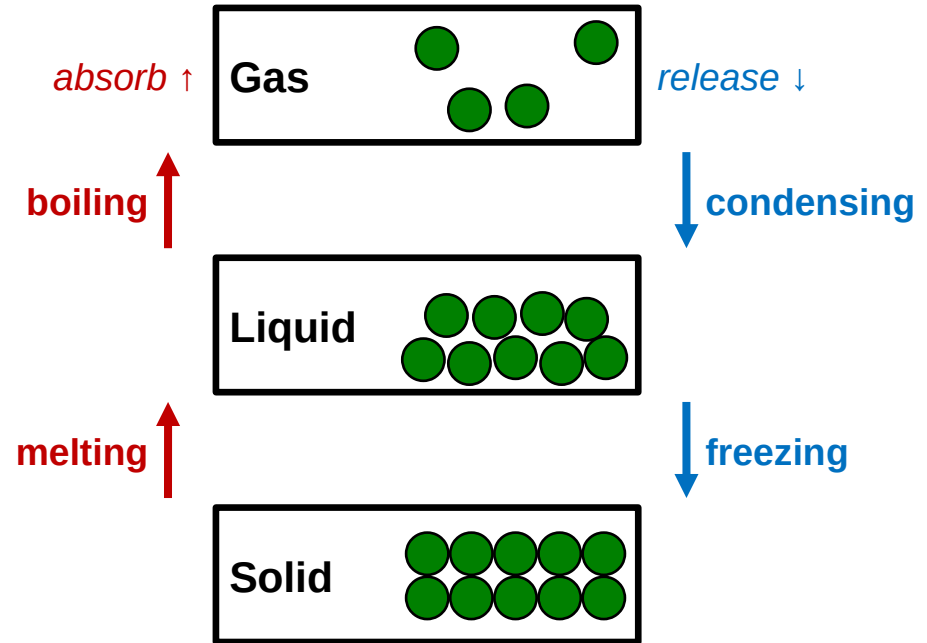


## Essential Question

Why does sweat cool you off?

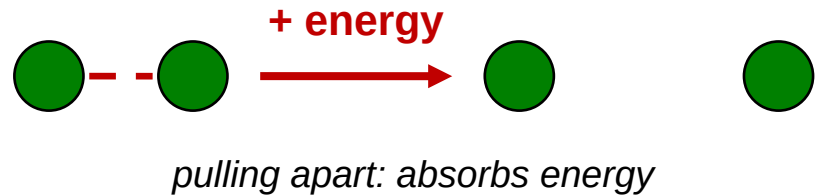
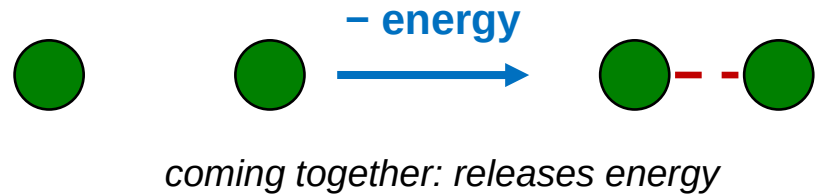
## Phase Changes Need Energy

