N38 - Odds and Ends

- Molar heat capacities to calculate changes in heat energy with moles instead of grams.
- Heat change during a chemical reaction
- Label reaction diagrams.
- Interpret phase diagrams.
- Calorimetry for solid and liquid mixtures.

Molar Heat Capacity

Energy required to raise the temperature of one **MOLE** of a substance one degree

$$Q = nC\Delta T$$

**If you make sure your units cancel, this is easy!!*

Molar Heat Capacity

A sample of barium chloride is increased in temperature by 3.8 °C when the sample absorbed 2.4×10^2 J of heat energy. Calculate the number of moles of barium chloride if its molar heat capacity is 75.1 J/K•mol.

$Q = nC\Delta T$

$$2.4 \times 10^2 \text{ J} = n\left(75.1 \frac{J}{K \bullet mol}\right)(3.8 \text{ K})$$

$$n = 0.84 \text{ mol}$$

Do we care that it is in moles and Kelvins? No! Does that change the concept of "plug and chug" and "cancel units" ? No!

Heat of Reactions

Amount of energy involved in a reaction

$$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3 \qquad \Delta H_{rxn} = -851.5kJ$$

(Remember, ΔH is basically Q)

ΔH negative → exothermic → product

ΔH positive → endothermic → reactant

Heat of Reactions per mole

Sometimes you want it per mole of a certain substance. Just take mole ratios into account!

$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3 \qquad \Delta H_{rxn} = -851.5 kJ$

$$\frac{-851.5 kJ}{1 \text{ rxn}} \left| \frac{1 \text{ rxn}}{2 \text{ mol Al}} \right. = -425.75 \frac{kJ}{\text{mol Al}}$$

Example Question

Calculate the energy released when 135g of aluminum are reacted in the below equation.

$$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3 \qquad \Delta H_{rxn} = -851.5kJ$$

$$\frac{135\text{ g Al}}{}$$

Example Question

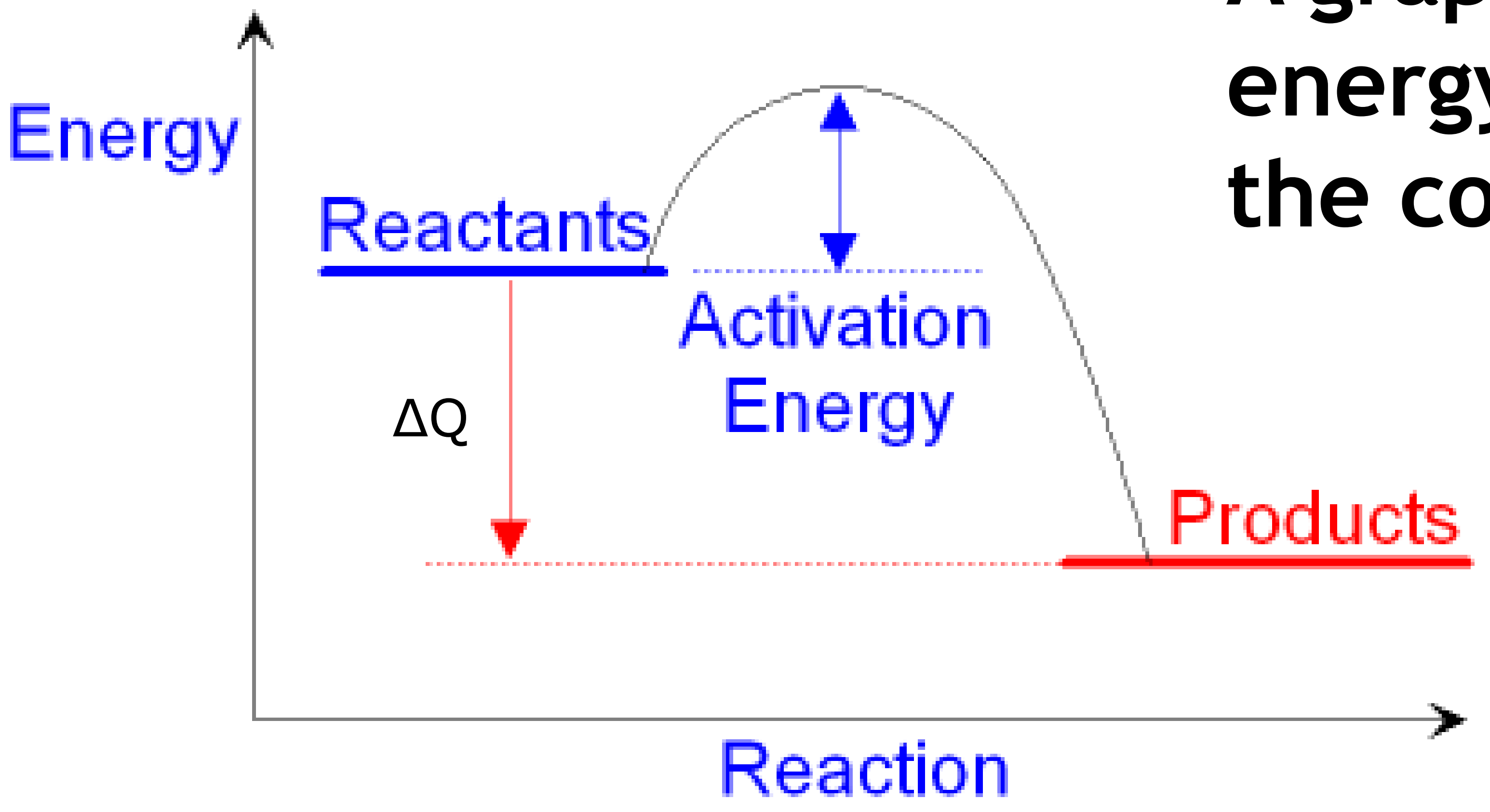
Calculate the energy released when 135g of aluminum are reacted in the below equation.

