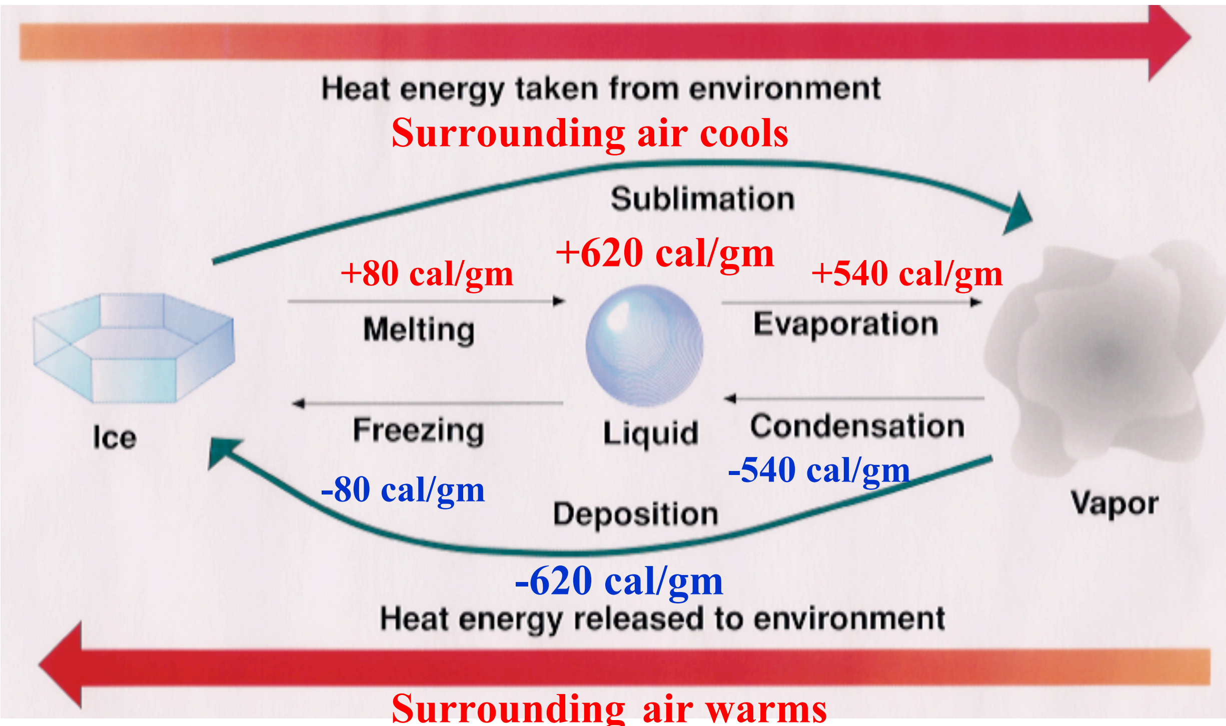
Latent heat of fusion and vaporization

Latent heat is the energy change associated with the phase change of a material between gas, liquid and solid. The latent heat is written as *L* and given in J/kg in mks units. It literally means how much heat energy must be added to a mass of material to convert its phase such as from solid to liquid (melt), liquid to vapor (evaporate) or solid to vapor (sublimate).

$$\Delta Q = m\,L$$

When the transition occurs the other way such as vapor to liquid, the latent heat defines how much energy is released from the mass into the environment.



Note that 1 calorie = 4.1868 J.

Examples of Latent heats of various materials

Substance	Latent Heat Fusion kJ/kg	Latent Heat Fusion J/mole	Melting Point °C	Latent Heat Vaporization kJ/kg	Boiling Point °C at 1013 mb
Alcohol, ethyl	108		−114	855	78.3
Ammonia	339		−75	1369	−33.34
Carbon dioxide	184		−57	574	−78
Helium				21	−268.93
Hydrogen	58		−259	455	−253
Lead	24.5		372.3	871	1750
Methane	58.7		−182.	510	−161.6 °C
Nitrogen	25.7		−210	200	−196
Oxygen	13.9		−219	213	−183
Water	334		0	2500 (at 0°C)	100

The magnitude of the latent heat is a measure of how strongly bound the molecules are to one another in the liquid and solid states. Note in the table above that water has the highest latent heat of vaporization. The next highest is ammonia, NH_3, which is similar in many ways to water, H_2O. Both are asymmetrical molecules with large permanent electric dipole moments that make the molecules readily and tightly bind to one another.

Molar form of the latent heat reveals more about the binding energy.

Heat required to melt and boil some water

Take 5 grams of ice initially at -20^{o}C. How much energy does it take to raise the water molecules in the ice to a temperature of 100^{o}C and fully vaporize the water molecules?

(1) add heat to raise the temperature of the ice to 0^{o}C.
(2) add heat to melt the ice
(3) add heat to raise the liquid water from 0^{o}C to 100^{o}C
(4) add heat to vaporize the liquid water and convert the molecules from liquid to gas phase

To make these calculations, we need to know the specific heats.

Material	C_p (J/g/K)	$C_{p,m}$ (J/mol/K)	$C_{V,m}$ (J/mol/K)
Water vapor (100 °C)	2.080	37.47	28.03
Water liquid (25 °C)	4.1813	75.327	74.53
Water ice (-10 °C)	2.050	38.09	

Given what we know about specific heats, what can we say about why these specific heats differ?