- Melting and boiling absorb energy
- Freezing and condensing release energy



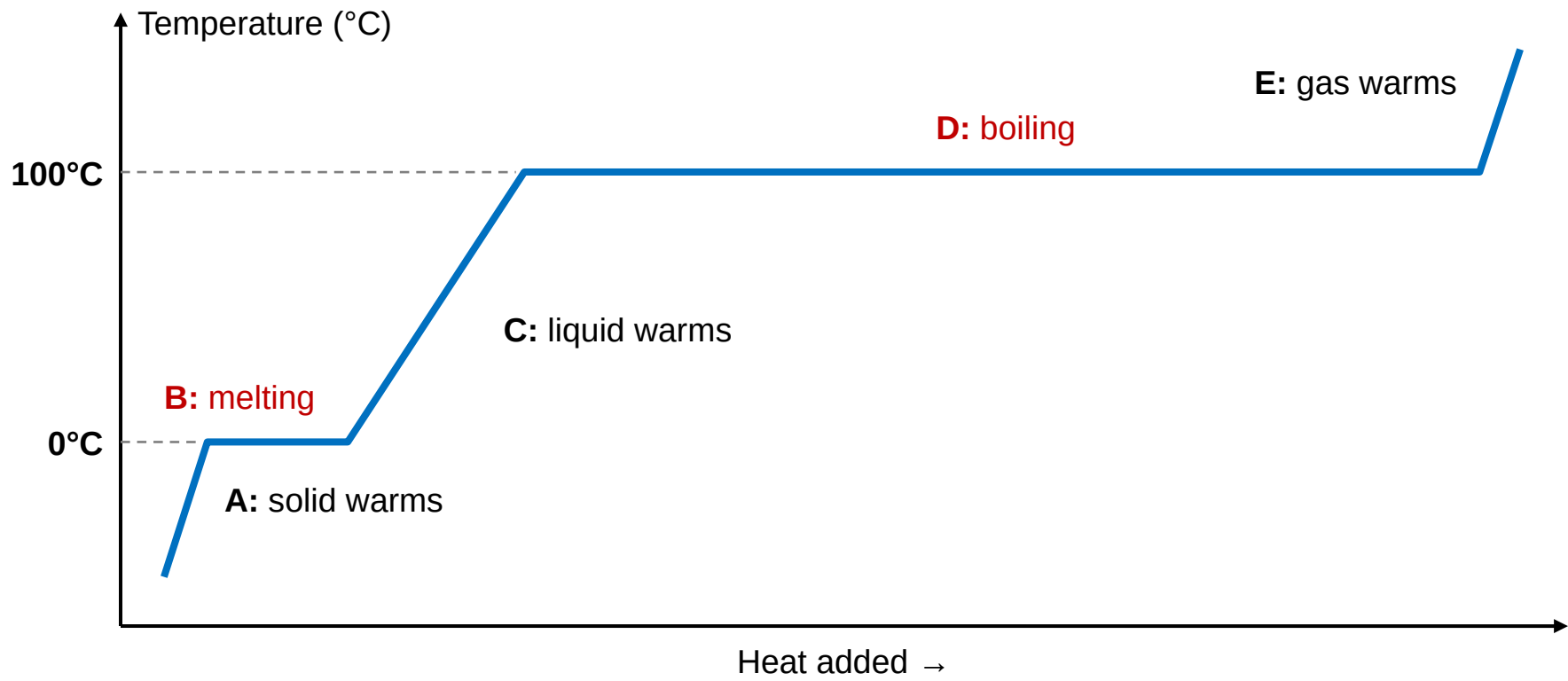
## It's About Attractions

- Pulling apart absorbs energy
- Coming together releases energy
- Attractions between molecules, not bonds



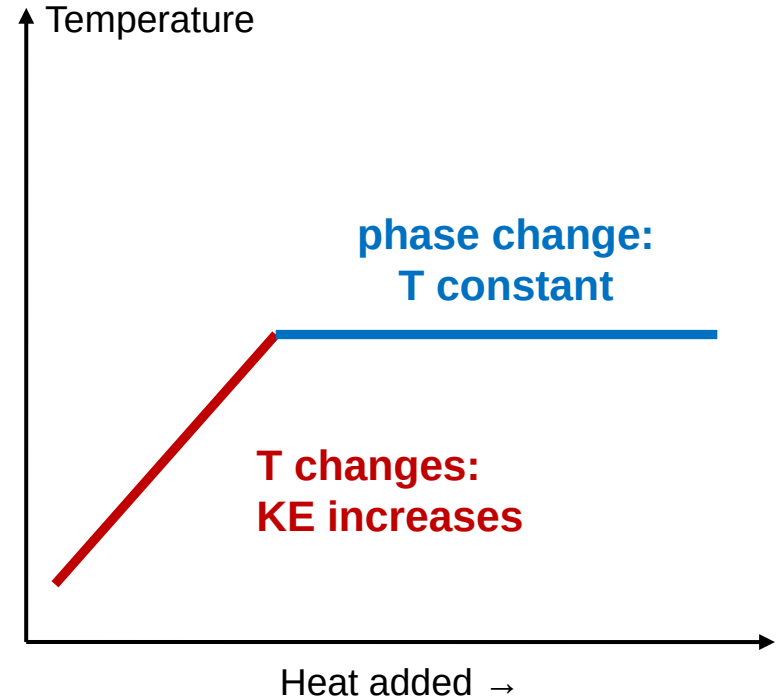
*red dashes = attraction between molecules*

# Heating Curve



### Flat Means Phase Change

- Temperature stays constant
- Energy breaks attractions
- Particles don't speed up
- Average KE stays the same

