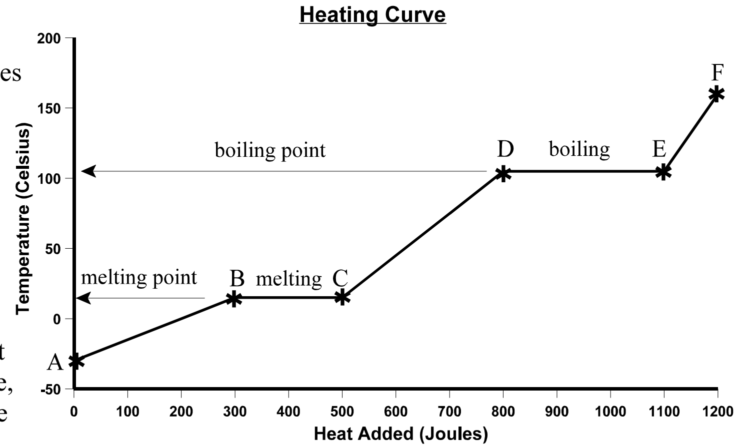
Energy Review

By now, you have learned through all of your science courses that energy is directly related to any type of change. In fact is almost impossible to evoke change without measuring an energy change. The first type of energy-change relationship you studied in high school was physical change in which a substance changes state or configuration of its particles without changing the chemical composition of those particles. Since bonding, and hence, particle structure is not changing, lower amounts of energy are measured in these cases.



You should now be well aware that two major types of energy can be identified in any process. Heat is really a measure of the average **kinetic energy (E_k)** of the particles of a substance and **potential energy (E_p)** represents the stored energy within the intramolecular bonds and intermolecular attractions. Also, average E_k directly reflects molecular motion which directly relates to Kelvin temperature. Consider state changes of a pure substance (adjacent). As heat is applied, substance temperature alternates between times when it is rising and times when it is constant. Since average E_k is proportional to temperature, E_k changes when the temperature changes. E_k rises because the particles are increasing in motion (A-B, C-D and E-F). When temperature (E_k) is constant, the substance is changing state (melting (B-C) and boiling (D-E)); thus, the intermolecular forces of attraction are changing and E_p is changing greatly. E_p increases only slightly because of expansion of solids (A-B) and liquids (C-D); thus, it is considered to be constant. When the gas phase is reached (E-F), both E_k and E_p increase and this will continue until particle break down occurs (chemical change). The relationship between inter-particle distance and E_p can be confusing. The stronger the intermolecular attraction between particles, the smaller the inter-particle distance but the lower the E_p of the substance. Think of it this way, the further apart the particles, the greater the amount of work done (to overcome the E_p) and thus, the greater the E_p which means there is an inverse relationship between particle attraction and E_p:

F_A: Solid > Liquid > Gas and E_p: Solid < Liquid < Gas!

There are many everyday occurrences that reflect this inverse relationship: air warming during snowflake formation and warmer lake-side winters (as air temperature decreases, the loss of heat slows water particles allowing them to move closer, but when they lock into a solid, E_p is converted into E_k which warms the air), cooler spring thaws and cooler lake-side summers (as air temperature rises, the input of heat forces water particles to vibrate more and spread apart until they change state, which requires E_p stolen from the E_k of the air so the air cools slightly), sweating to cool down (the warm air forces water particles to vibrate more and spread apart until they change state, which requires E_p stolen from the E_k of the air and your skin), and finally the scalding burn of steam (as water cools, the particles slow down to become more locked into place resulting in the conversion of E_p into E_k which warms your skin, but the amount of E_p converted is significantly greater for the steam changing state that it is for liquid water just cooling (very little intermolecular change).

There are also practical applications of this inverse relationship: dehumidifiers (cools water vapour causing tighter intermolecular attractions removing water humidity), refrigerators (use low pressure to allow a liquid to change to a gas which consumes heat (E_k) from the air inside the freezer and then raises pressure outside the refrigerator to compress the gas into a liquid converting E_p into E_k as heat), spraying fruit prior to a frost or keeping water barrels in fruit cellars (as air temperature decreases, the loss of heat slows water particles allowing them to move closer, but when they lock into a solid, E_p is converted into E_k which warms the air around the fruit protecting it from damage) and using unglazed water pitchers in tropical countries (water can't collect on the outer surface and so it cannot gather to condense which on them as easily which keeps their contents cooler since condensation releases heat as the water vapour becomes liquid).

Now, recall that during any chemical reaction, heat is also associated with the change; in fact, it is often a clear indication that a chemical change has occurred if the heat is not due to some external event such as boiling or cooling. If heat is released during the chemical reaction, the reaction is **exothermic** and if heat is used up or absorbed during the reaction, the reaction is **endothermic**. Keep in mind that these are net results because some heat (**activation energy**) is needed to destabilize the reactants to allow the reaction to proceed. Also, recall the process is associated with bonding in that, typically, bond creation results in a release of energy (assuming the product is more stable which means it persists) and heat absorption is associated with bond breaking in that it takes energy to destabilize a compound.