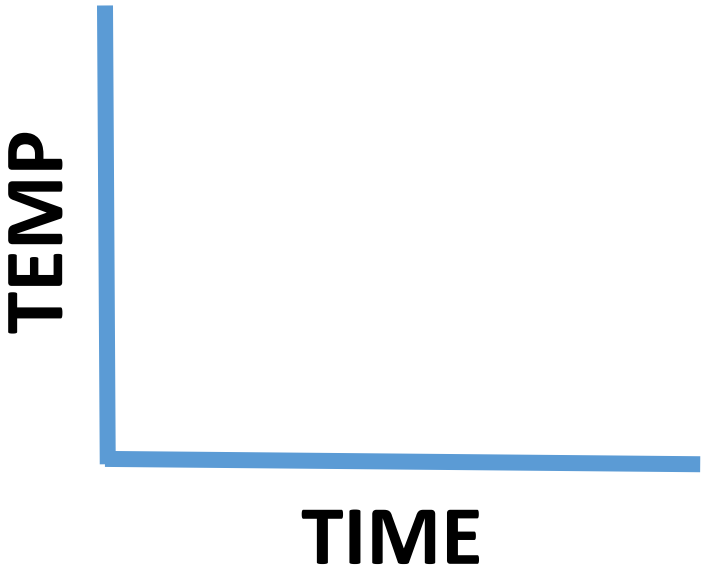
# N37

# Heating and Cooling Curves

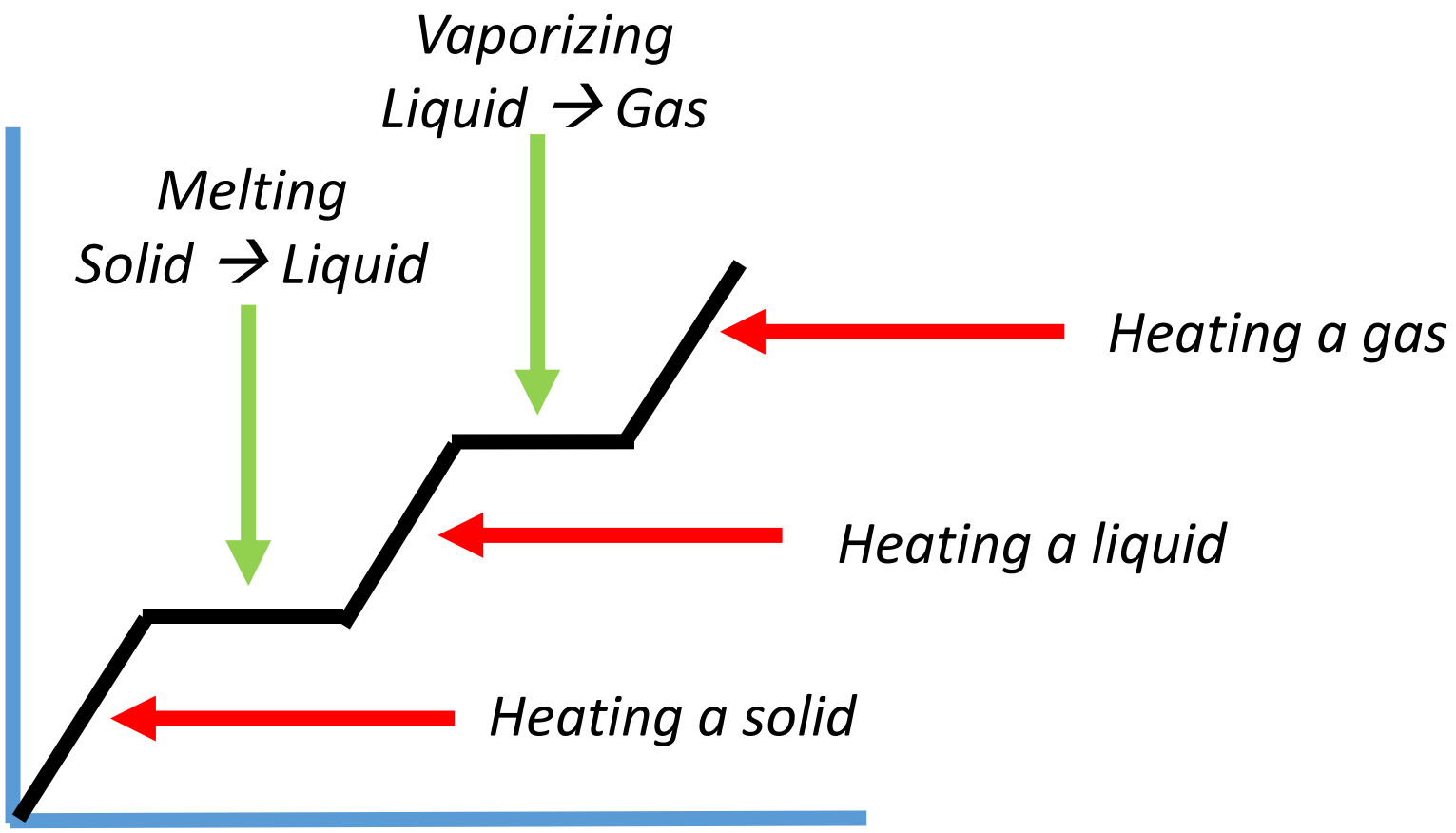
**I can use heating and cooling curves to help calculate the energy changes during phase changes**