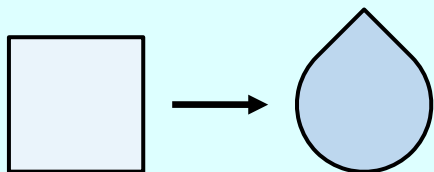


# Molar Enthalpies

$$\Delta H_{\text{fus}} = 6.01 \text{ kJ/mol}$$

*enthalpy of fusion*

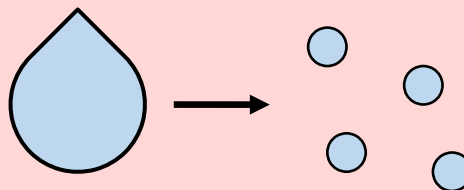
melting: solid  $\rightarrow$  liquid



$$\Delta H_{\text{vap}} = 40.7 \text{ kJ/mol}$$

*enthalpy of vaporization*

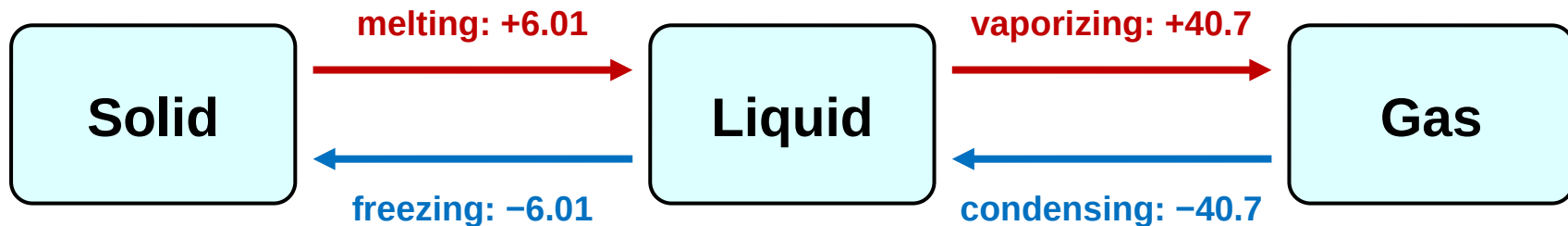
vaporizing: liquid  $\rightarrow$  gas



- Energy per mole of substance

*values shown are for water*

## Opposite Changes, Opposite Signs



*values in kJ/mol for water*

- $\Delta H_{\text{freeze}} = -\Delta H_{\text{fus}}$
- $\Delta H_{\text{cond}} = -\Delta H_{\text{vap}}$
- Same size, opposite sign

$$q = n\Delta H$$

$$q = n\Delta H$$

**$q$**

heat  
*kJ*

**$n$**

moles  
*mol*

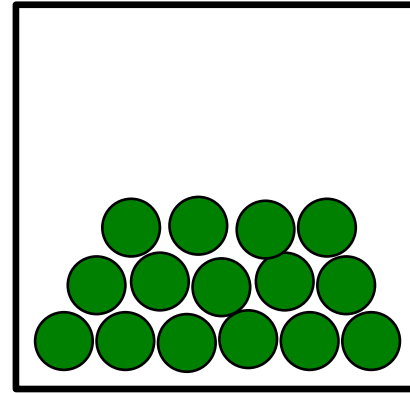
**$\Delta H$**

molar enthalpy  
*kJ/mol*

- Sloped parts:  $q = mc\Delta T$ . Flat parts:  $q = n\Delta H$ .

## Why Is Boiling Harder?

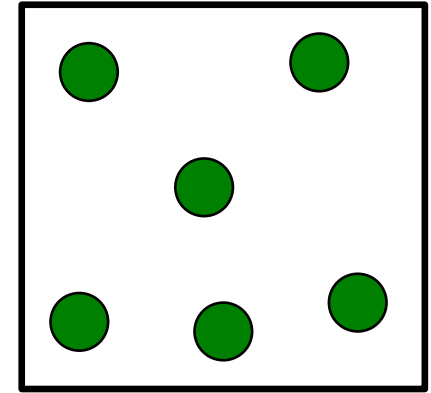
- Melting: loosen attractions
- Boiling: break them completely
- So  $\Delta H_{\text{vap}} > \Delta H_{\text{fus}}$



