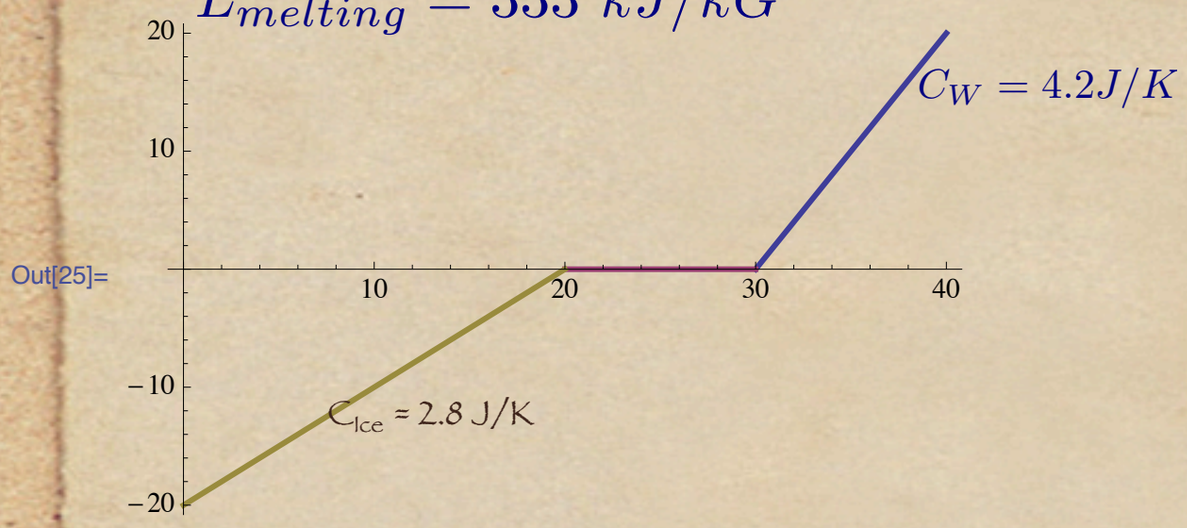
Latent heat is associated with melting and also with vaporizing
(boiling)
also sublimation

$$\Delta Q = M\ L$$

Defines a new and important number:
The latent heat L

Melting of ice: endothermic
(needs heat)

$L_{melting} = 333\ kJ/kG$



L is the heat necessary to change the phase per unit mass
at the
phase transition temperature

Boiling of water into Steam!
also endothermic

$L_{vapourizing} = 2.25\ MJ/kG$

Mixing problems:

Energy is conserved

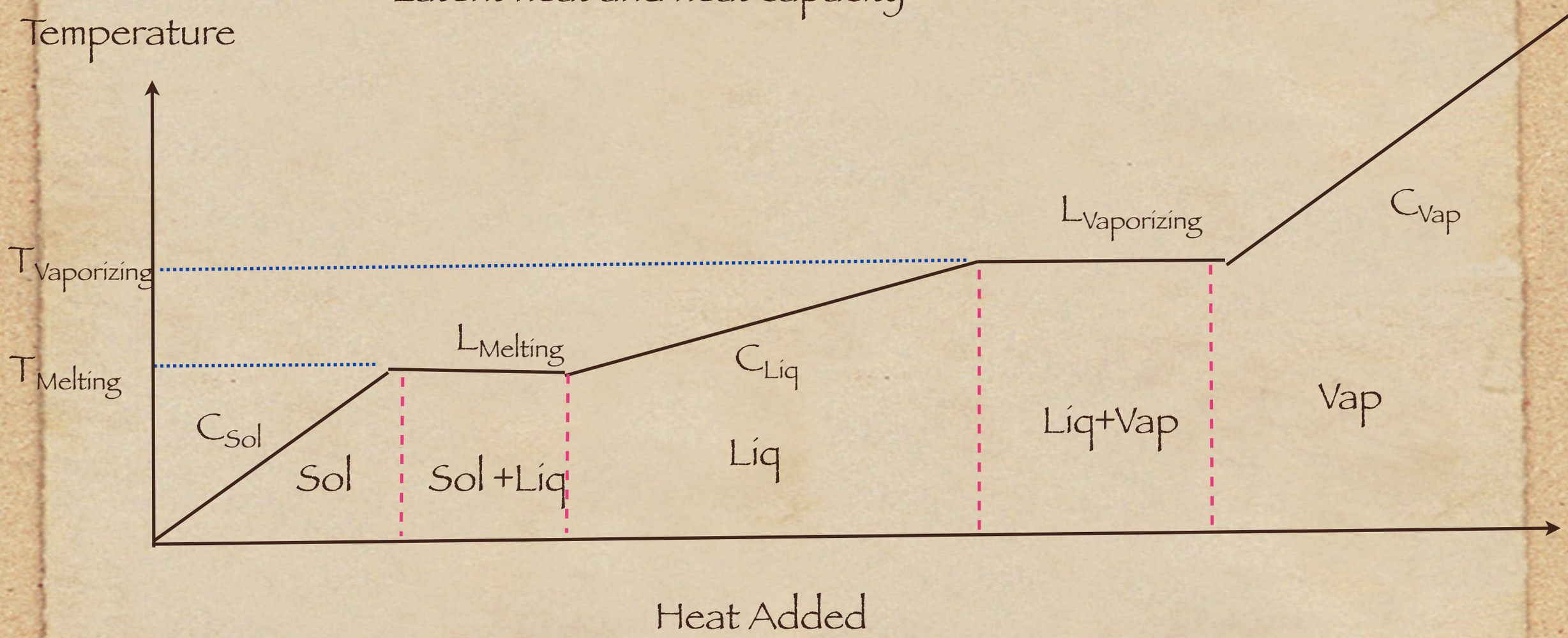
Phase changes (transitions)

