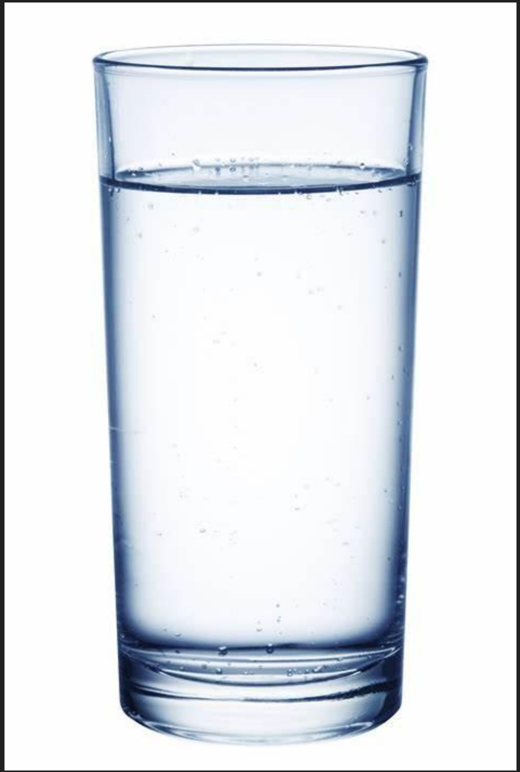
Thermodynamics Notes

Internal Energy

- All objects have some internal energy, consider this glass of water.

- The glass looks like it might not have much energy

- If you shrunk down to the molecular scale, you would be overwhelmed by the commotion of water molecules and minerals colliding with one another.



Internal Energy

- Internal energy is the sum of all energy contained within a system.

- For an ideal gas, the internal energy is equal to the thermal energy

$$U = \frac{3}{2}nRT$$

- When assessing the internal energy of a system one must consider the limitations of the assumptions within the ideal gas law.

Internal Energy

- The ideal gas law assumes that gas particles do not interact.
- This is an okay assumption for noble gases. However, all atoms and molecules undergo some form of electrostatic interaction.
- These interactions can carry a significant amount of energy with them depending on the amount of electric charge on a gas. Unfortunately, we will not be discussing these electric interactions any further. Just know that they are another source of internal energy.

Internal Energy

- In general the more atoms(i.e. mass or matter or stuff) something has, the more internal energy it has.

Which of these two have more internal energy?

Heat

- Heat is energy in transit.

- Heat should never be thought of in any context other than an object giving off heat or an object taking heat in.

- Objects never possess heat. When an object absorbs heat, it is converted into thermal energy and other forms of internal energy.

Heat Transfer

Heat, conductivity, and specific heat

- We all know to use an oven mitt or towel when grabbing something that is hot. Why is this?

- Cloth is a poor conductor of heat so it will take a long time for the energy from a hot object to be transferred to your hand.

- Although oven mitts slow the flow of heat, they do not prevent it and one could eventually burn their hand

Heat, conductivity, and specific heat

- There is another factor that plays into the flow of heat. This factor is similar to the role of mass in Newton’s Second Law.

- We called mass a inertial quantity because it represents an object’s resistance to changes in velocity

- With heat there is something called specific heat capacity. Specific heat capacity is sometimes called thermal inertia because it represents an object’s resistance to changes in temperature

Heat, conductivity, and specific heat

- The formal definition of heat capacity is the heat required to raise the temperature of a material by one degree. Every material has a different specific heat capacity

- In our discussion of specific heat capacity, it is convenient to adopt a “new” unit for energy. This unit is the calorie, for every calorie there are 4.184 Joules. The unit for specific heat capacity is cal/g*C^{o}. These are not SI units, they are units frequently used in chemistry. Specific heat capacity is typically represented by the letter “C”.

Heat, conductivity, and specific heat

- Having introduced specific heat, we can discuss the relationship between heat and change in temperature.