$$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3 \qquad \Delta H_{rxn} = -851.5 kJ$$

135 g Al	1 mol Al	1 rxn	-851.5 kJ
	26.98g Al	2 mol Al	1 rxn

= -2130.3 kJ

Reaction Diagrams

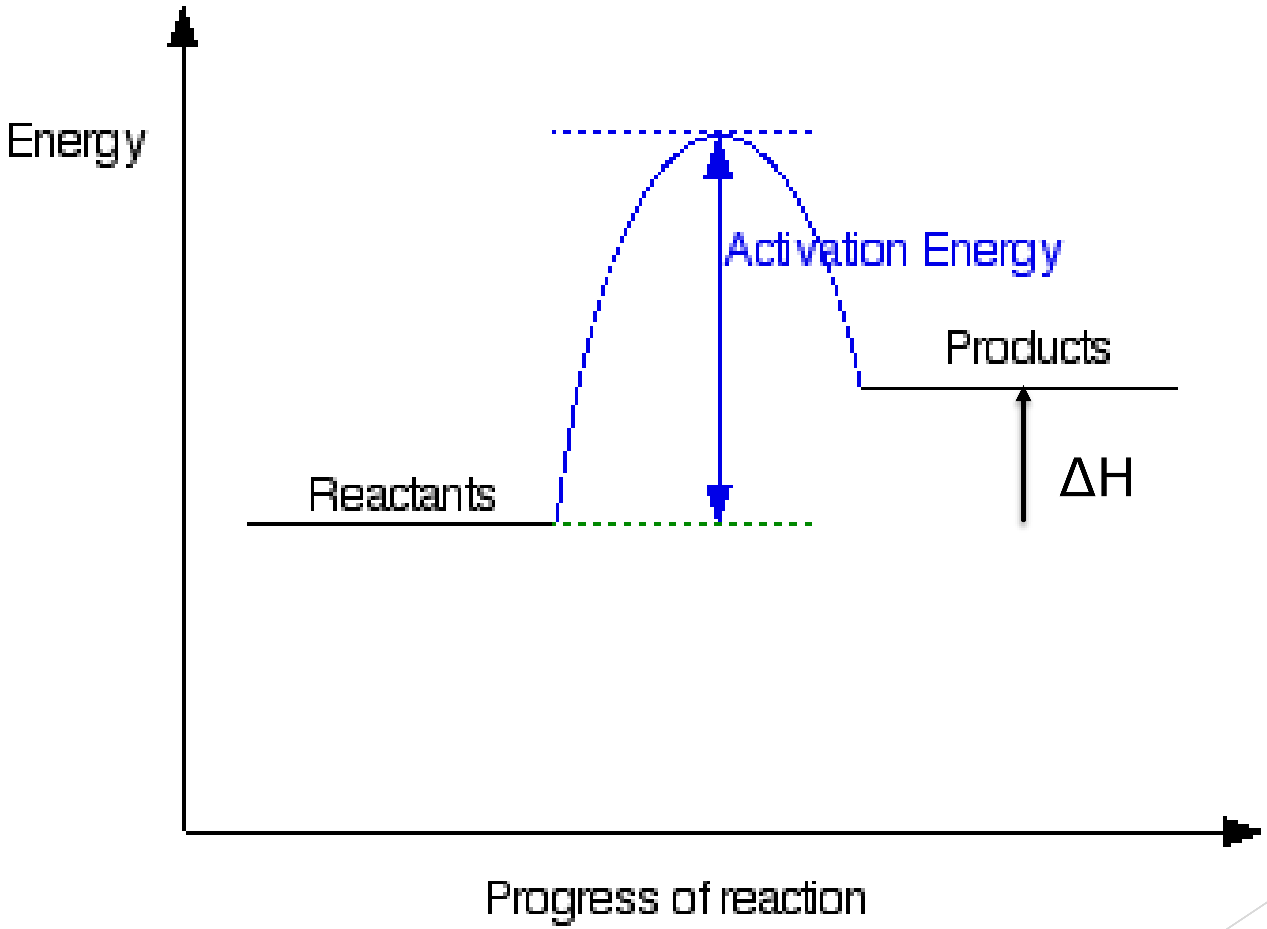


A graph representing energy changes during the course of a reaction

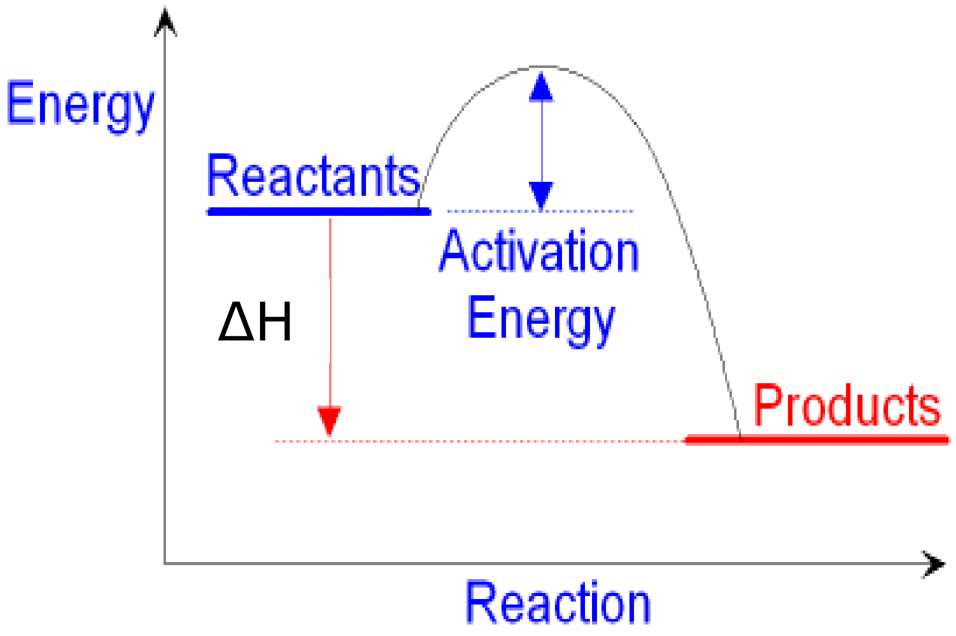
