Physics **Name:** ____KEY___________________
Date: ______________ **Period:** _______

Matter & Thermodynamics

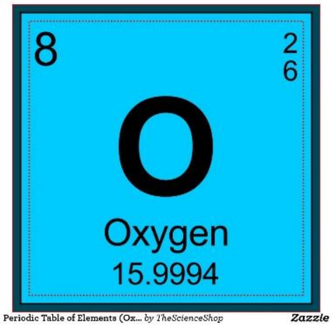
(Unit Review)

Key Vocabulary	
Atom	Liquid
Atomic Mass	Mass Number
Atomic Number	Matter
Boiling point	Melting point
Bose-Einstein condensate	Mixture
Boyle's Law	Molecule
BTU	Plasma
Buoyancy	Random motion
Calorie	Solid
Compound	Specific heat
Condensing point	Sublimation
Conduction	Superconductor
Convection	Surroundings
Density	System
Deposition	Temperature
Element	Thermal energy
Enthalpy	Thermal conductors
Entropy	Thermal expansion
Fluid	Thermal insulators
Freezing point	Thermal radiation
Gas	Thermistor
Heat	Thermometer
Intermolecular Forces	Thermodynamics
Ion	Viscosity
Isotopes	First Law of Thermodynamics
Joule	Second Law of Thermodynamics
Kinetic Molecular Theory	Third Law of Thermodynamics

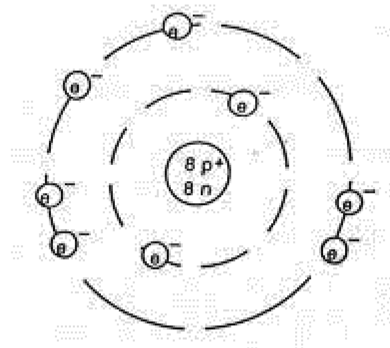
1. What are the four tenants of Dalton's Atomic Theory?
   a. All matter is made of atoms. Atoms are indivisible and indestructible.
   b. All atoms of a given element are identical in mass and properties
   c. Compounds are formed by a combination of two or more different kinds of atoms.
   d. A chemical reaction is a ***rearrangement*** of atoms.

2. List the four fundamental forces at work in the universe. Number them from strongest and weakest (1 = strongest, 4 = weakest).
   the strong force (1), the electromagnetic force (2), the weak force (3), and the gravitational force (4).

3. Draw the square from the period table for Oxygen. Then use it to determine the number of protons, neutrons, and electron. Finally, draw a Bohr Models of the atom.



p^+ = **8**
n^0 = **8**
e^- = **8**



4. Complete the following table using your periodic table.

Name of Element	**Symbol** for Element	**Atomic Number**	**Atomic Mass**	Mass Number	Number of **Protons**	Number of **Electrons**	Number of **Neutrons**
Fluorine	F	9	18.998	19	9	9	10
Calcium Ion	Ca^{+2}	20	40.078	40	20	18	20
Bromine Ion	Br^{-1}	35	79.904	80	35	36	45
Chlorine 36	Cl–36	17	35.453	36	17	17	19
Neon	Ne	10	20.180	20	10	10	10

5. Oxygen consists of three major isotopes, one with 8 neutrons (99.75 percent of natural oxygen atoms), one with 9 neutrons (0.04 percent of natural oxygen atoms), and one with 10 neutrons (0.20 percent of natural oxygen atoms). Calculate the average atomic mass of oxygen.

   (16 x 0.9975) + (17 x 0.0004) + (18 x 0.0020) = 15.96 + 0.0068 + 0.036 = 16.0028

6. Explain just how big an atom is. Keep in mind the size of the protons, neutrons, and electrons and how much space they take up in the atoms.
   Atoms are incredibly small (the diameter of an atom ranges from about 0.1 to 0.5 nanometer). The exact size is difficult to ascertain as the electrons are flying around in the electron cloud. However, the protons, neutrons, and electrons are even smaller and most of the atom is “empty” space (about 99.999999999999%). However, atoms vary from one to the next based on the number of protons, neutrons and electrons. Atoms increase in size going down and left on the period table.

7. Compare and contrast an atom with a molecule, compound, and element.
   A compound can be separated into the individual elements that it is comprised of ($H_2O \rightarrow 2\ H + 1\ O$), and an element can separated into its individual atoms ($H_2 \rightarrow 2\ H$). An atom represents the smallest possible part of an element that still retains the properties of that element. The sub-atomic particles that represent the individual components of an atom no longer possess the same properties as the element from which they came.

8. State the lowest possible temperature in Celsius and in Kelvin.
   -273°C and 0K

9. Compare and contrast the mass number with the atomic mass.
   Mass number is the number of protons and neutrons in an atom, and it tells us about the mass of the atom in amu, or atomic mass units. Atomic mass is the average mass of all the isotopes of a certain type. It is a weighted average that takes into account the abundances of all of the different isotopes.