# What do they show us?

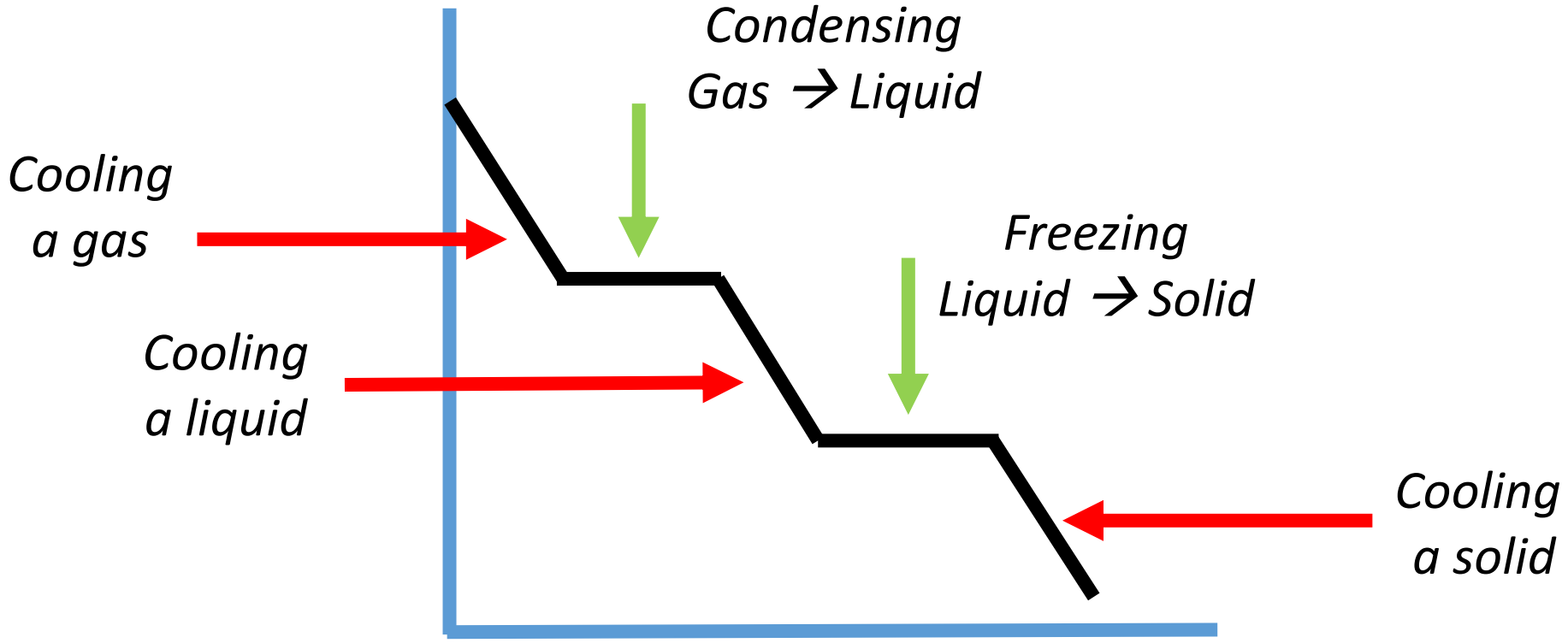
- Heating or cooling → *the sloped parts of graph*
- Phase changes → *the flat parts of graph*



# Heating Curve



# Cooling Curve



# Why are some areas sloped and some flat?

| Heating | Phase Changes |
| --- | --- |
| | |
| | |
| | |

(Cooling would just be the opposite of these things!)

# Why are some areas sloped and some flat?

| Heating | Phase Changes |
|---|---|
| Issue:<br>**SPEED** | Issue:<br>**POSITION** |
| All the energy is going towards **SPEEDING UP** the molecules | All the energy is going towards **SPREADING OUT** the molecules |
| Results in a temperature change | Results in **NO** temperature change |

**(Cooling would just be the opposite of these things!)**

# How is our math changed by NO ΔT?

## HEATING/COOLING

- $Q = mC\Delta T$
- $C = J/g°C$ → Has a temperature component.
- So…. Cant use it for phase changes

## PHASE CHANGES

- $\Delta T = 0$ BUT $Q \neq 0$
- Get rid of ΔT, and replace C with something else
- **$Q = mL$**
- L = "Latent Heat" → J/g
  The energy required to phase change one gram of substance