*Is this reaction endo or exothermic? How do you know???

Reaction Diagrams

Draw and label an ENDOTHERMIC reaction diagram.



But what is "Activation Energy?"



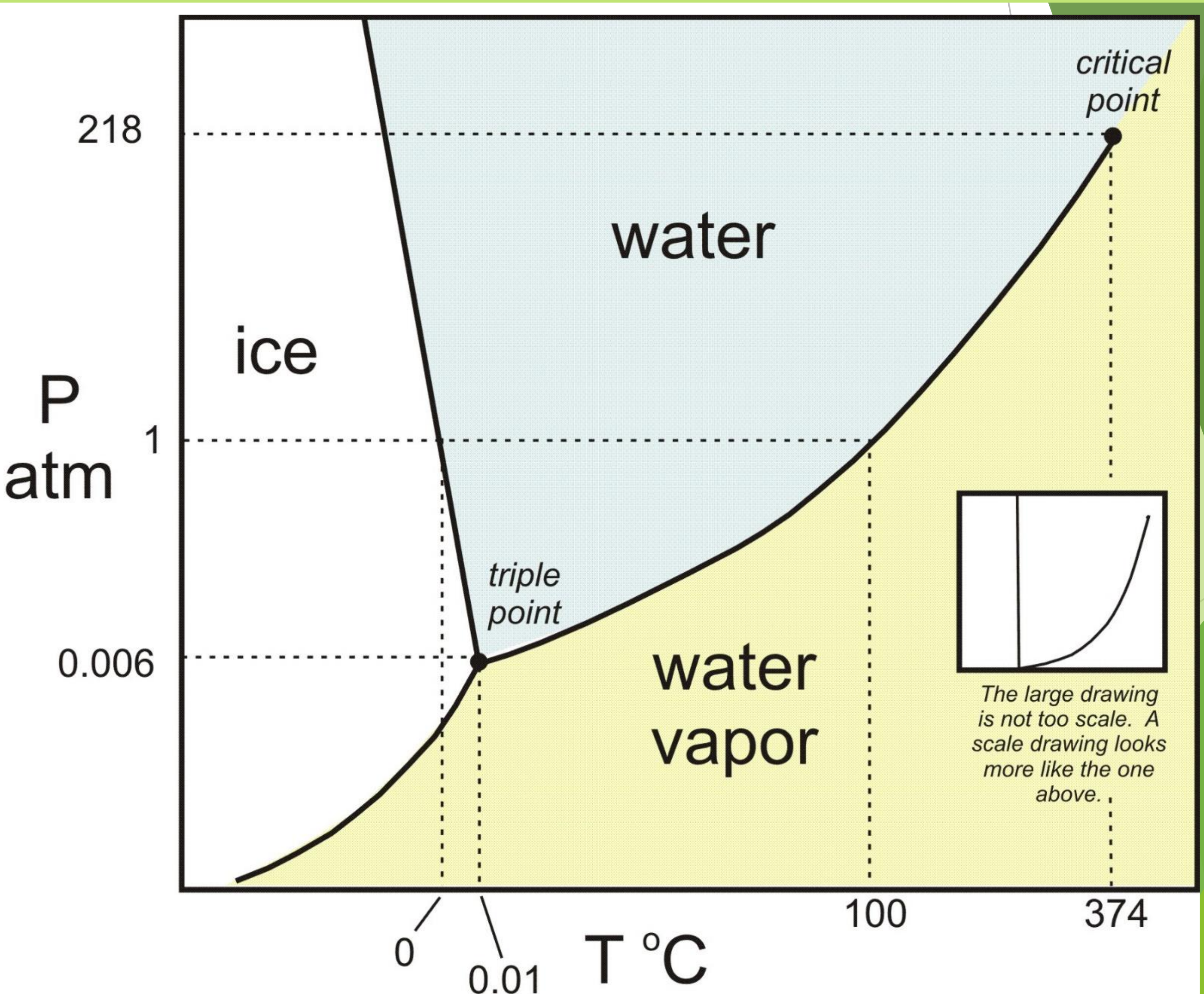
<u>Activation energy:</u>

the smallest amount of energy required for molecules to be "activated" in order to undergo a specific chemical change