Latent heat and heat capacity

$$\Delta Q = c\ M\Delta T \quad (SpecificHeat)$$

$$\Delta Q = M\ L \quad (LatentHeat)$$

Heat change = Heat due to change of temperature
+ Heat due to phase change



Examples $\Delta Q = M\ L$

$L_{melting} = 333\ kJ/kG$

a) 5 kG water freezes: how much heat does it generate in the process? and what is the temperature after freezing?

Using given formula: ΔQ = 5 kG x 333 kJ/kG = 1665 kJ = 1.665 MJ

b) 10 kG ice melts: How much heat does it absorb from the environment?

Answer= 3.333 MJ

c) 10 kG water boils: how much heat does it require?

$L_{vapourizing} = 2.25\ MJ/kG$

Answer= 22.5 MJ (Note the much bigger scale)

Summarizing the difference between
Specific heat versus Latent Heat

$\Delta Q = M\, c\, \Delta T$

(State is fixed but T changes)

$\Delta Q = M\, L$

(T is fixed but state changes)

Example combing the two

Find the heat needed to heat 10 kG water at 90°C to steam at 110°C

A) There is heating of water from 90 to 100 C,
B) change of state to steam at 100 C
C) heating of steam from 100 C to 110 C

Data given: Latent heat for boiling 2.25 MJ/kG
Specific heat of water 4.2 kJ/kG
Specific heat of steam 1.996 kJ/kG
Specific heat of ice 2.18 kJ/kG

$\Delta Q = Qa + Qb + Qc$

Qa= 420 kJ, Qb= 22.5 MJ, Qc= 199.6 kJ

Nice demonstration of ice water equilibrium and effect of salt at the URL:

http://antoine.frostburg.edu/chem/senese/101/solutions/faq/why-salt-melts-ice.shtml

A) An unknown amount of water at 20 C is mixed with 6 ice cubes at 0C, each with weight 30 grams. The mixture becomes cold water at 5 C. what is the weight of the total mixture?

B) A shot of lead of unknown mass is dropped into 1 litre of water at 30 C and is just hot enough to convert the water to steam at 120 C in equilibrium with the shot. Calculate the mass of the shot.
Specific heat of lead = .13 kJ/kG

Process:

1) Locate the appropriate formulas- make sure you have all the needed ones.

2) Identify the object required for answering the question and give it a symbolic name - e.g. "x" kGs in the above problems.

3) Using "x" in the formulas, set up an equation where the unknown is on the LHS and the rest on RHS. Here you have to use (1)

4) Solve for x!! :-)

Q-1 One kg of ice is melted by absorbing heat from 20 kg of water in a chamber surrounding the ice, initially at 50^0C. What is the final temperature of the water in the chamber, assuming that the melted ice runs off at 0^0C (i.e. does not absorb further heat)

Solution:

- L=333 kJ/kg

Hence1 kg ice releases 333 MJ

- Use $\Delta Q = Mc\,\Delta T$ to calculate heating of water
- M = 20 kg, c = 4.2×10^3 J/(kg ^{0}C)
- $\Delta T = 333\ 10^3 \text{J} \times \text{kg}\ ^0\text{C} / (20\ \text{kg} \times 4.2 \times 10^3 \text{J}) = 3.96\ ^0\text{C}$
- $T_{final} = 46^0$C

Q- 2 What happens with 1 kg water rather than 20 kg?

- $\Delta T = 3.96 \times 20 = 79.2\ ^0$C
- We are in trouble since 79.2+50= 129.2 0 C, i.e. higher than
- boiling point
- Some water would evaporate.
- How much water evaporates? HW