# Specific Heat and Latent Heat Labels

## HEATING/COOLING

- $C_{solid}$
- $C_{liquid}$
- $C_{gas}$
- Always positive values

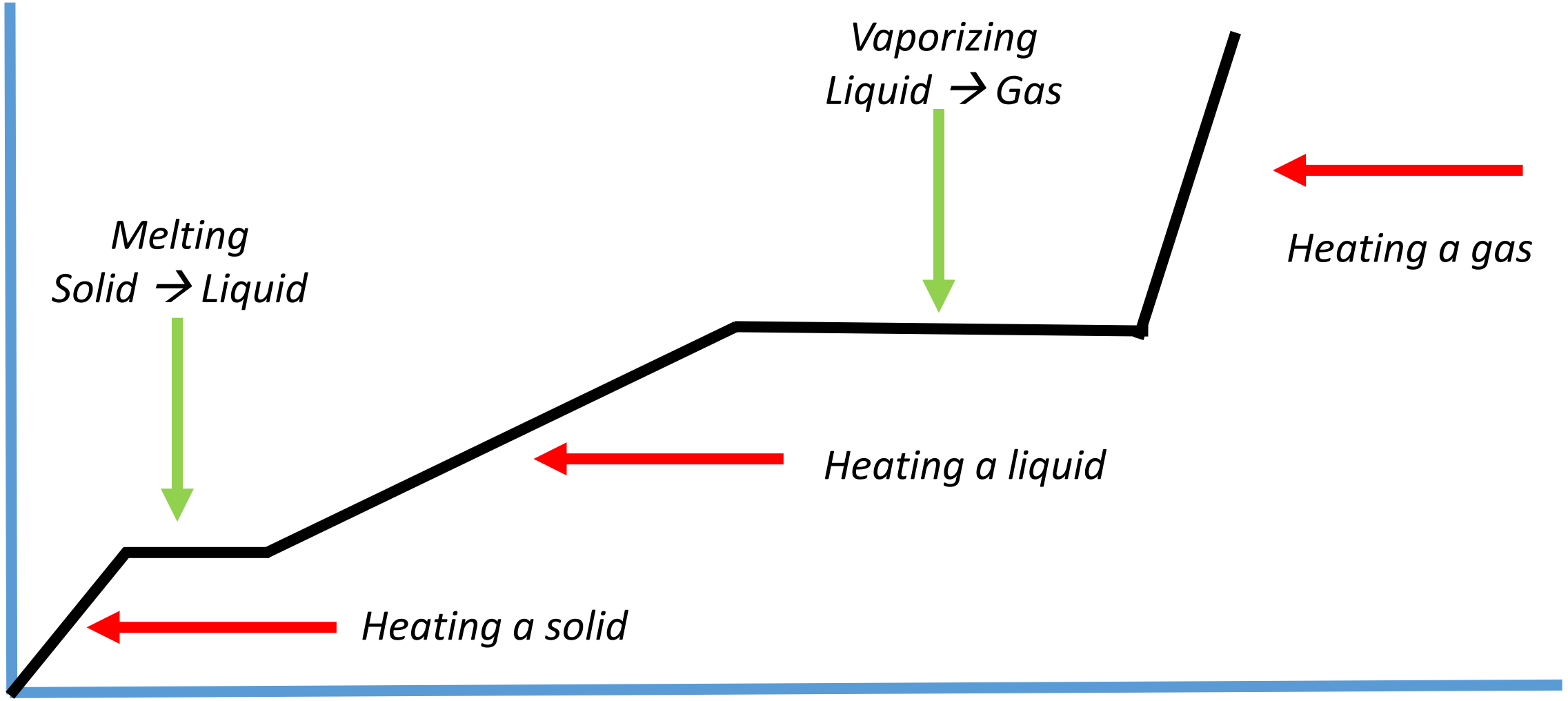
## PHASE CHANGES

- $L_{fusion}$
- $L_{vaporization}$
- ***Positive if endothermic process (melting/vaporizing)***
- ***Negative if exothermic process (condensing/freezing)***