- ***Speed them up to hit hard enough***
- ***Proper orientation to collide in the right spot***

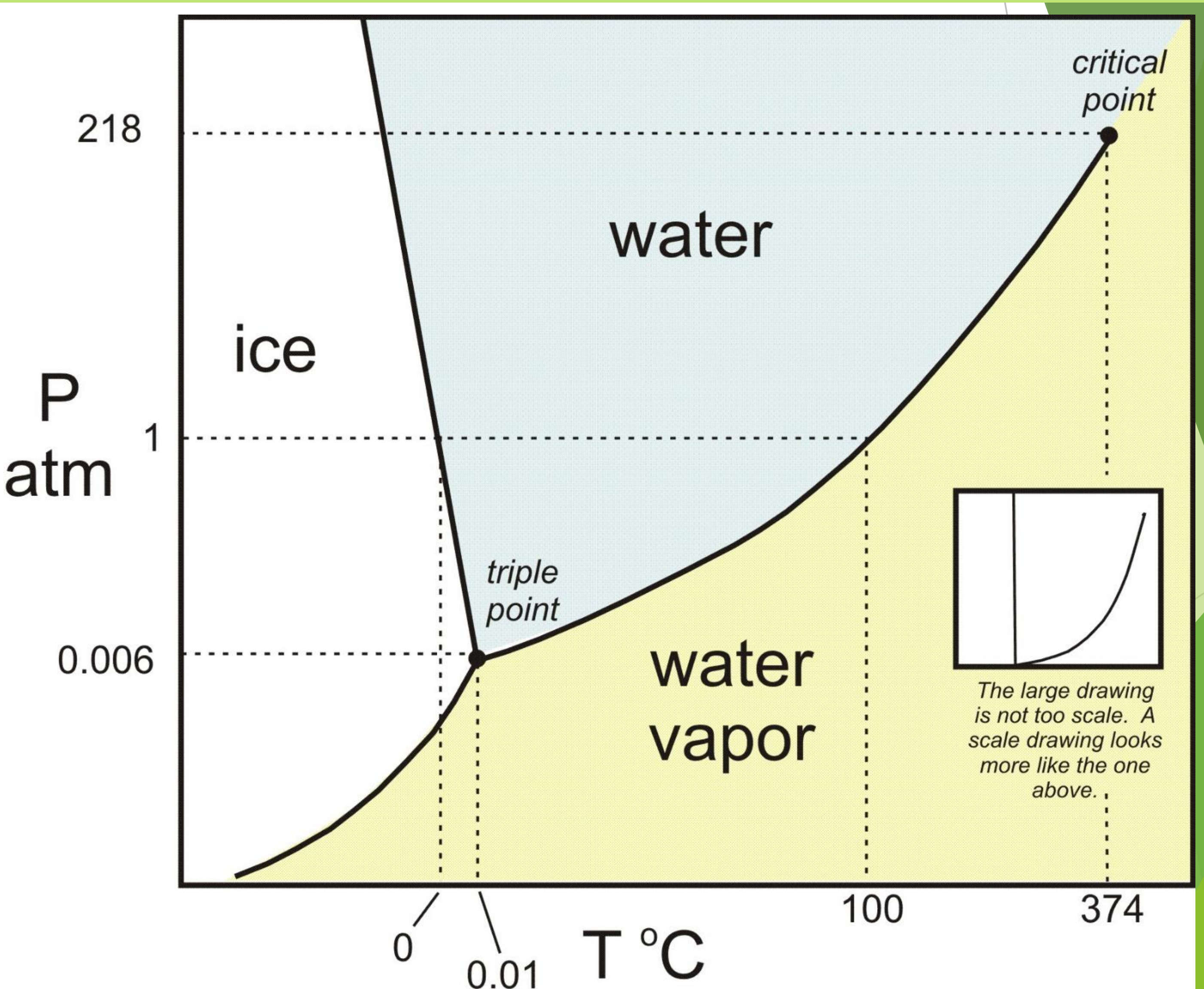
Phase Diagrams

A graph representing the phases of a substance at a given temperature and pressure



