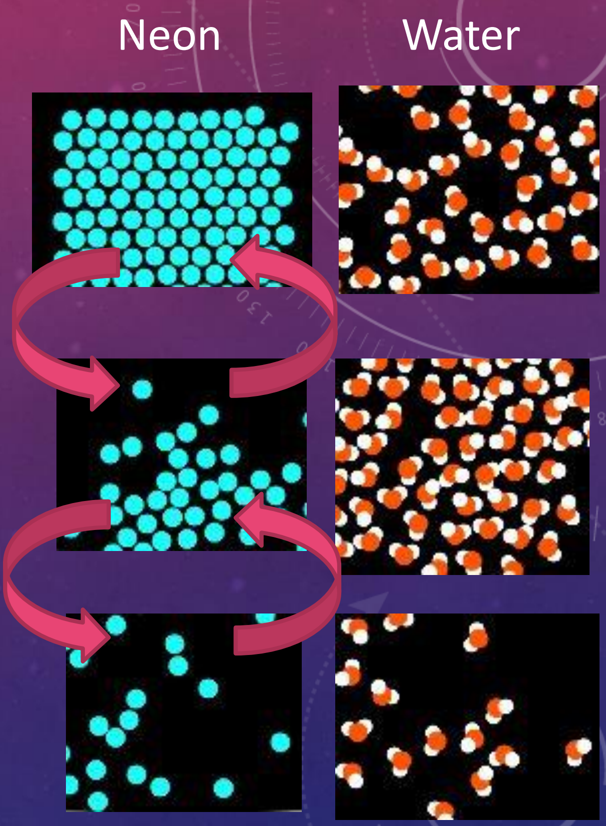
STATE CHANGES AND HEAT CAPACITY

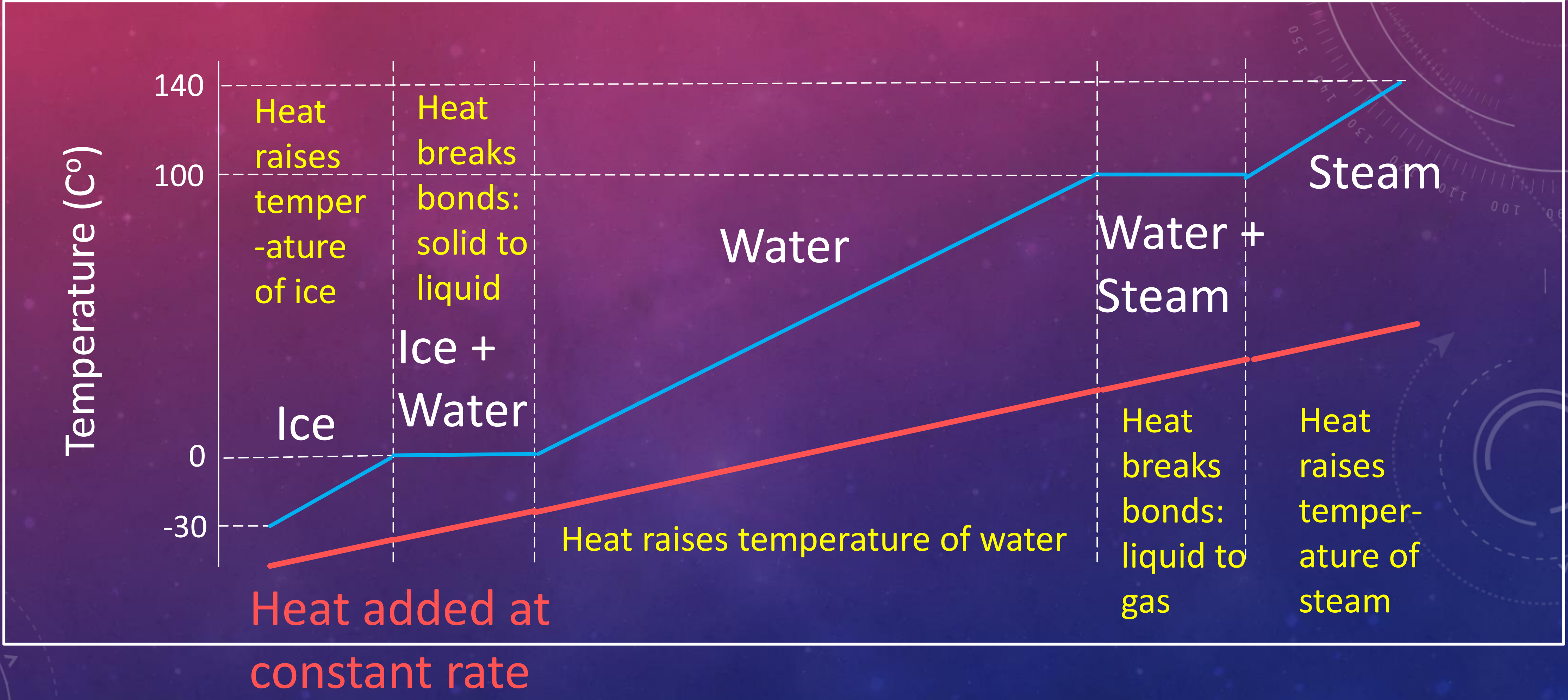
PES 1000 – PHYSICS IN EVERYDAY LIFE

STATES OF MATTER

- Review of the microscopic model for the basic states of matter:
  - Solid – The particles are held in place by molecular bonds with their neighbors. They vibrate about this point due to internal energy (thermal energy).
  - Liquid – The particles are loosely bound together. They still maintain contact, but can slide around and over each other.
  - Gas – The particles are not connected to each other at all. They fly around within the container.
- When one state turns into another due to addition or removal of heat, we call this a *state change* or a *phase change*.