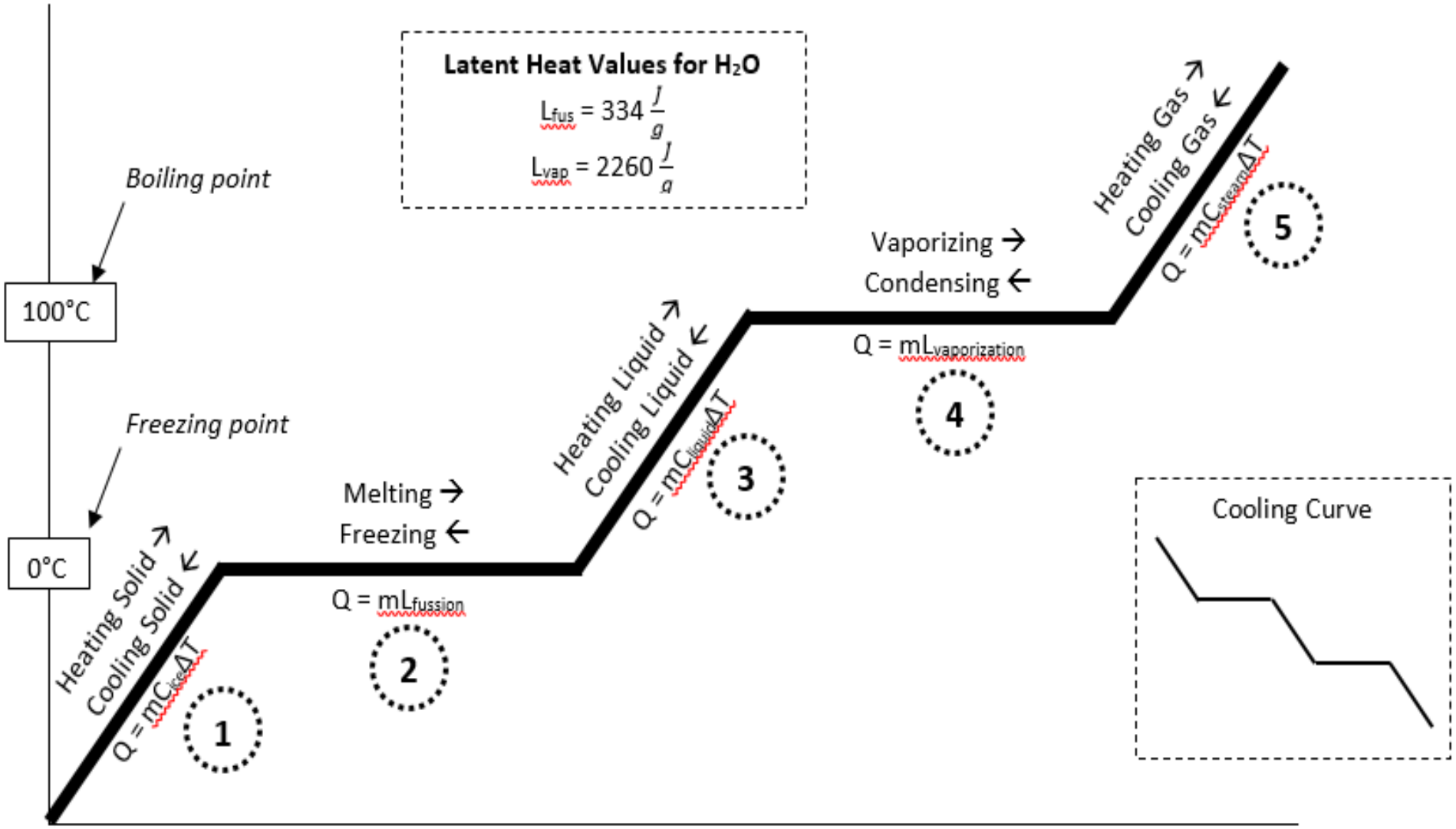
# Values to Memorize for Water

| Heating/Cooling | | Phase Changes | |
|---|---|---|---|
| $C_{ice}$ | 2.09 J/g°C | $L_{fus}$ | 334 J/g |
| $C_{liq}$ | 4.18 J/g°C | $L_{vap}$ | 2260 J/g |
| $C_{steam}$ | 1.87 J/g°C | *L is (+) or (–) depending on direction!* | |