Phase Diagrams

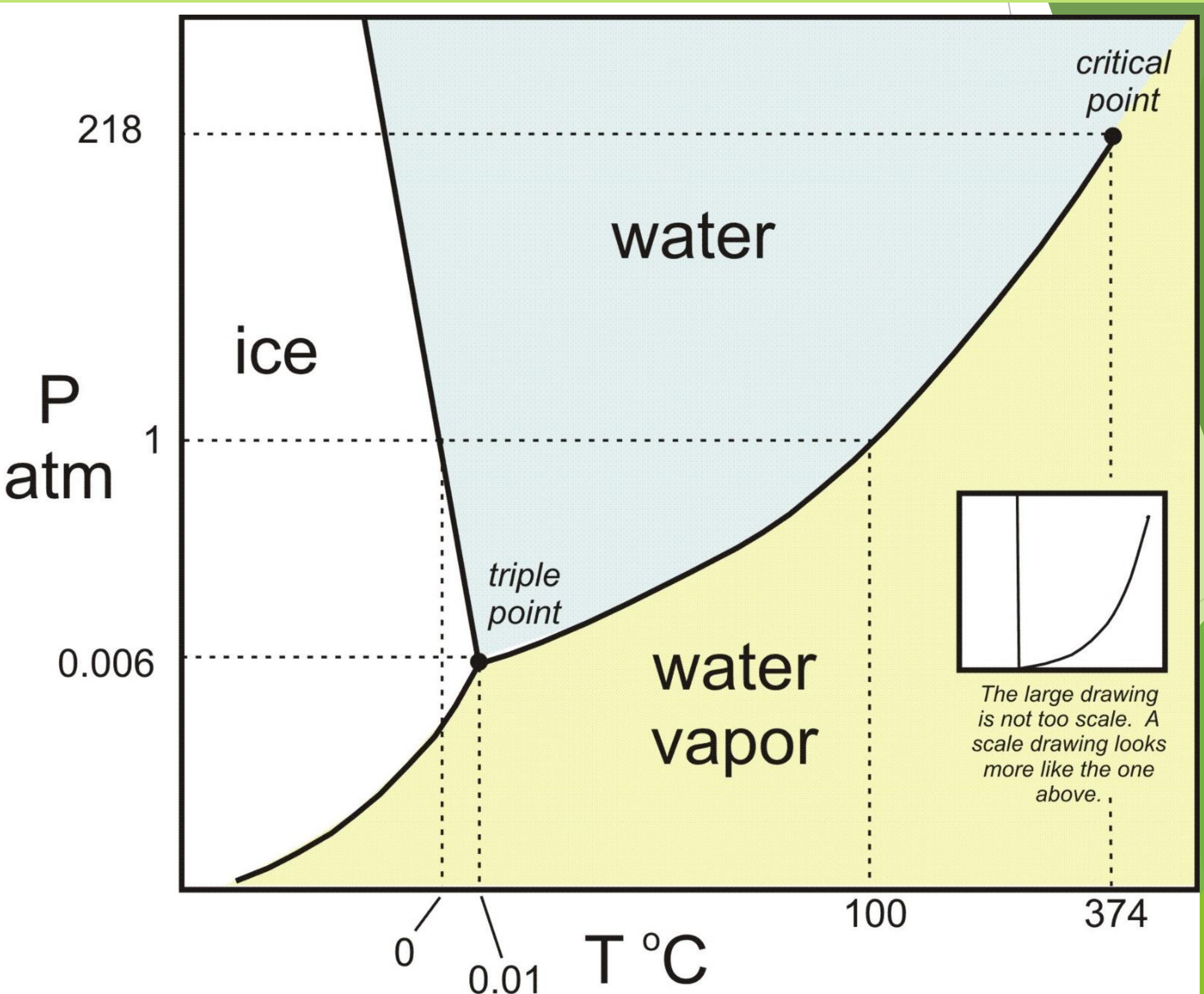
<u>Triple point-</u>
The point (temp and pressure) where solid, liquid and gas can coexist simultaneously.