10. What is the Kinetic Molecular Theory? Explain how this relates to temperature and intermolecular forces.
    Kinetic Molecular Theory states that particles are in constant motion and exhibit perfectly elastic collisions. As such, the movement of the molecules is directly related to the temperature of the material. The more movement, the higher the temperature. There is constantly an ongoing battle between the movement of the molecules and the intermolecular forces between the molecules. Temperature wants to push the molecules apart and intermolecular forces want to pull the molecules together. The state of matter of a material is dependent on which force is "winning" this battle. Solids are more stable and less fluid due to stronger intermolecular forces. Liquids are less stable and more fluid due to weaker intermolecular forces. Gasses are even less stable and even more fluid due to the weakest intermolecular forces as the particles are pushed farther apart due to greater movement (higher temperature).

11. What is the relationship between heat added to a system, change in its internal energy, and external work done by the system? (HINT: First law of thermodynamics)
    If heat is added to a system, then its internal energy will increase (think about the relationship between temperature and movement of the molecules). If work is done by the system, then its internal energy must decrease (work requires energy; if work is performed, the energy to do some must come from the system decreasing available energy). Energy is never created or destroyed.

12. What is the difference between heat and internal energy?
    Heat is the measure of energy transferred between objects at different temperatures. Internal energy measures the energy that is inside the object as kinetic energy of the object's constituent particles and potential energy between them. An object that is perfectly insulated from the outside world would have some internal energy (how much depends on its temperature), but would have no heat.

13. List the three primary states of matter and describe their shape and volume.
    Solid, liquid, gas. Solid: fixed shape and volume. Liquid: variable shape, fixed volume. Gas: variable shape, variable volume.

14. What generally happens to the temperature of rising and sinking air? Explain.
    Rising air is surrounded by air of lower pressure and it therefore expands. Because it expands, it does work. Since it does work it must loose energy. Therefore, its temperature decreases. When air sinks, it is surrounded by air of higher pressure. The surrounding air compresses it, doing work to the sinking air. Since work is done to it, the sinking air gains energy and its temperature increases.

15. What is the density of a piece of wood that has a mass of 25.0 grams and a volume of 29.4 cm^3?
    Density = mass / volume
    Density = 25.0 g / 29.4 cm^3
    Density = 0.85 cm^3

16. A little aluminum boat (mass of 14.50 g) has a volume of 450.00 cm^3. The boat is place in a small pool of water and carefully filled with pennies. If each penny has a mass of 2.50 g, how many pennies can be added to the boat before it sinks? (HINT: density of water = 1g /cm^3)
    Density = mass / volume

$1\ g/cm^3 = (14.5g + 2.5x) / 450\ cm^3$
450 g = 14.5g + 2.5g x
435.5 g = 2.5g x
174.2 = x

So 174 would still keep the boat afloat. 175 pennies would cause it to sink.

17. Why do some materials have a higher specific heat than other materials?
The specific heat of the material measures how much energy has to be added to raise the temperature of 1 kg of the material by 1 °C. Raising the temperature of any material by 1 °C raises the energy of each particle in that material by the same amount (on average). If it takes more total energy to raise 1 kg of some material that means that there must be more particles soaking up the energy and it takes more total energy to raise each of those particles by the right amount. Therefore, materials with smaller molecules typically have a higher specific heat since there are more molecules making up the 1 kg.

18. Why is the second law of thermodynamics necessary? Why isn't the first law of thermodynamics enough?
The first law of thermodynamics is just a statement of the law of conservation of energy. But there are many processes which obey the law of conservation of energy, that we never see happen. For example, we never see a glass of water sitting on the counter cool down and start freezing in one half while the other half heats up and boils. This would be possible according to the law of conservation of energy as long as the energy lost by the freezing water is equal to the energy gained by the boiling water. The second law of thermodynamics is there to explain why such events never happen in our experience.