**Melting**

*stay close*

**6.01 kJ/mol**



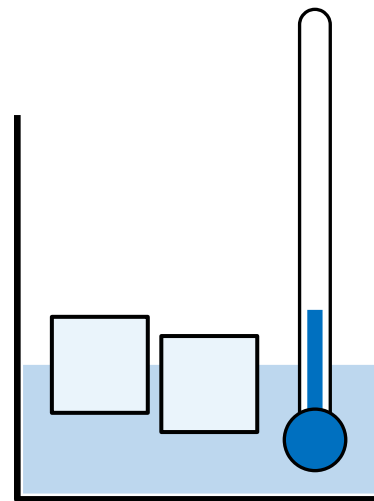
**Boiling**

*far apart*

**40.7 kJ/mol**

## Example: Melting Ice

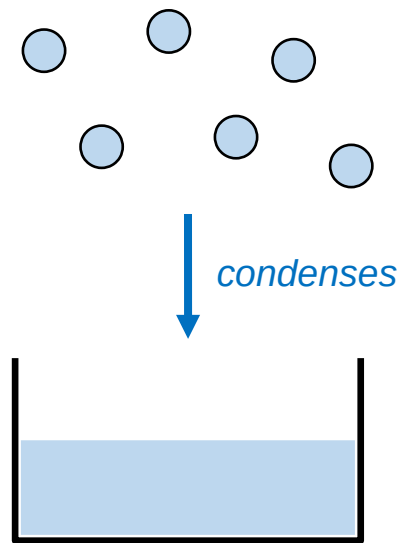
How much heat is needed to melt 36.0 g of ice at 0°C?  $\Delta H_{\text{fus}} = 6.01 \text{ kJ/mol}$



36.0 g ice at 0°C  
 $\text{H}_2\text{O}$ : 18.02 g/mol

## Example: Condensing Steam

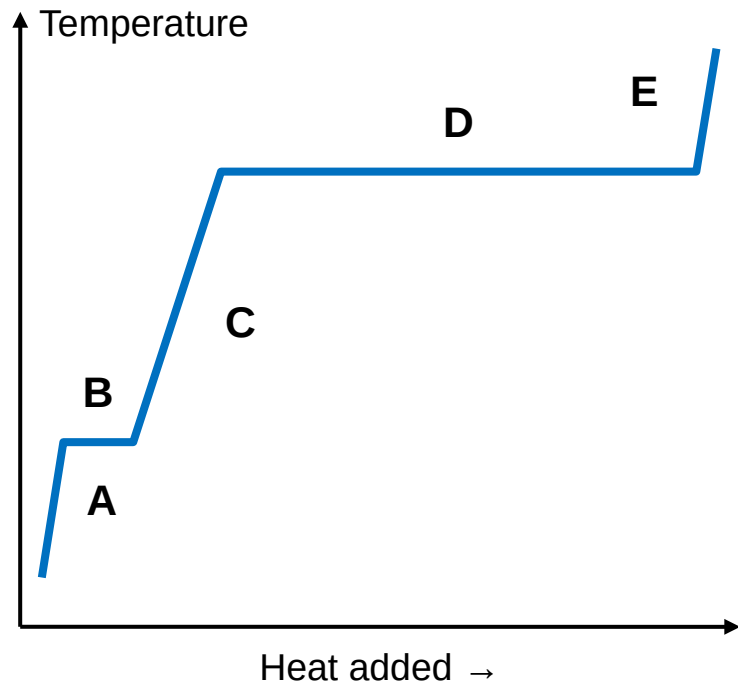
How much heat is released when 25.0 g of steam condenses to liquid water at 100°C?  $\Delta H_{\text{vap}} = 40.7 \text{ kJ/mol}$



25.0 g steam at 100°C  
 $\text{H}_2\text{O}$ : 18.02 g/mol

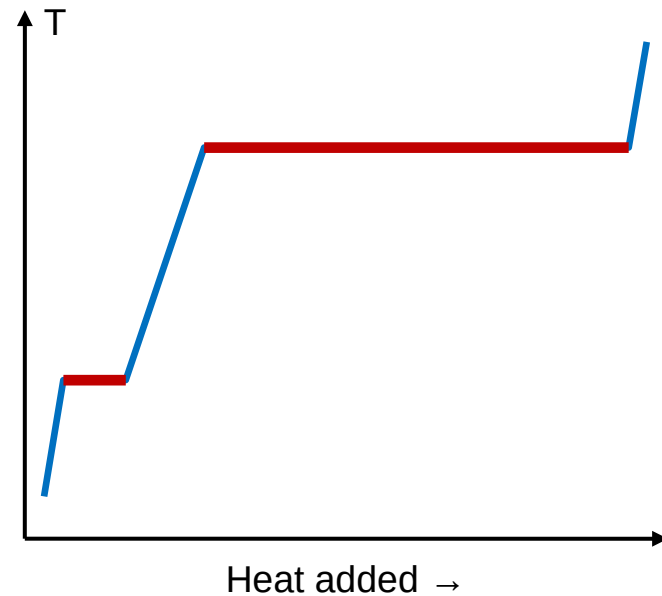
### Example: Explaining the Curve

Heat is added to a sample of water at a constant rate. Why does the temperature stay constant during segment D (boiling)? Where does the energy go?



## Big Ideas

- Melt/boil absorb, freeze/condense release
- T constant during a phase change
- Phase change:  $q = n\Delta H$
- Reverse change  $\rightarrow$  opposite sign



*red flats: phase changes,  $q = n\Delta H$*