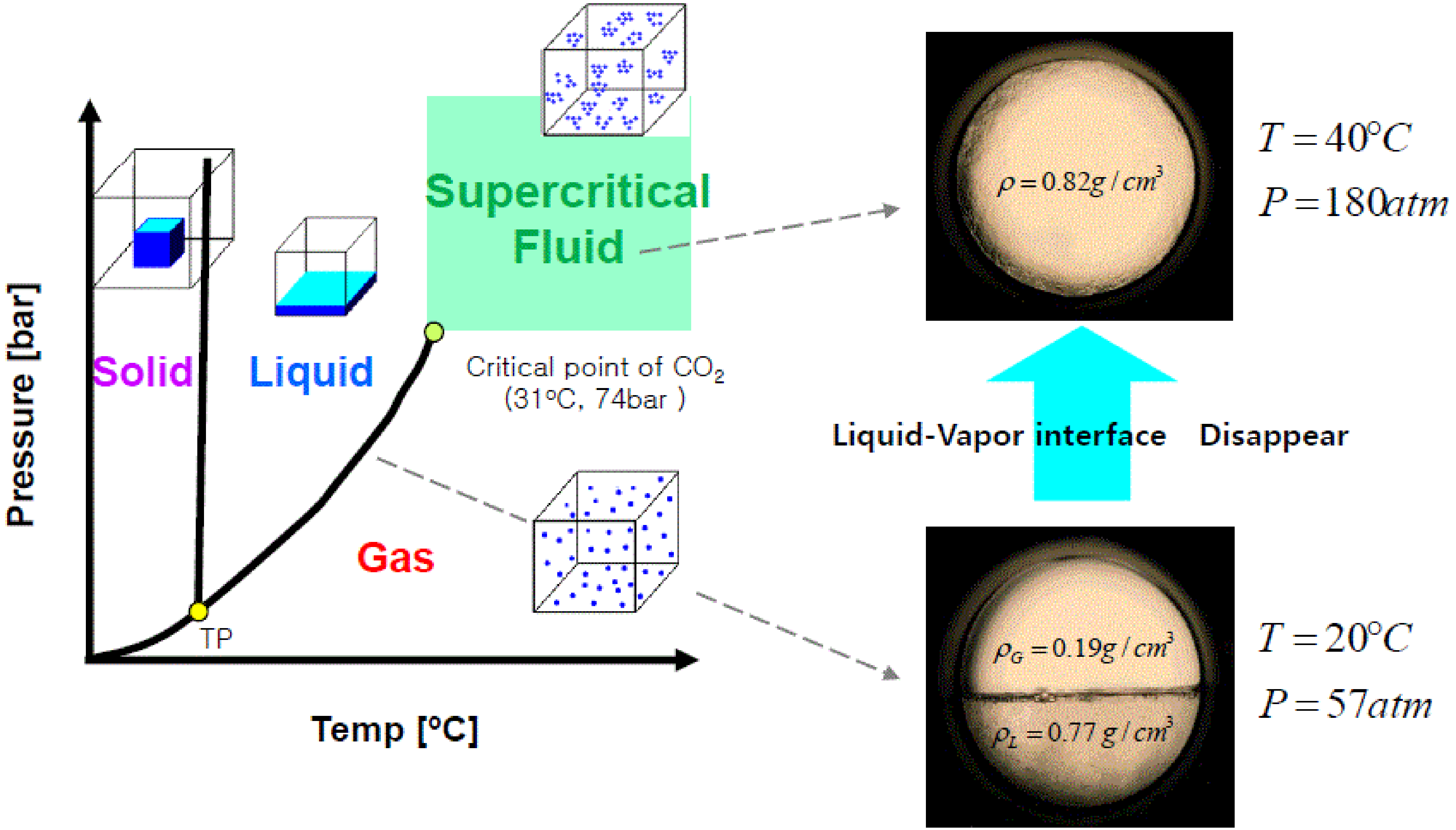
Phase Diagrams

<u>Critical point-</u>

Above this point, gas and liquid have the same densities and have odd combinations of properties and cannot be distinguished from each other

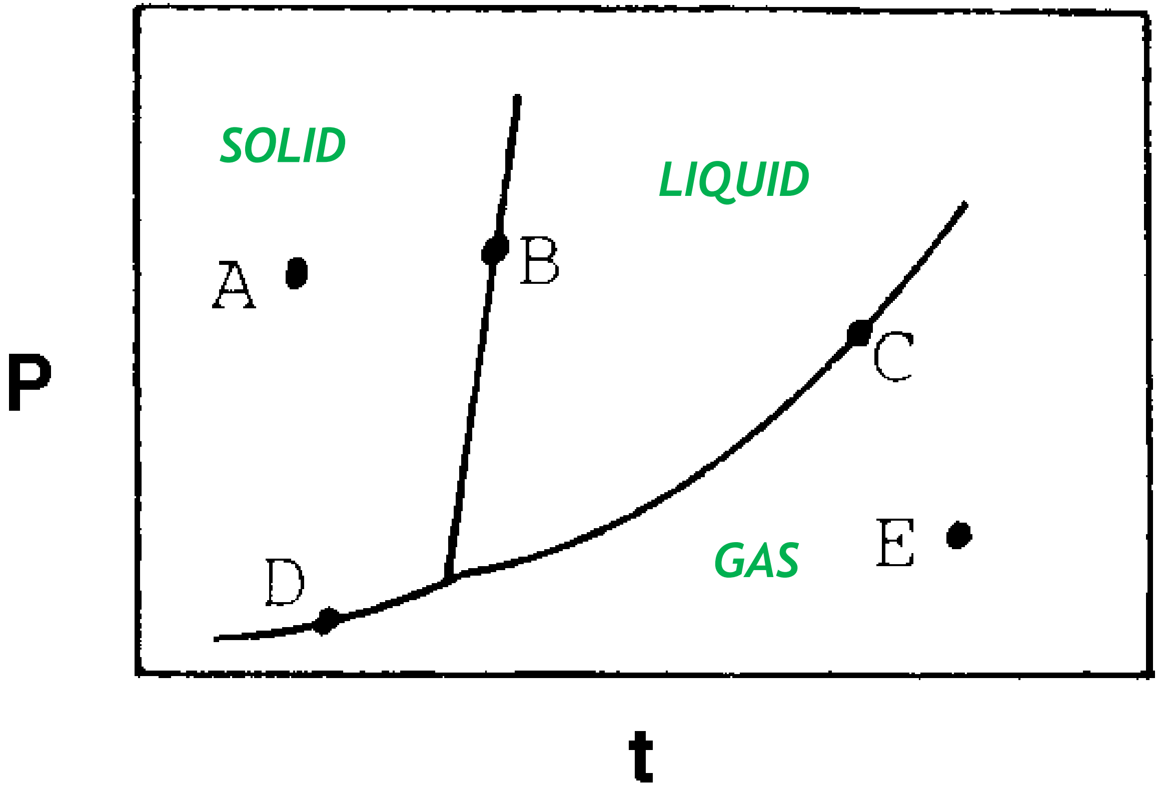


Supercritical Fluids!



A typical phase diagram for a substance is given below. At what point on the diagram do solid and liquid exist at equilibrium?

- A
- B
- C
- D
- E



The phase diagram of a substance is given below. What occurs when the substance is heated from 100° C to 120 ° C at 3 atm pressure?