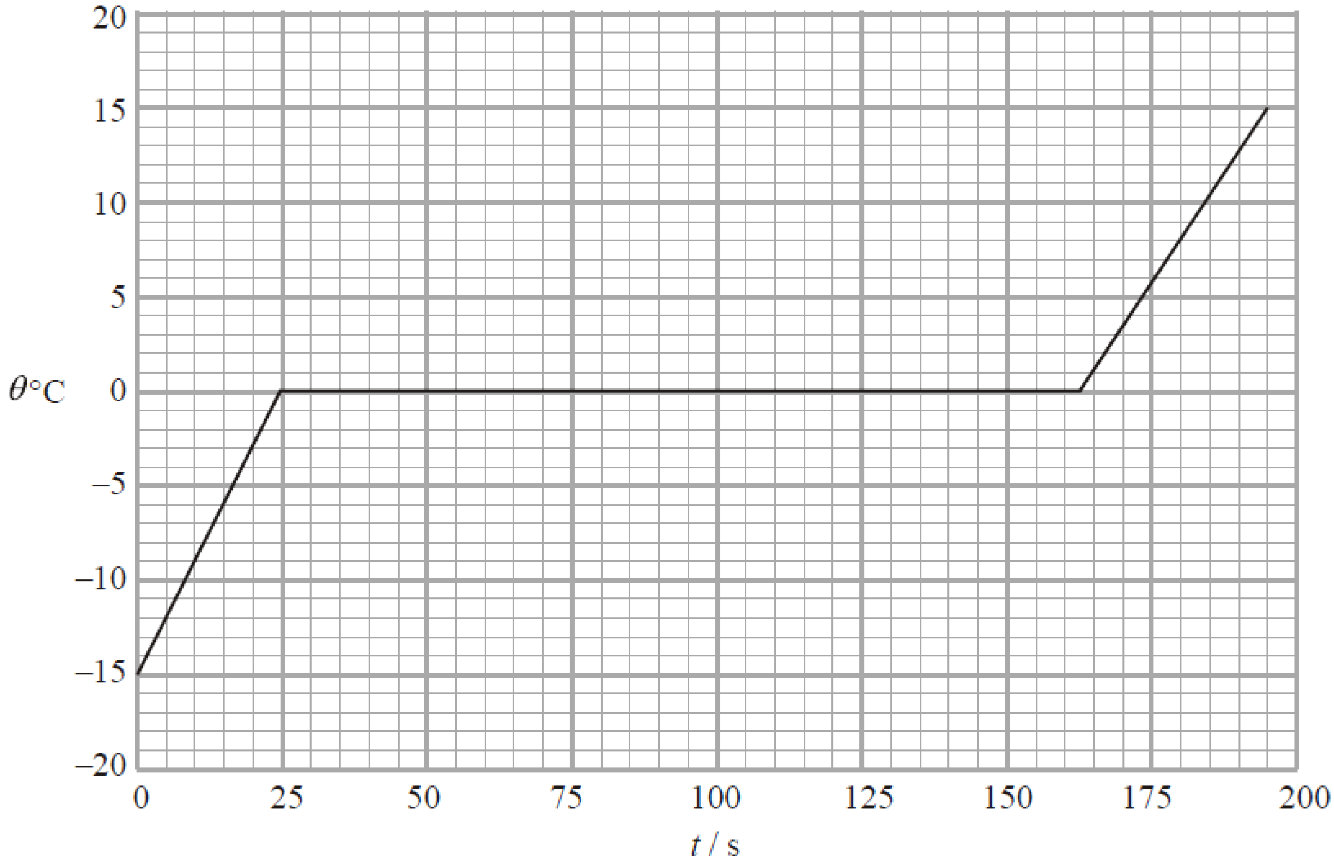
19. A gas occupies 1.56 L at 1.00 atm. What will be the volume of this gas if the pressure becomes 3.00 atm?
$P_1V_1 = P_2V_2$
(1.56 L)(1.00 atm) = x (3.00 atm)
1.56 L • atm = (3.00 atm) x
0.52 L = x

20. Aluminum metal melts at 660.37 °C. What is the temperature in Kelvin? In Fahrenheit?
660.37°C = 933.52K = 1220.666°F

21. Body temperature is 98.6 °F. What is the temperature in °C? In Kelvin?
98.6°F = 37°C = 310.15K

22. This question is about the change of phase (state) of ice. A quantity of crushed ice is removed from a freezer and placed in a calorimeter. Thermal energy is supplied to the ice at a constant rate. To ensure that all the ice is at the same temperature, it is continually stirred. The temperature of the contents of the calorimeter is recorded every 15 seconds.

The graph below shows the variation with time t of the temperature θ of the contents of the calorimeter.



a. On the graph above, mark with an X, the data point on the graph at which all the ice has just melted.
(165, 0)

b. Explain, with reference to the energy of the molecules, the constant temperature region of the graph.
In order to change the phase of the material, the separation of the molecules must increase, so all the energy input goes to increasing the PE of the molecules (overcoming the intermolecular forces), thus KE of the molecules remains constant, hence temperature remains constant.

c. The mass of the ice is 0.25 kg and the heat applied to the system is 7848 J. Use information from the graph to determine the specific heat capacity of ice. (HINT: Use t=0 to t=25)
$Q = cmT$
7848 J = c (0.25 kg) (15°C)
7848 J = c (3.75kg°C)
2092.8 J/ kg°C = c

d. State what property of the molecules of the ice is measured by a change in entropy.
Entropy measures the degree of disorder / order (of the molecules of the ice).

e. State, in terms of entropy change, the second law of thermodynamics.
In any process the overall entropy of the universe / a closed system increases.

f. State what happens to the entropy of water as it freezes. Outline how this change in entropy is consistent with the second law of thermodynamics.

