This unit is **Unit 9 - ____________**. What sets this unit apart is the size scale we look at. Last unit we dealt with Kinetic energy of large objects. This one, we still talk about kinetic energy, but it is on an atomic level. Anything that has any temperature above _______ _____ (more on that later) has some wiggle in its molecules, and therefore has molecular kinetic energy. How this totals up, averages out and is transferred is our first topic. To begin, we will differentiate between three similar thermal terms: _________, ______, and ___________.

_____ **energy** is the _______ amount of molecular Kinetic Energy in a substance. Similarly, __________ is the _________ amount of molecular kinetic Energy in a substance. **Heat** is the amount of molecular Kinetic Energy that _______ from one substance to another.

(Those were the definitions, kids!) Note that all three contained the phrase "**Molecular Kinetic Energy**" All molecules wiggle a bit - some a lot. In a ______, the molecules are in a fixed position but still wiggle, kind of like a hyperactive third grader still in his seat. In a ______, the molecules are free to move around, but must be touching other ones at all times, The more wiggle the farther they shove each other outward, like a mosh pit of slam dancers. If the energy is sufficiently high, the molecules go flying off at wild speeds in unknown directions with large spaces between them except for occasional high-speed collisions between particles. These are now _____ molecules. So in a given type of substance, gas molecules are more active than solid ones.

Note also that there were **distinguishing** words in the definitions. The key word for Thermal Energy is **Total**, for Temperature: **Average**, and for heat: **Moves** (you can tell because I made you write them in, silly!) Thermal energy, being concerned with totals, cares about how many molecules we are talking about, and so is _______-DEPENDENT. Averages cancel out the total number, so Temperature doesn't care at all if the substance is large or small, just how hyper each molecule is on average.

If I have a cup of boiling hot water in a mug next to a swimming pool, which one has more thermal energy? Many people want to say the ________, since it sure burns a lot more, but they would be ________. Thermal energy is concerned with total wiggle, remember? If I could grab out one molecule from each container, sure, the hot water one would be much more hyper than the pool molecule, (average wiggle = temperature!) but if I added up the total wiggle of each molecule the pool HAS to win, since there are so many more participants. If I took the starting five from the Spurs into a kinder classroom, the **average** height surely favors the spurs, yet the **total** height of 22 kinder kids totals more than 5 giants, (even Timmy.)

The only way to find Thermal energy is to calculate it, which we will do next time, but the unit will be ???? (__________) Temperature is much more easily measured. We use an instrument known as a ____________. But which type to get? There are three different scales used to measure temperature. The first one was devised by a German named Gabriel ____________, who solved a water quality issue. It was brilliant.

In the Fahrenheit scale, pure water freezes at 32^{o} and it boils at 212^{o}. Weird numbers, but that's what he got with what he started with. Later, scientists devised the metric system, and when they did that, they decided to do a temperature overhaul as well, since pure water was now readily available. This was headed up by a French man named Anders ___________, who named the scale the ___________ scale. (Centigrade means hundred steps... why?) In his scale the freezing point of pure water was set at 0^{o} and the boiling point at 100^{o}. After his death, people decided to honor him by doing the exact opposite of what he asked while alive, and now the scale is also know as the ________ scale. A short time later, two scientists were working on gasses and temperatures and pressures and ended up creating the combined gas law. They also developed a simpler formula they named after one of them, Sir Charles. (Not Barkley) That's not the point. The other thing they figured out when working with gas laws is that they derived a theoretical temperature where the wiggle left the molecule. No wiggle left means that you could never get any colder. You can't get less than zero energy. So they decided to make a new temperature scale that started at this point, which they called _______ _______. It is absolute because it isn't based on some arbitrary value such as freezing point of water, but was based on zero energy. The other scales have negative numbers, but this one cannot. To make conversions simple, they left the degree size identical to centigrade's, so to convert you simply add 273^{o} to the centigrade temperature, since absolute zero turned out to be -273^{o}C. Since Charles got the gas law named after him, we called the temperature scale after his partner, Lord Byron ___________.

Again, to convert: $^{o}C + 273 = ^{o}K$ or $^{o}K - 273 = ^{o}C$ (Kelvins are always bigger!)

Heat has the key word _______! The other two are worried about **internal energy,** but this one is concerned with the energy moving from one object to another. This only happens one direction: from the _____ object to the ______ one. Heat moves in three ways, which we will learn later, but in only that one direction. The reason for this is if you attach a hyper molecule to a sluggish one, the sluggish one could never get slower, making the hyper one faster, they will always move toward _____________ where the fast one slows, speeding up the slow one. Heat is also a simple calculation we will learn next time, and has the same unit as thermal energy which is ????? So if I put a cool object on a hot one heat must move from the hot one into the cold one until they have the same temperature (i.e. equal average wiggle) which we call _______________ __________________.

Lastly, we will briefly overview the concept of __________________. Thermodynamics literally means "motion of heat energy" and it is one of the most studied areas of all science. We've been doing it so far today! Wiser men than I have defined thermodynamics into 2 (3) simple rules (the following are in my words:)

1. All energy must be accounted for either through work or heat or internal thermal energy in or out.

2. All energy moves into less useable forms over time. The fancy word for this is **entropy**, or randomness, and all natural processes move toward entropy. The only way this appears to be violated is when there is a) a plan in place and b) the total energy becomes less useable even though part may become more organized. An example of this is that you eat food and build complex proteins your body needs. This only occurs because you have DNA (the plan) and you must consume like 1000 calories to gain an increase of 300 calories of more organized matter, so the overall effect is still negative. The planet is running down, not winding up. ouch. The big picture says that eventually the entire universe will be a completely unusable 4 degrees Kelvin uniformly distributed across the universe. It also says that outside of the living organism's protections and plans, that complex organic soup you hear about in evolution stories would be destroyed about 1000 times faster than it forms... (an ouch at both ends of the time scale.)

Recently, a 3rd rule has been added by some: You can never truly achieve _________ ______. (but you can get really _________!) Please do problems A for homework.