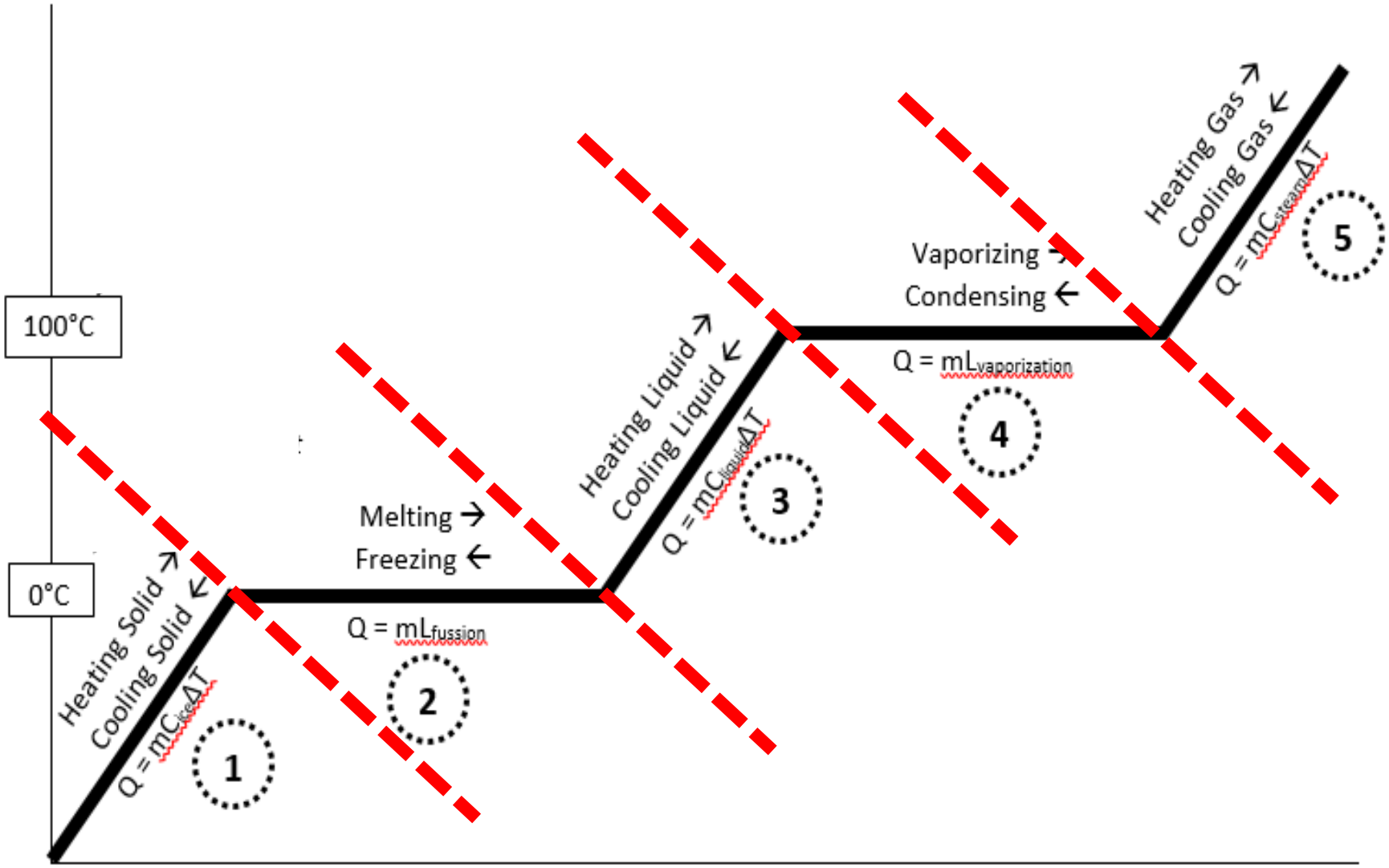
# More Realistic Heating Curve of H2O



# Completely Labeled Heating Curve

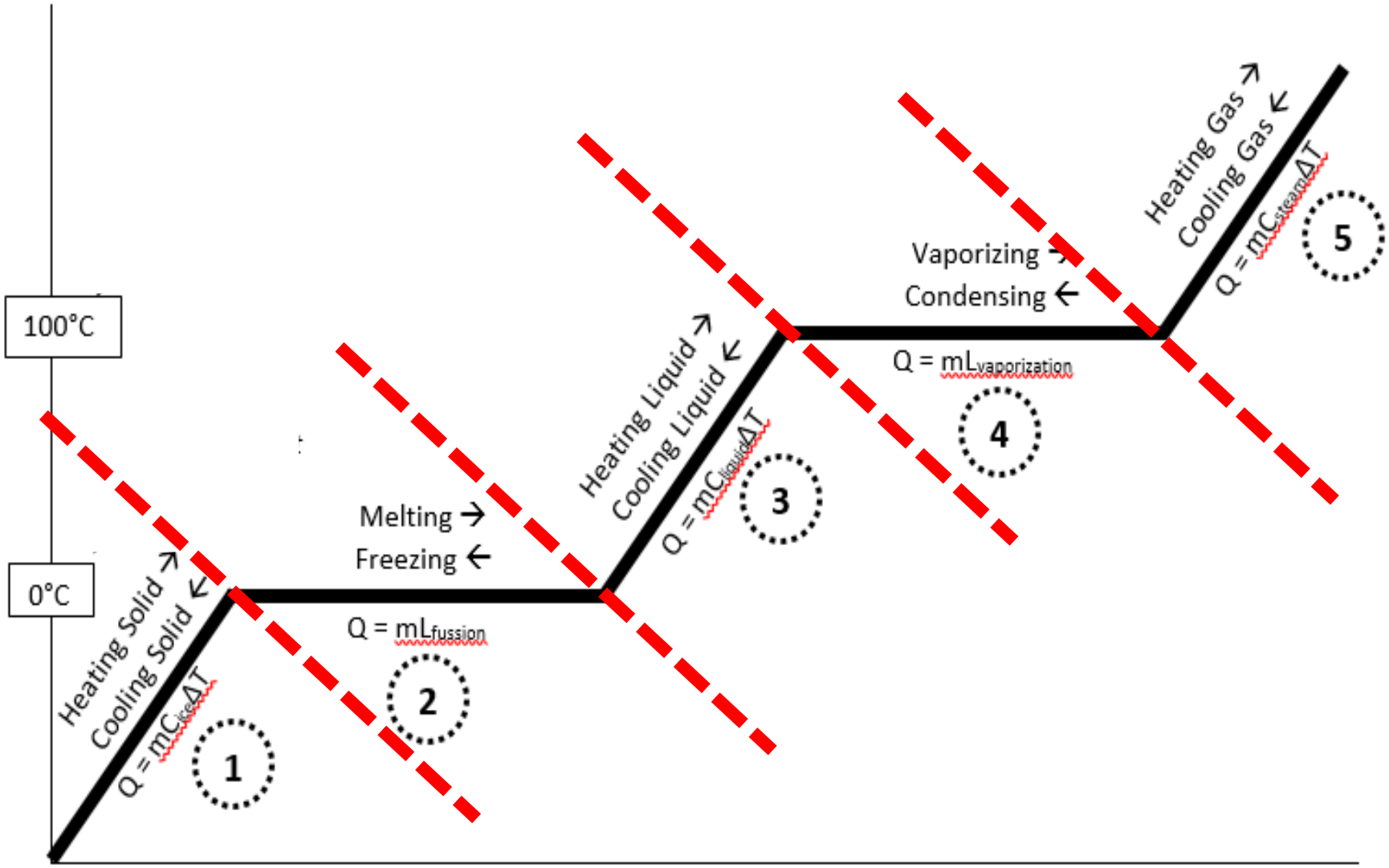


# Calculate ONE line segment at a time!!!




Calculate everything separately and then add up your answers. You could have up to five Q values to add up!