HEAT CHANGES JUST TEMPERATURE OR JUST THE STATE



HEAT CAPACITY

- Heat capacity is defined as the heat required to raise the temperature of a substance
  - Specific heat capacity is the heat required to raise 1 gram of a substance 1 Celcius degree.
  - Variable: c
  - SI Units: J/kg·K (Also, J/g·K is often used.)
  - Heat capacity equation (assumes constant pressure and no state change):
    - $Q = m \cdot c \cdot \Delta T$ where Q=heat, m=mass, and ΔT=temperature change
- Example values: ·
  - c_{steel} = 0.502 J/g·K One consequence: A metal spoon in boiling water heats up rapidly.
  - c_{water} = 4.171 J/g·K One consequence: Ocean-side city temperatures are stable.

LATENT HEAT

- Recall that during state changes (solid ⇔ liquid or liquid ⇔ gas) the heat added goes into breaking molecular bonds and there is no temperature increase.
- Since the heat appears to an observer to be doing nothing, it has been termed *latent heat*.
- A substance will continue to absorb heat and not change temperature until the state change is complete. Only then will the temperature begin to rise again.
  - Latent heat of fusion: the heat added to melt solid to liquid (or the heat removed to fuse liquid to solid).
  - Latent heat of vaporization: The heat added to vaporize liquid into gas (or the heat removed to condense gas into liquid).
- Example numbers for water:
  - Latent heat of fusion: L_f = 334 J/g
  - Latent heat of vaporization: L_v = 2230 J/g

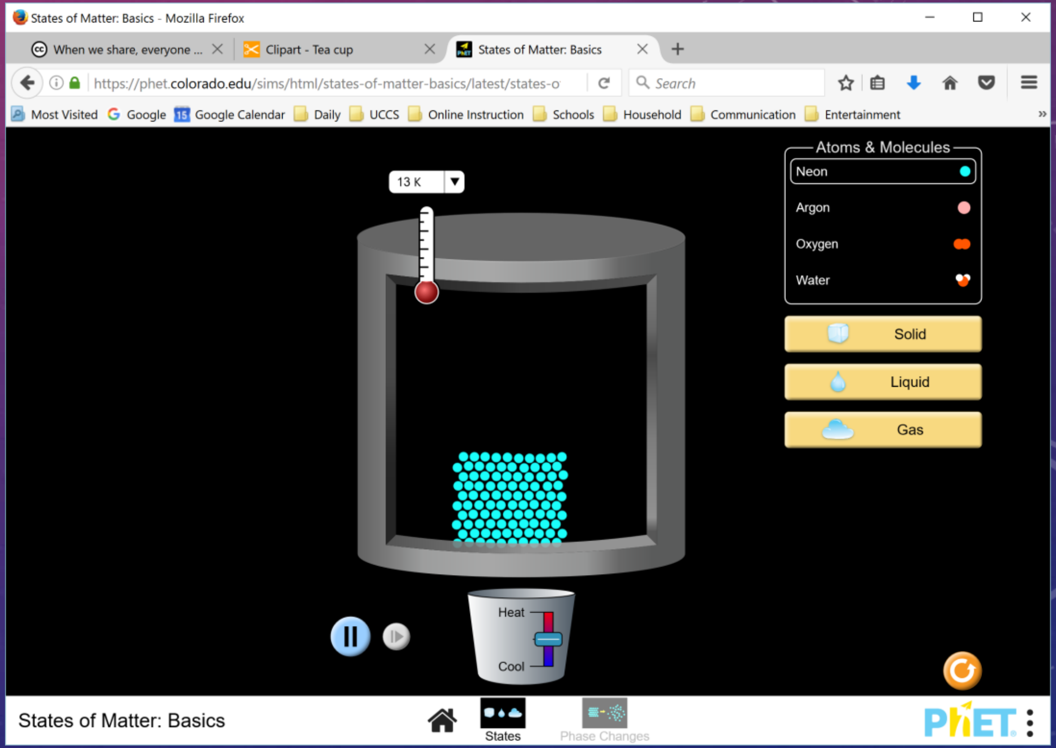
$$Q = m * L_f$$

$$Q = m * L_v$$

STATES OF MATTER SIMULATION

- Link to simulation: https://phet.colorado.edu/sims/html/states-of-matter-basics/latest/states-of-matter-basics_en.html

- Things to do:
  - Choose the 'States' option when starting up.
  - Switch between 'Solid', 'Liquid', and 'Gas' by pressing the buttons on the right. Observe the different molecular configurations.
  - Switch to 'Solid', then add heat below the chamber until the substance turns to liquid (melts).
  - Keep adding heat until the substance turns to gas (vaporizes).
  - Remove heat (add 'cold') to reverse the entire process, condensing the gas, then freezing the liquid.
  - Try the same things with different atoms and molecules.



CONCLUSION

- The basic states of matter (solid, liquid, gas) can transition into one another when heat is added or removed from a substance. This is called a state change or phase change.
- Heat that is added can either increase the temperature OR change the state, but not both at the same time.
- Heat capacity measures the sensitivity of temperature changes when heat is added to a substance.
- Latent heat is the term for heat added that causes a state change but not a temperature change.