- The amount of heat flowing into or out of an object is directly proportional to its change in temperature. This can be represented by the following equation.

$$Q = mC\Delta T$$

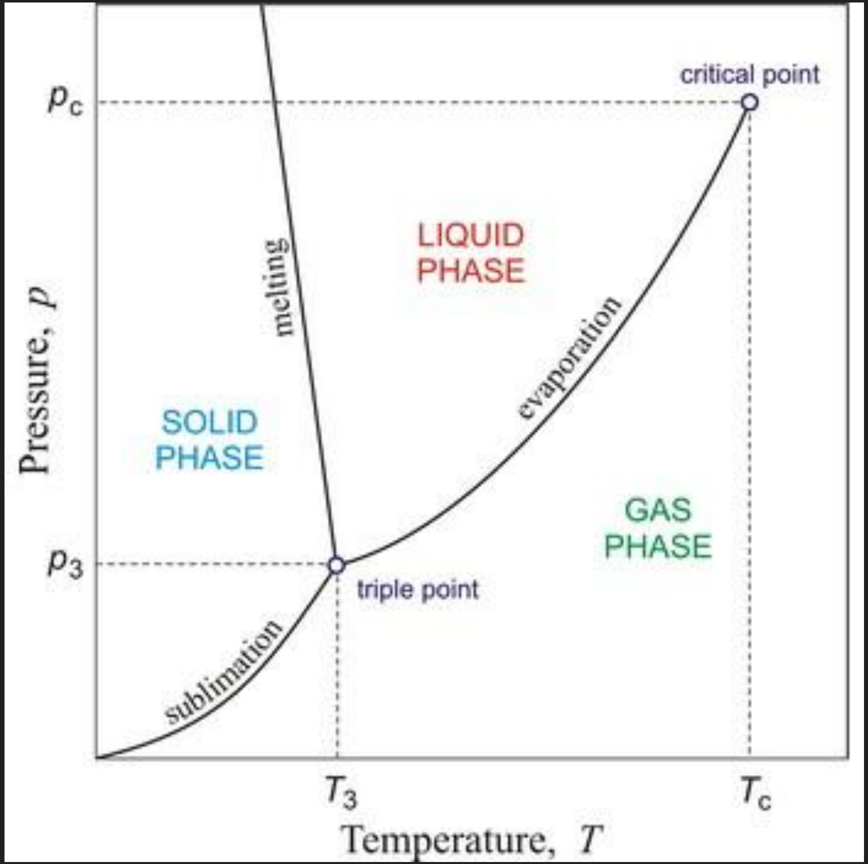
- Q represents heat, m represents mass, C represents specific heat capacity, and T represents temperature.

Phases of Matter

- We all are hopefully familiar with the three “main” phases of matter.

- The main phases of matter are solid, liquid, and gas.

- Many other states of matter occur such as plasma, superconducting, superfluid,



Change of Phase

- Phase changes require a gain or loss of energy

- There is a simple formula for finding the amount of heat that should be added to an object to change its phase.

$$Q = mL$$

- L is a quantity referred to as latent heat. There is a latent heat associated with every phase transition. For melting/freezing there is a latent heat of fusion and for evaporation/condensation there is a latent heat of vaporization.

Work

- We have been talking about work for some time. Even in our discussion of ideal gases, we have been using the notion of work.

- The quantity “PV” is equal to the work done on a gas by a piston in our derivation of the ideal gas law.

1st Law of Thermodynamics

- The first law of thermodynamics states that the change in internal energy of a system is equal to the sum of the heat added to the system and the work done by the system. This is essentially conservation of energy.

- Both heat and work only exist as energy in transit. They are methods of energy exchange.

- Internal energy is a measure of the total energy of a system. Therefore, any energy lost or gained by a system is done so in the form of heat or work. Energy is not created or destroyed, it is transferred via heat and work.

1st Law of Thermodynamics

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