# Careful with ΔT Values!

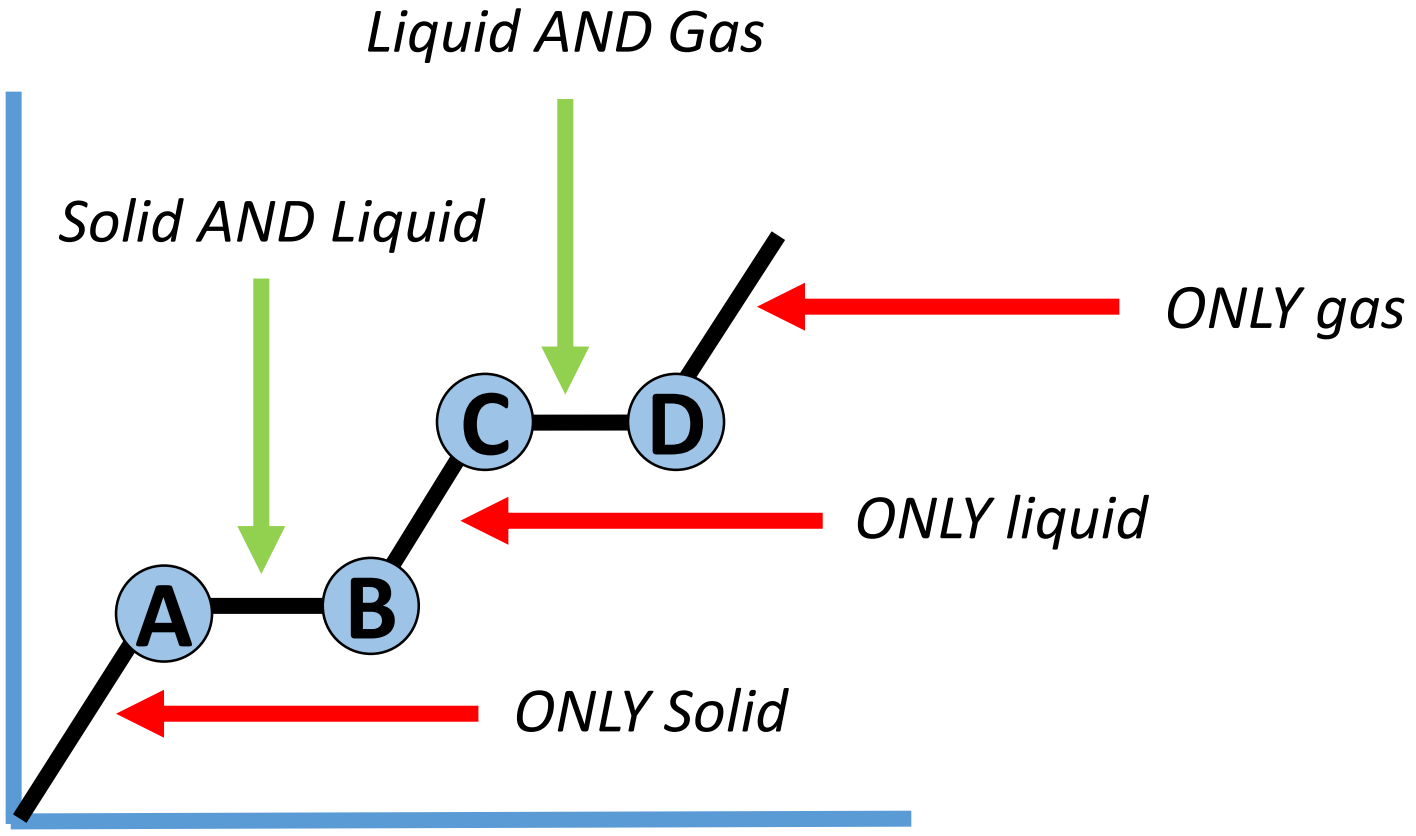



**Use ONLY the temperature change on the ONE LINE you are working with at a time!**

*You will see this on our practice problems in a minute…*

# What phases are happening where?

- **A** *ONLY Solid at 0°C*
- **B** *ONLY Liquid at 0°C*
- **C** *ONLY Liquid at 100°C*
- **D** *ONLY Gas at 100°C*



# Practice Problems

- Glue the questions in your notebook
- Show your work the way I do!
- Annotate the practice problems with comments, tips, warnings, explanations, etc! These are NOTES not just practice problems!

