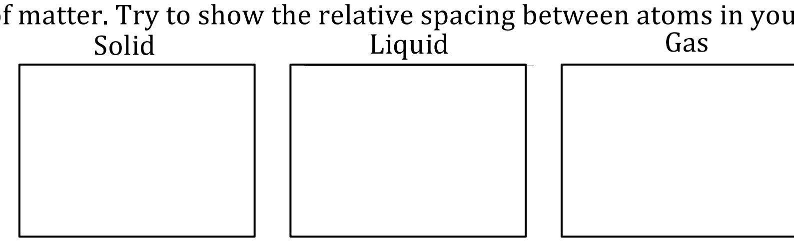
INTERNAL ENERGY

Answer these in a typed document as a group

Use some in class activities, the Internet and/or Chapter 15-18 of Hewitt as resources.

"If, in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generations of creatures, what statement would contain the most information in the fewest words? I believe it is the atomic hypothesis (or the atomic fact, or whatever you wish to call it) that all things are made of atoms—little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another." -- R.P. Feynman

1. Visualizing atoms as little particles that behave as described above will help you to answer some of the questions in this activity. List the key properties of matter and atoms from Feynman's description.
2. Redraw the boxes shown below, and in them, draw 5 or 10 circles to represent a snapshot of atoms in the different states of matter. Try to show the relative spacing between atoms in your picture.



3. What is temperature?
4. On the difference between temperature and thermal energy:
   a. Which has a higher temperature: atoms jiggling slowly, or the exact same atoms jiggling rapidly?
   b. Which has more thermal energy: atoms jiggling slowly, or the exact same atoms jiggling rapidly?
   c. Which has higher temperature: a few atoms jiggling slowly, or a lot of the same kind of atoms jiggling equally slowly?
   d. Which has more thermal energy: a few atoms jiggling slowly, or a lot of the same kind of atoms jiggling equally slowly?
   e. Which has a higher temperature: a hot cup of coffee, or a giant iceberg?
   f. Which has more thermal energy: a hot cup of coffee, or a giant iceberg?
5. A liquid-in-glass thermometer is calibrated so the volume of the liquid lets you read off the thermometer's temperature, because the liquid expands as its own temperature increases, a process called thermal expansion.
   a. Does all matter expand as it increases temperature? Do some substances contract? (Don't guess.)
   b. Is the thermometer telling you its own temperature or the temperature of whatever it is touching? Explain. (Hint: If you place a thermometer in contact with the air but also in direct sunlight, is the thermometer telling you the temperature of the air? Of the sunlight (whatever that means)?)
   c. Why do you have to wait a little while before reading the temperature the thermometer is reporting?
6. The word "heat" means a TRANSFER of energy due to a temperature difference between two things. It is not a type of energy because heat is not stored. Heat is only transferred. When people say heat they often mean thermal energy. The net heat flow is always from a higher temperature object to a lower temperature object.
   i. Describe the different kinds of heat?
   ii. In the simplest possible terms, how does heat conduction transfer thermal energy from hot objects to cold objects? (Why do the colder atoms start jiggling faster during the heat transfer?)
   iii. What property of a material measures how well it conducts heat?
   iv. Why does metal in a room feel colder than wood, or cloth in the same room? Are they at different temperatures?

7. Why does cloud cover lead to a cooler day-time but a warmer night-time (if everything else is the same)? You can Google PhET The Greenhouse Effect for a visual representation.
8. As an object goes through a phase change from a liquid to a gas, does bond energy increase or decrease?
9. A cup of hot coffee sits on a counter and eventually comes to thermal equilibrium with the air surrounding it. What energy type is changing in the coffee during this process (be more specific than just "internal energy")? Is it increasing or decreasing?
10. You set an ice cube on your counter and watch it melt. What energy type is changing in the ice cube during this process (be more specific than just "internal energy")? Is it increasing or decreasing?
11. You vigorously rub your hands together to increase their temperature. Draw two energy pie charts for this process with you as the system (one pie chart at the beginning and one after your hands have "heated up" a little). Ignore things that are not relevant to the process described.
12. A water balloon is dropped from the top of a 2-story building but does NOT break!
    a. Draw 2 energy pie charts for the balloon from when it is dropped to when it COMES TO REST on the ground below. Ignore air resistance. What energy type does the gravitational energy transfer into?
    b. Is there anything in conservation of energy that prevents a water balloon on the ground from spontaneously cooling down and leaping back to the top of that 2-story building? (Hint: no, nothing.) If not, why don't you ever see it? (Hint: the next question addresses this. It relates to the second law of thermodynamics, which you should look up now.)
13. Entropy measures the amount of disorder in a system. It involves counting different ways things can either behave and be arranged. In other words, it deals with statistics. Here is a simplification that captures all the important details for the last question. Imagine the thermal motion of the atoms in your water balloon can roughly jiggle in 6 different directions, like the different faces of a cube: up, down, left, right, front, back. They jiggle randomly, so at any given time they have an equal chance of moving in any of the 6 directions.
    a. Since atoms are so tiny, there are a lot of them…say there are roughly $6x10^{23}$ atoms (600,000,000,000,000,000,000,000) in your water balloon. At any given moment, roughly how many of these are moving toward one of the 6 directions (left, for example), if jiggling is random?
    b. If your water balloon is going to jump up, in which direction do all of them need to move, on average, at a particular time?
    c. Qualitatively, how likely is this to happen? (This helps with question 12ii.)
14. The kinds of processes that increase entropy:
    a. You may have noticed that any process involving friction, or air resistance increases the thermal motion of neighboring atoms. Friction of some kind occurs with basically all macroscopic processes, even if it's small enough to neglect (which we often do). Thinking of entropy as disorder, does entropy increase when the energy of a sliding box (for example) turns into the energy in the jiggling atoms in the box and the floor?
    b. Boiling water lets the water molecules escape and fill the entire room. Thinking of entropy as disorder, does entropy increase when we let atoms that are contained in a small volume spread out throughout a large volume? (What if we were discussing building blocks that a child took from out of their toy chest and flung around the room: would you say the blocks had become more disordered?)
    c. Entropy even increases when a hot object and cold object come to equilibrium. This is the total entropy that increases, that is, the change in the hot object's entropy plus the change in the cold object's entropy. There are two ways you can add 2 numbers together so the sum is positive: 1) they are both positive, or 2) one is a big positive and the other is a small negative. Which of the two is happening here? Support your answer. (Look at your answer to (a) for help.)
15. What are some long-term effects of entropy always increasing in the Universe?
    (Note: a short story by Isaac Asimov called The Last Question discusses some real long-term implications of entropy in the Universe, with some artistic license, of course. It is freely accessible on the Internet and only 9 pages long. It also contains some slight religious subtext, which I am not endorsing, so it is entirely optional.)