Phase Change Problems

Phase Change Energy

- These values are constant for a certain amount of a substance.
- The energy required to go from solid to liquid is called the heat of fusion (H_{fus}).
- The energy required to go from liquid to gas is called heat of vaporization (H_{vap}).
- q = H n

Phase change names

- solid to liquid- melting
- liquid to gas- vaporization (boiling)
- gas to liquid- condensation
- liquid to solid- freezing
- solid to gas- sublimation
- gas to solid- deposition
- *evaporation is also liquid to gas but is a different process

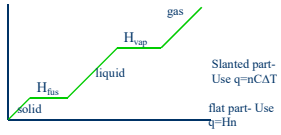
One way or the other

- Remember melting/freezing point and boiling/ condensation point are the same thing.
- The name only implies which way you are going.
- The energy required to melt an object is the same as the energy removed when it freezes.
- The same goes for boiling and condensing.

New Equation

- q = nCΔT is used for problems with a change in temperature
- q = Hn is used for phase changes
- Some problems require both

Temperature vs. Energy Graph



Heat of fusion and vaporization

	melting point	Heat of fusion	Boiling point	Heat of vaporization
Water	273 K	6010 J/mol	373 K	40700 J/mol
Nitrogen	63 K	719 J/mol	77 K	5590 J/mol
Lead	601 K	4770 J/mol	2023 K	177800 J/mol

Problem

- How much energy is required to convert 2.45 moles of solid lead at 601 K to a liquid?
- q = H_{fus} n

Problem

- How much energy is required to convert 2.45 moles of solid lead at 601 K to a liquid?
- q = H_{fus} n
- q = 4770 J/mol (2.45 mol)
- q = 11,700 J or 11.7 kJ

A slightly tougher phase change problem

- How much energy is required to convert 3.4 moles of water at 25° C to 100° C steam?

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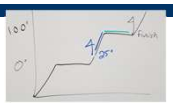

- q = n C ΔT + q = H_{vap} n
- q = 3.4 (75.3) 75 + 40700(3.4)
- 19201 J + 138380 J
- 160,000 J or 160 kJ

Another

- How much energy needs to be removed from 1.25 mol of nitrogen at 21° C to make liquid nitrogen at 77 K?

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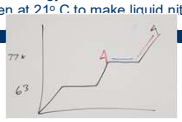

- cool to condensation point (77K- 294K), cool to condense
- q = 1.25(29.1)(-217) – 1.25(5590)
- q = -7890 J – 6990 J
- q = -14880 J

Problem

How much energy needs to be added to 4.7 mol of liquid nitrogen at 77 K to heat it to 291 K?

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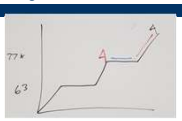

q = 4.7(5590) + 4.7 (29.1)(214)

=55541.78 J

q = 56 kJ

Again

- How much heat needs to be added to 97.2 mol of 273 K ice to make it to 373 K steam?

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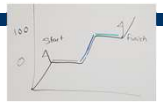

- q = 6010J/mol (97.2mol) + 97.2mol(75.3J/molK)100K+ 97.2mol(40700 J/mol K)
- =5272128 J
- q = 5.27 MJ (5270 kJ or 5 270 000 J)

Another

- How much energy needs to be added to 2.7 mol of solid lead at 210 K to heat it to 650 K?

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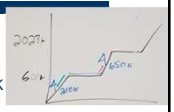

- H_{fus} lead – 4770 J/mol
- C_{lead} (solid) = 26.7 J/molK
- C_{lead} (liquid) = 27.4 J/molK

q = 2.7 mol (26.7) 391K+ 2.7 mol (4770) + 2.7 mol (27.4)(49 K)
=44691.21 J

- q = 45 kJ

Last one

- How much heat is required to heat 3.65 mol of ice at –15° C to steam at 120° C?

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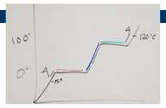

- (heat to melting-15 to 0) (heat to melt) (heat to boiling 0 to 100) (heat to boil off) (heat to 100 to 120)
- q = 3.65 (38.09) 15 + 3.65(6010) +3.65(75.3)100 + 3.65(40700) + 3.65(36.8)20
- q = 203 kJ