# Practice Problems

1. What is the energy needed to melt 326 grams of ice and heat it to 100°C?
2. Determine the energy required to convert 21.1 grams of ice at -6°C to steam at 100°C
3. What is the heat transfer involved when you convert 51 grams of water 0°C to ice at -20.3°C?
4. What is the energy absorbed when you melt 75 grams of ice at -5°C to water at 90°C?

# 1. What is the energy needed to melt 326 grams of ice and heat it to 100°C?

② Melt ice

③ Heat liquid

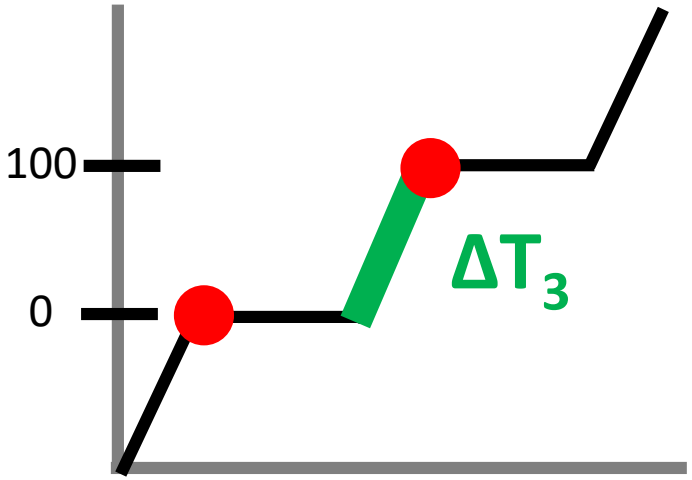
$Q_2 = mL = (326g)(334\ J/g) =$ *108884 J*

$Q_3 = mC\Delta T = (326g)(4.18\ J/g)(100° - 0°) =$ *136268 J*

$Q_T = Q_2 + Q_3$

$\boxed{= 245152\ J}$

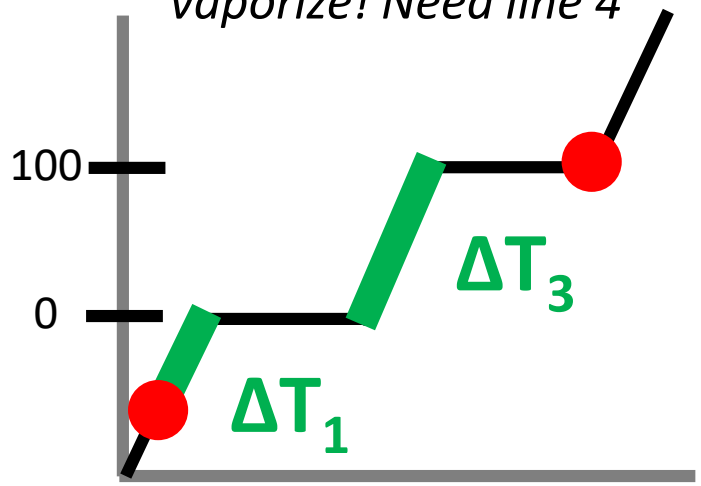
*You could put it in kJ but we often don't bother*