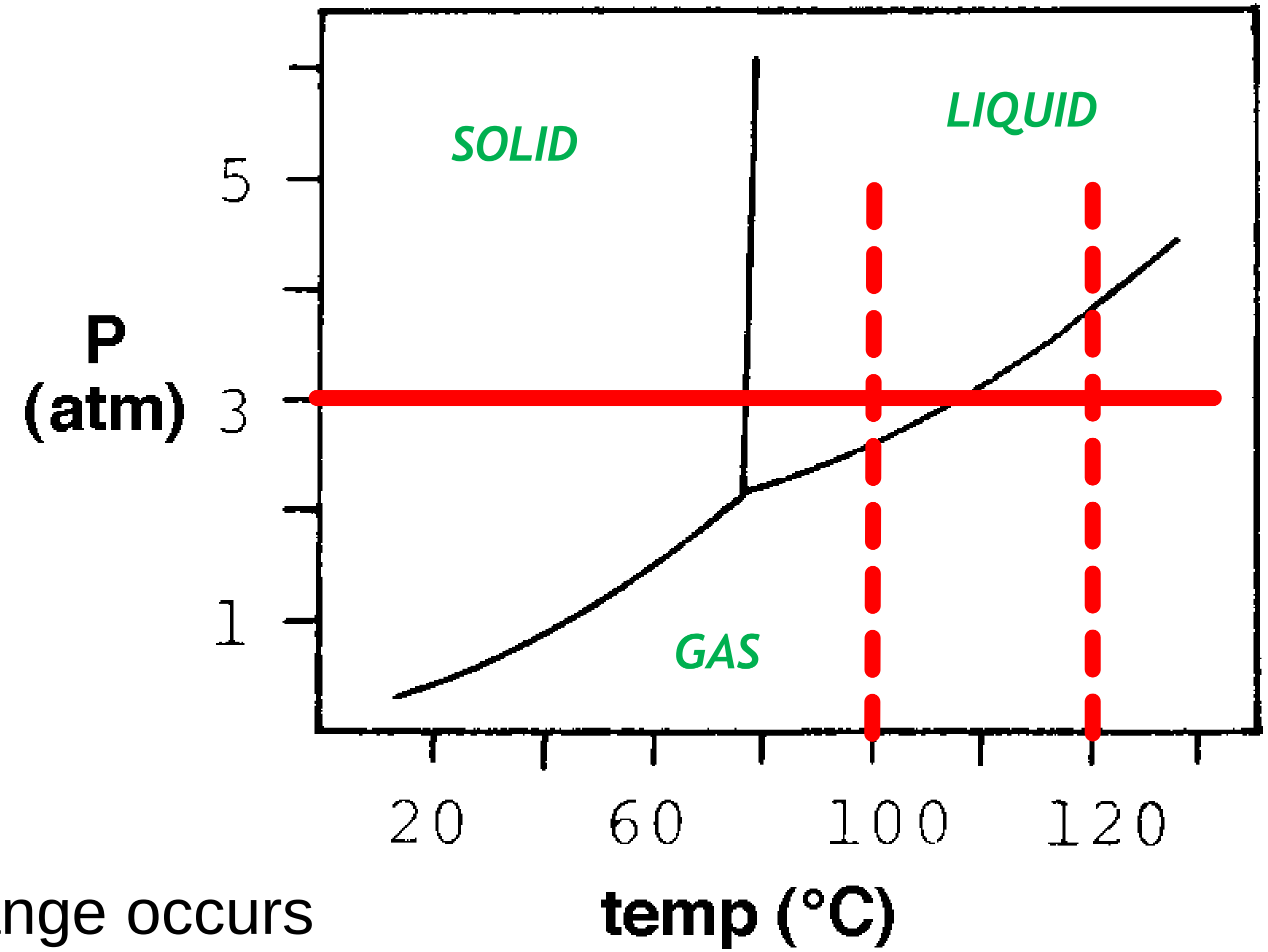
A It melts

B It sublimes

C It vaporizes

D It freezes

E No phase change occurs



“Mixed Phase Calorimetry”

When you have a mixture
of solids, liquids, gases

Think About It

What happens when (in terms of heat) when you add ice to your water bottle?

+

Ice is absorbing, water is releasing energy…

We can still calculate Q!

Mixtures of Solids and Liquids

The Problem: We are going to do problems that involve a phase change AND heating. Something like you drop ice into water, what temperature will the mixture be at the end?

To solve this, think about this:

- As ice melts, the temperature does not change
- BUT as soon as the ice melts the temp will rise
- We are still using

$$Q_{ice} = -Q_{water}$$

These can get tricky…

What if you have ice at -10°C and water at 50°C?

Have to heat ice AND melt it AND heat it up a bit
And also cool water down

Still have to do $Q_{ice} = -Q_{water}$ but this time…

$$(mC\Delta T \quad + \quad mL \quad + \quad mC\Delta T) \quad = \quad -mC\Delta T$$

Heat ice	melt ice	heat cold liq.	cool warm liq.