The entropy of the system decreases. When water freezes it gives out energy (heat), therefore the speed (KE) of the surrounding air molecules increases. The air surrounding the ice is therefore in a more disordered state than that of the ice itself. Therefore, the disorder (or entropy) of the universe increases.

23. A 200 W microwave runs for 30 s on a coffee cup containing 150 g of water. If the water is at 20 °C when it is placed in the microwave, how hot is it when it comes out? (Pretend that all the microwave oven's energy is transferred to the water. Ignore the cup or anything else in the microwave. The specific heat of water is 4184 J/kg°C.)
The power of the microwave can be expressed as energy per unit time (J / s). As such a 200 W microwave running for 30 s produces 6000 J of energy (200 J / s • 30 s = 6000 J). We can figure out the final temperature of the water using the specific heat equation.
$Q = cm(T_f - T_i)$
$6000\ J = (4184\ J/kg°C)\ (0.15kg)\ (T_f - 20°C)$
$6000\ J = 627.6\ J/°C)\ (T_f - 20°C)$
$9.56°C = T_f - 20°C$
$29.56°C = T_f$

24. When a chicken develops inside an egg, the entropy of the egg and its contents decreases. Explain how this observation is consistent with the second law of thermodynamics.
While the system may become increasingly ordered, the entropy of the surroundings increases by a greater factor since the process gives off thermal energy.

25. How does the second law of thermodynamics relate to the direction of heat flow?
The second law of thermodynamics states that left to itself, a systems entropy will increase. A consequence of this is that net heat flow is from higher temperature objects to lower temperature objects. This happens because of the transfer of kinetic energy during the random collisions of atoms and molecules.

26. According to the second law of thermodynamics, is the universe moving to a more ordered or to a more disordered state?
While there may be isolated pockets of the universe that are becoming increasingly ordered, the universe as a whole is moving toward a more entropic or disordered state.

27. Explain how well conduction works in space and why.
In space conduction is almost entirely nonexistent. Conduction works through the collision of particles or molecules. Since there is very little matter in space, there is limited ability to transfer the energy in space via collisions and hence conduction.

28. Explain chaos theory and how it relates to the "butterfly effect".
Chaos Theory is a mathematical discipline that studies complex systems. This is important because there are many systems throughout science, art, and so on that contain so many elements or variables that change that it is difficult to predict the outcome unless ALL of the factors are known and thus outcomes seem chaotic or unpredictable. Even with the advent of computers calculating various possibilities based on many variables some systems are so complex that knowing ALL variables becomes near impossible. The butterfly effect suggests that very small changes in the initial parameters of a system can have a great impact on the final outcome, or as the saying goes "a butterfly flaps its wings in Australia and a hurricane is born that strikes the US." While an overt overstatement, the idea of a simple change having major ramifications is useful in many fields including physics (especially when dealing with quantum mechanics).

29. Summarize the meaning of the Heisenberg Uncertainty Principle and explain why it has been applied across so many different fields and areas of interest.
    The Heisenberg Uncertainty Principle says that the position and the velocity of an object cannot both be measured exactly, at the same time, even in theory. The very concepts of exact position and exact velocity together, in fact, have no meaning in nature. Much of this stems from the idea that observing the outcome for one changes the outcome for the other (known as the observer effect). The concept of the observer effect and incorrectly by relation the Heisenberg Uncertainty Principle, have been applied across many fields and areas of interest because of the idea that observing any event has a direct impact on its outcome.

30. Explain the idea of emergence and how it can be used to simulate complex systems.
    Emergence is a process whereby larger entities, patterns, and regularities arise through interactions among smaller or simpler entities that themselves do not exhibit such properties. The idea is that it is possible to use simple local rules to generate higher levels of organization from the parts of a system interacting as a whole. The idea of greater and more complex patterns arising from simple rules is known as emergent complexity and is the basis for development of AI as well as much modeling in natural systems.

31. What is Brownian motion and how does it relate to thermodynamics?
    In essence thermodynamics studies the movement of energy and how energy instills movement. Einstein asserted that the Brownian motion originates in the continual bombardment of the particles by the molecules of the surrounding fluid, with successive molecular impacts coming from different directions and contributing different impulses to the particles. As a result of the continual collisions, the particles themselves had the same average kinetic energy as the molecules. This being the case the amount of Brownian motion is related to the number of collisions within the fluid and the kinetic energy of those collisions – in other words, their temperature.