## 2. Determine the energy required to convert 21.1 grams of ice at -6°C to steam at 100°C

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

*Steam @ 100, have to vaporize! Need line 4*




*Double Negative! Be Careful!*

$Q_1 = mC\Delta T = (21.1g)(2.09\ J/g)(0° - -6°) = 264.59\ J$

$Q_2 = mL = (21.1g)(334\ J/g) = 7047.4\ J$

$Q_3 = mC\Delta T = (21.1g)(4.18\ J/g)(100° - 0°) = 8819.8\ J$

$Q_4 = mL = (21.1g)(2260\ J/g) = 47686\ J$

$Q_T = Q_1 + Q_2 + Q_3 + Q_4$

$= 63817.79\ J$

## 3. What is the heat transfer involved when you convert 51 grams of water 0°C to ice at -20.3°C?

② **Freezing**

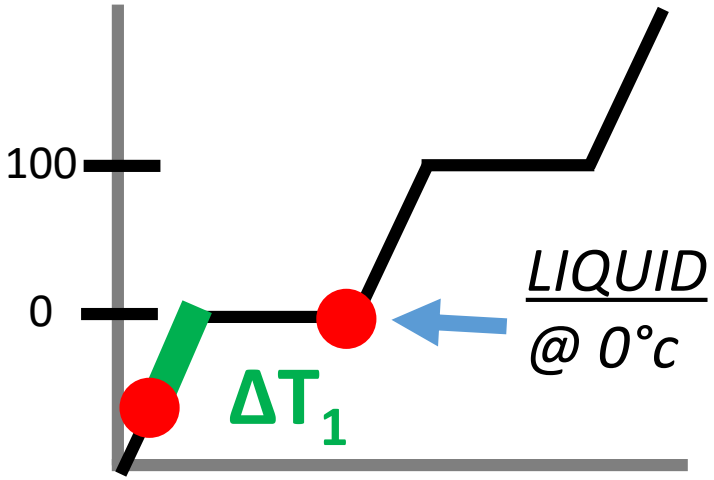
① **Cooling ice**

***Going backwards!***

*L will be negative!*

*ΔT will be negative*

*Q will be negative!*




$Q_2 = mL = (51g)(-334\ J/g) = -17034\ J$

$Q_1 = mC\Delta T = (51g)(2.09\ J/g)(-20.3° - 0°) = -2163.78\ J$

$Q_T = Q_2 + Q_1$

$= -19197.78\ J$

*Negative because energy was RELEASED!*

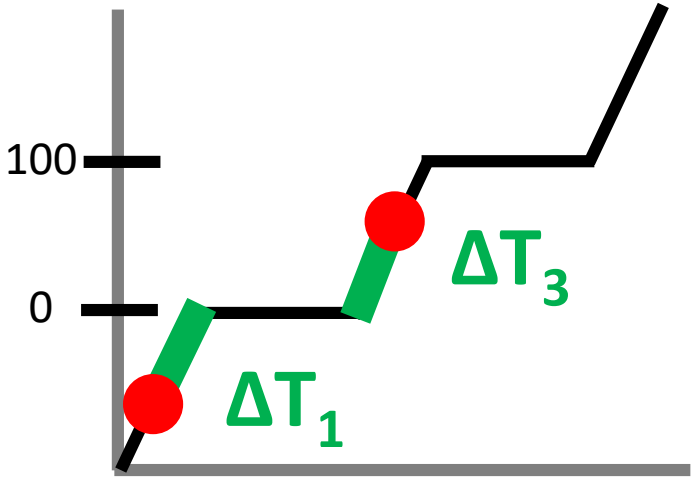
*Cooling down is EXOTHERMIC!*

*Yes, that seems strange to us but it is true!*

# 4. What is the energy absorbed when you melt 75 grams of ice at -5°C to water at 90°C?

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

*You aren't "finishing" line 3! Stop early! Careful with you ΔT !*




*Double Negative! Be Careful!*

$Q_1 = mC\Delta T = (75g)(2.09\ J/g)(0° - -5°) =$ ***783.75 J***

$Q_2 = mL = (75g)(334\ J/g) =$ ***25050 J***

$Q_3 = mC\Delta T = (75g)(4.18\ J/g)(90° - 0°) =$ ***28215 J***

***CAREFUL!***

*You are only going to 90°C !*

*You are stopping early!*

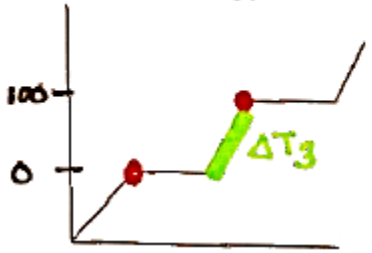
*Tfinal = 90°C*

$Q_T = Q_1 + Q_2 + Q_3$

$\boxed{= 54048.75\ J}$

# YouTube Link to Presentation

1. What is the energy needed to melt 326 grams of ice and heat it to 100°C?




② melt ice
③ heat liQ.

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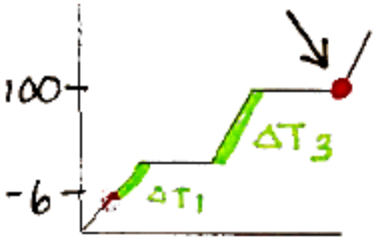
$Q_T = Q_2 + Q_3$

$= \boxed{245152\ J}$

2. Determine the energy required to convert 21.1 grams of ice at -6°C to steam at 100°C

Steam @ 100°! Have to vaporize




① heat ice
② melt ice
③ heat liQ.
④ vaporize

$Q_1 = mC\Delta T = (21.1g)(2.09\ J/g°C)(0° - -6°) = 264.59\ J$

double negative! be careful!

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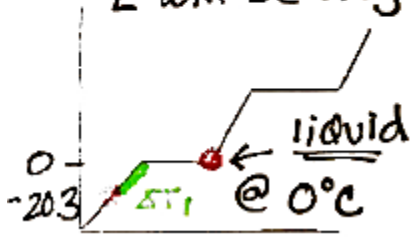



② freezing
① cooling ice

$Q_2 = mL = (51g)(-334\ J/g) = -17034\ J$

$Q_1 = mC\Delta T = (51g)(2.09\ J/g°C)(-20.3° - 0°) = -2163.78\ J$

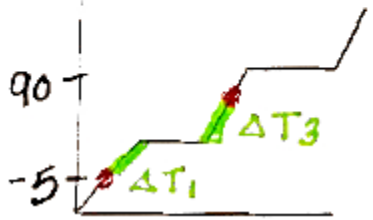
$Q_T = Q_2 + Q_1$

$= \boxed{-19197.78\ J}$

negative b/c energy is released!

4. What is the energy absorbed when you melt 75 grams of ice at -5°C to water at 90°C?

you arent "finishing" line 3! Stop early!
careful w/ $\Delta T$




① heat ice
② melt ice
③ heat liq.

$Q_1 = mC\Delta T = (75g)(2.09\ J/g°C)(0° - 5°) = 783.75\ J$ double negative!

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only going to 90°C!

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