Practice Problem

Let’s do problem #16 from WS #7 together

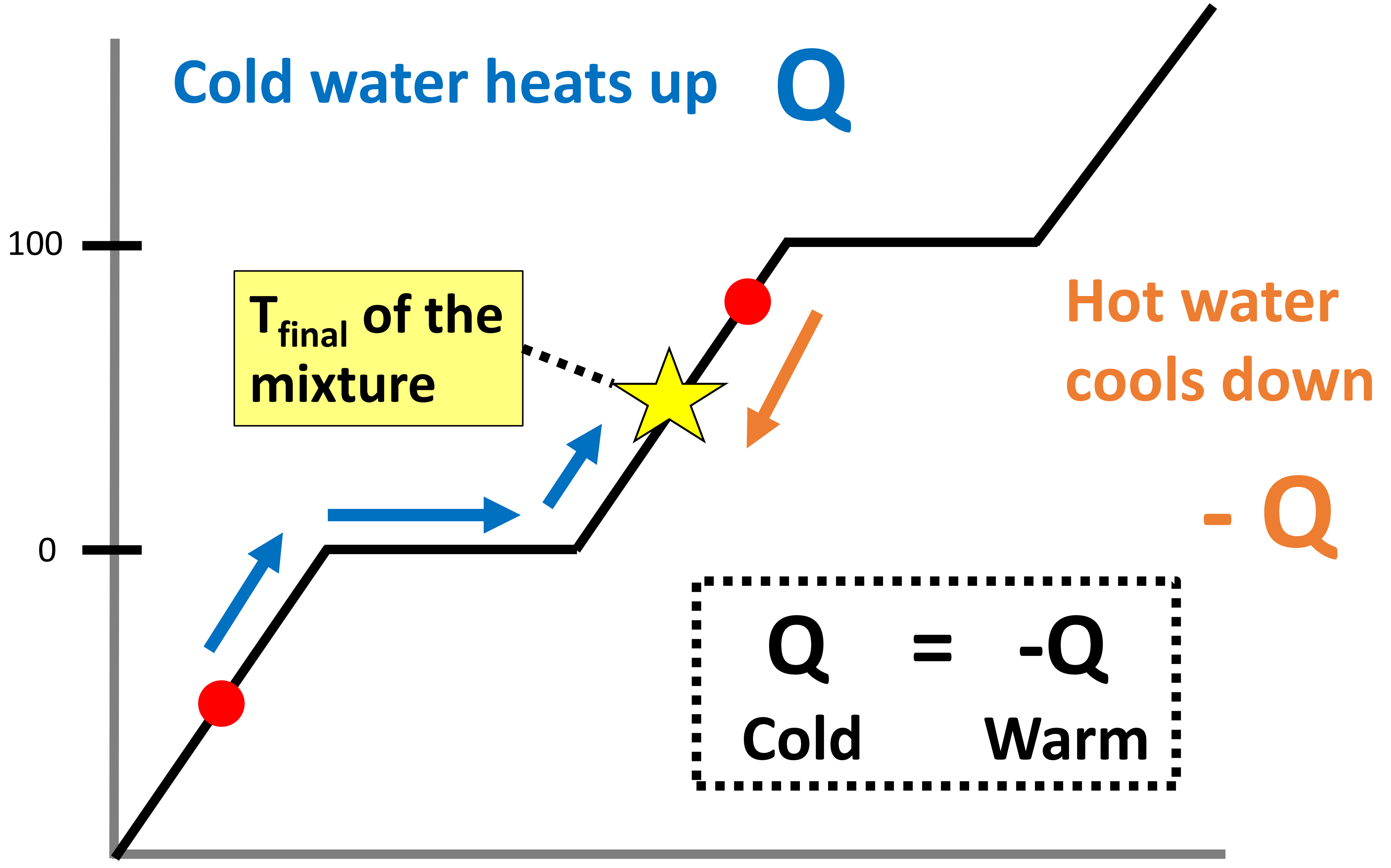
16. Determine the final temperature when 18.0 g of ice at -10.0°C mixes with 275.0 grams of water at 60.0°C

Cold

1. Heat ice
2. Melt ice
3. Heat liquid

Warm

3. Cool liquid



16. Determine the final temperature when 18.0 g of ice at -10.0°C mixes with 275.0 grams of water at 60.0°C

Qcold = -Qwarm

Cold

1. Heat ice
2. Melt ice
3. Heat liquid

Cold

$Q_1 = mC\Delta T = (18g)(2.09 J/gC)(0° - -10°) = 376.2\ J$

$Q_2 = mL = (18g)(334\ J/g) = 6012\ J$

$Q_3 = mC\Delta T = (18g)(4.18 J/gC)(Tf° - 0°) = 75.24Tf$

$Q_{cold} = Q_1 + Q_2 + Q_3$ $\boxed{= 6388.2 + 75.24Tf}$

Warm

3. Cool liquid

Warm

$Q_3 = mC\Delta T = (275g)(4.18\ J/gC)(Tf° - 60°) =$

$\boxed{1149.5 – 68970Tf}$

16. Determine the final temperature when 18.0 g of ice at -10.0°C mixes with 275.0 grams of water at 60.0°C

$$Q_{cold} = -Q_{warm}$$

I personally like to do this because I don't see as many algebra mistakes or double negative issues!

$$Q_{cold} = -\,Q_{warm}$$

$$Q_{cold} + Q_{warm} = 0$$

$$6388.2 + 75.24T_f + 1149.5 - 68970T_f = 0$$

$$\frac{\cancel{1224.74}\,T_f}{\cancel{1224.74}} = \frac{62581.8}{1224.74}$$

$$\boxed{T_f = 51.1\ °C}$$

Make sure your ending temperature is actually between the starting temps!

YouTube Link to Presentation

- https://youtu.be/A7z5ixKMBQs