What is Thermal Energy? U4P1a

- There is only one "real" energy, which is ________________. It is real because it can do a _______ and if an object with a lot of _____ hits you it will ________. In contrast, objects with a lot of ____________ energy might be perfectly safe to touch, like a rock on top of the Empire States building (the rock will only hurt if the _____ is converted to _____ by ___________ to the street).
- Objects with a lot of thermal energy (aka _____ objects) ________ to touch. Boiling water ________ be used as an energy source to do a ______, like in a ___________ ___________ for a train. Ergo, __________________ must be real energy, which means it is _____. But how?
- In Chemistry you learned that while a cube of salt might look like a single thing, it is actually made of __________ and ___________ ________. In fact, 117g of table salt contains __ moles or _________________ ions of NaCl.

(math)

- Just because the salt as a whole might be stationary ____________ mean that the atoms are ______________. In fact, they are ______________. These vibrations mean that each atom has _____. The more thermal energy an object has the more ____ the ______________ atoms have on average.
- Another way to think of it is atomic motion energy comes in organized and disorganized forms. Organized atomic motion causes an object to _________. We say it has _____. In contrast, _____________ atomic motion won't create ____________, but it will make an object feel _____, and we say it has ____________ energy.

What is Heat?

- Work is __________________________, ___=____. Heat is ______________________________, ___=____. But, remember thermal energy is really the ________ energy of all the ________ in an object. So, heat and work are really _______________________ (philosophically).
- On a human scale, however, heat and work look ______________. With work you can see the ________ of an object change as it transfers its KE through a push or collision. With heat, there may be no obvious change in ___________, because you can't see the ________ _______________. Still, heat is transferred by _______________.

Heat Flow

- It is said, "Heat always "flows" from ____ objects to ______ objects." The word "_______", however, is very misleading. Heat is not a __________. For "heat flow" to occur, really means for atoms to _____________ in such a way so that their atomic _____ are more evenly/randomly distributed (2nd Law of Thermodynamics).

Absolute vs. Relative Temperature

U4P1b

- Temperature measures the average KE per particle within a substance.
- Absolute temperature scales also have 0 set to ____________________________. In the metric system, 273 __ means __________________________________
- Relative temperature compares the average atomic _______ of a _____________ to a known average. For example, 0 ___ means _________________ at 1 atm, 100 ___ means _________ _____________ at 1 atm. In Fahrenheit, that's ______ and ______, respectively.

*** ***Note:*** $\Delta T = \pm 1$ ºC = ____ K while $T = 0$ ºC = ____ K

Internal Energy vs. Temperature

- Internal Energy is ***all*** the microscopic ________ and _______ an object has collected (ignoring any that was converted to macroscopic _____ or ____ related to external objects.)
- In contrast temperature is the _____________ microscopic ____.
- Note: This mean two substances could have the same temperature and ___________ internal energies. For example: ____
- Note: High temperature doesn't have to mean High thermal energy. 1 microgram of salt might be very hot, but it would have little thermal energy because ____________________________. The Great Lakes in are very cold even in the middle of summer. They have absorbed _______ energy from the sun, but they are so _________ that they don't _____________________ a lot.
- In Chemistry, you learned every material heats up slightly differently (has a different specific heat). Heat added to an object = ____ = _________. (If no phase change has occurred.)
- So, Q may be proportional to _____, but ____ has a big effect on how much ____ is observed.

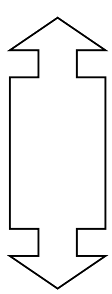
Examples:

Thermoequilibrium and Heat Transfer Processes

- Thermoequilibrium is when two "touching" objects have the same _____________, a.k.a. **on average**, you are equally likely to find high ________ energy particles or _____________ particles anywhere. Thermoequilibrium __________ mean the atoms stop ________________, nor does it even mean that all the atoms have the _________ _____. It just means the energy transferred into a "touching" object __________ the energy received from it.

There are 3 ways thermoequilibrium is achieved: *Diagrams:*

- ____________ -- when two fluids _____ (________ atom can touch ________ atom)
- ____________ -- when two solids ________ (________ atom can touch _________ atom)
- ______________ -- when objects exchange light energy (_____ atom can touch _____ atom)

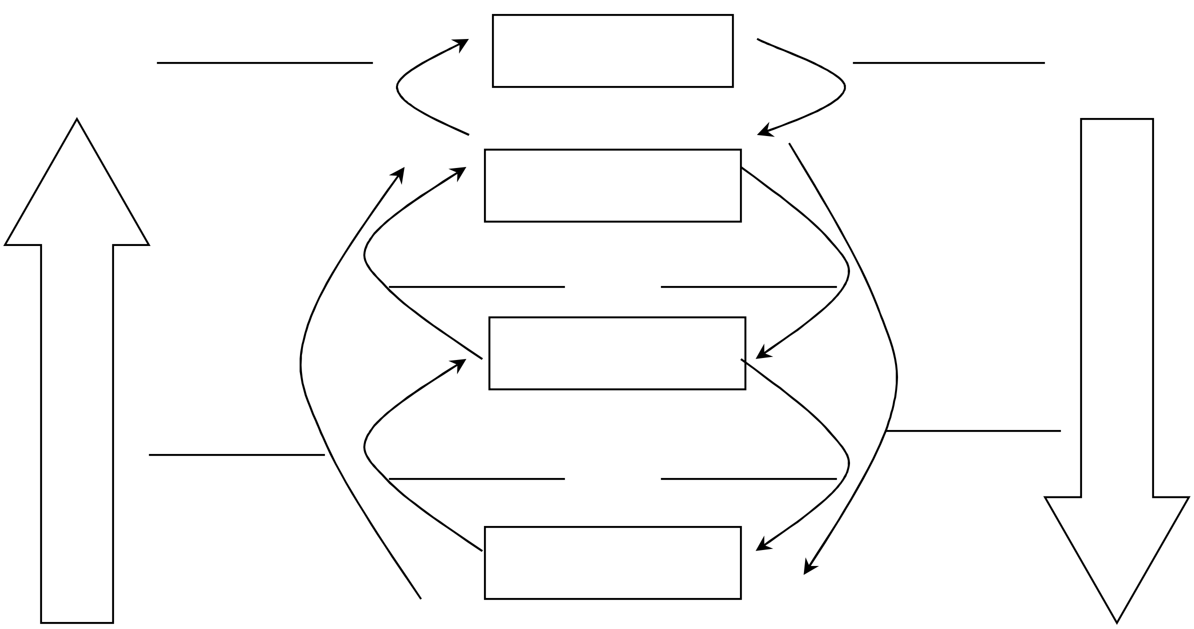


Phases of Matter U4P1c

- As heat is added or _______ from a substance it will change ________. The phase changes with added heat because the _____ of atoms becomes too big for the atomic _______ to hold the current configuration. NOTE: phases are based on _______ type, not on __________. After all, solid _________ is less ________ than liquid _________.
- Solid -- __________ shape, __________ volume, __________ bonds
- Liquid -- __________ shape, __________ volume, __________ bonds
- Gas -- __________ shape, __________ volume, __________ bonds
- Plasma -- same as _______, but electrons and proton are ___________, so ______ form.

Solid	Liquid	Gas	Plasma

Phases Transitions



Measuring Heat Loss/Gain Directly and Using Conservation of Energy U4P1d

- There are two formulas learned from Chemistry that measure heat transfer in/out of a system.
  1. If no phase change occurs: Q = _________ where C is ____________ _______.
  2. If a phase change is occurring: Q = ______ where H is ___________ _______.
- Note: the second formula has no _____, which means that even though heat might be being added to the system, the ________________ in not changing. This might sound odd, until you realize you've observed this every time you get a glass of water at a restaurant. When you first drink from the glass, you are basically ___________ surprised by the temperature. This is because the glass contains both __________ and ________ guaranteeing the temperature is roughly ______. If it were colder, the contents would be ___________, if warmer __________________________. It take heat to __________ _________ in the ice. So, temperature doesn't change until that process is done.

Example:

- When two objects "touch", they come into ____________________. Since energy is never __________ nor _____________, the heat emitted by a hot object _______ the heat __________ by a cold object. NOTE: This does not mean the temperature loss and gain will be equal. Normally a massive object's temperature will change ___________ a light object's temperature.
- Calorimetry uses the knowledge that ________ = ________ or ________ = ________ to learn the mass or specific heat of an unknown object by measuring its temperature change when placed in a known fluid.

Example: