KMT and Gas Laws Review Sheet

To completely answer any of the below questions be sure to talk about what is going on at an atomic level. Think about these general questions whenever answering:
- Are atoms or molecules colliding?
- Is energy being exchanged?
- If so, what is getting energy and what is losing it?
- Is equilibrium important for answering this question? If so, which kind?
- Have you talked about collisions of molecules if you are talking about gas pressures?

Simple Atomic Motions and Interactions
- 1) Describe how atoms move?
- 2) What is Brownian Motion?
- 3) What is kinetic energy and what would you need to know to determine how much kinetic energy something has?
- 4) How can an atom or molecule lose or gain kinetic energy?
- 5) Describe the interactions between two atoms or molecules when they collide.

Equilibrium
- 6) Describe spatial equilibrium.
- 7) Describe thermal equilibrium.
- 8) A balloon has been inflated and now sits on a table not moving or changing in any way. However, it can be considered to be in equilibrium with various gas pressures. Describe what pressure equilibrium is in this case.
- 9) Cells allow some substances to freely diffuse into and out of them. Sodium for example is sometimes allowed to do this for certain cells. The process of how the sodium moves into and out of a cell under these circumstances is called diffusion. If there is sodium both inside and outside of a cell, but a higher concentration outside:
  - a) Describe what happens to the concentrations of sodium both inside and outside of the cell as time progresses
  - b) Equilibrium will eventually be reached. Describe what equilibrium looks like at an atomic level.
  - c) Nerve cells somehow maintain higher concentrations of sodium outside and potassium inside of their cells. Can you think of a way they might be able to prevent these ions from reaching equilibrium?

Heat and Temperature
- 10) What is the difference between heat and temperature?
- 11) Explain how it is possible for two things to be at the same temperature, but for one object to have more heat energy.
- 12) Why can a slow moving molecule be at the same temperature as a fast moving molecule? What must be different about those molecules?
- 13) When a substance reaches thermal equilibrium, what is true of the kinetic energies of the atoms? How does this relate to temperature?

- 14) Why do all non-living things eventually become the same temperature as their surroundings?
- 15) Why does getting hit with a drop of boiling water not burn you, but having a whole cup of boiling water hit you will cause major tissue damage?
- 16) Explain why IT DOES NOT MAKE SENSE to say something is radiating “cold energy”.

Gasses

- 17) How do gasses exert a pressure?
- 18) List three factors that affect the pressure of a gas.
- 19) Explain why there is no such thing as suction.
- 20) Why do your ears pop when you go on a plane?
- 21) What is the difference between pressure and force?
- 22) Explain why a bicycle tire needs to have much higher pressure than a car tire even though the bicycle tire doesn’t need to support as much weight.

Answers

Simple Atomic Motions and Interactions

- 1) They move in a straight line until they hit another atom.
- 2) The random path followed by atoms or molecules as they are bumped into by other atoms and/or molecules.
- 3) Kinetic energy is the energy of motion. The mass and velocity of an object determines its kinetic energy. The more mass or higher velocity an object has the more kinetic energy it has.
- 4) Energy is always conserved so the only way an atom or molecule can lose or gain kinetic energy is by either transferring its kinetic energy to other molecules (or getting from other molecules) or by converting its kinetic energy into some other form of energy.
- 5) When two atoms collide the one with lower kinetic energy usually gets energy from the one with higher kinetic energy.

Equilibrium

- 6) Spatial equilibrium decries a state in which the average number of atoms or molecules in a particular area is the same wherever you look. It is a dynamic state in which the atoms and molecules continually move but maintain a concentration of particles that doesn’t change.
- 7) At thermal equilibrium all parts of a substance are at the same temperature, which means all the atoms have the same average kinetic energy. It is like spatial equilibrium in the sense that the kinetic energy is spread out “evenly” between the atoms. This does not mean they all have the same kinetic energy, but that the average is the same.
- 8) Pressure equilibrium is such that two pressures balance each other out. The balloon does not get bigger or smaller because it is being hit by molecules both inside and outside so that both sides of the balloon wall feel the same pressure. The size of the balloon remains constant even thought it is continually being bombarded by molecules trying to push it in and out.
- 9) a) If there is sodium both inside and outside of the cell then sodium atoms will move both into and out of the cell. However, if the concentration of sodium is greater outside of the cell then there will be a better chance that, just through random Brownian motion, a sodium atom will go into the cell rather than come out. Therefore, more sodium will go in than will come out, eventually reaching spatial equilibrium through the process of diffusion.
  b) Equilibrium is reached when the rate of sodium going into and out of the cell is equal. The concentration of sodium atoms inside and outside of the cell will be equal even though it is not the same sodium atom all of the time in the same place.
  c) There must be some active mechanism that is pushing sodium atoms out of the cell and potassium atoms into the cell. Otherwise they would naturally reach spatial

equilibrium through diffusion.

Heat and Temperature

- 10) Temperature describes the AVERAGE kinetic energy of atoms or molecules, and heat is a measure of the TOTAL kinetic energy from adding up all the kinetic energy of each of the atoms.
- 11) Temperature is just the average kinetic energy. You can have only 2 or 3 molecules with an average kinetic energy (or temperature) that is the same as several thousand molecules. Because they have the same average kinetic energy they have the same temperature. However, the heat energy is the total kinetic energy, so the batch of several thousand molecules will total up to a lot more kinetic energy than the 2 or 3 that are at the same temperature.
- 12) To be at the same temperature they must have the same average kinetic energy. Kinetic energy is determined by both mass and velocity. So, if they have the same energy but one is moving faster, it must be lighter. For example, a bowling ball and a tennis ball can have the same kinetic energy only if the tennis ball is moving faster. If two molecules are at the same temperature, then they have the same kinetic energy, thus the lighter one would be moving faster.
- 13) At thermal equilibrium the average kinetic energies of all the atoms are equal. Because temperature IS a measure of the average kinetic energy, being in thermal equilibrium means all the atoms are at the same temperature.
- 14) Atoms are continually in motion and colliding with each other, so as they collide they can transfer kinetic energy. Atoms with more kinetic energy generally give energy to colliding atoms that have less kinetic energy. Eventually, the average energy of all the colliding atoms becomes the same and thermal equilibrium is reached. Some living things convert chemical energy in food to heat energy, so that they constantly increase the kinetic energy of their own atoms and molecules.
- 15) The drop and cup have the same temperature, but the cup has more molecules so it carries more heat energy than the drop. Heat energy can cause tissue damage so the cup does more damage.
- 16)There is no such thing as cold energy. Something that is cold just has less heat energy. Its molecules are moving slower so when we touch it, heat energy is transferred through collisions with our warm molecules to the cold molecules. So, the molecules in our fingers slow down and become cooler because they gave some of their kinetic energy to the cooler molecules, not because they got cold energy from the cold molecules.

Gasses

- 17) Through the impacts of their molecules.

- 18) a) The number of molecules. The more molecules there are the more impact and the greater the pressure.
  - b) The temperature of the molecules. The higher the temperature the faster the average molecule is moving, so it will hit harder and more often causing more pressure.
  - c) The size of the container for the gas. If you make a container smaller then the gas molecules will be closer together and hit the sides more often, causing an increase in the pressure.
- 19) Suction implies there is some pulling forces. However, the appearance of "suction" only occurs with gasses which are made of atoms and molecules bouncing around. The only thing the molecules can do is push on things. Whenever some pulling force of suction seems to be happening, it is really the unbalanced pressures of two gasses with one gas having higher pressure than another. For example, breathing happens because we make our lungs bigger, which gives the molecules inside our lungs more room. This causes them to hit the sides less often, lowering the pressure inside our lungs. However, the outside air pressure is the same as it was before, so the higher pressure outside air molecules push there way into our lungs. We just make the space for the outside air molecules to push their way into our lungs.

- 20) As you go higher in the atmosphere the pressure decreases because the air molecules are more spread out. If the air molecules are more spread out then they collide with my ears less frequently, so the pressure is lower. As the pressure lowers outside my ears the air pressure inside is higher, so my ears pop as some gas leaves them to form a pressure equilibrium.
- 21) Pressure describes how much force is on a specific area. It is calculated as

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

- 22) The bicycle tire has much less area touching the ground, so the pressure needs to be a lot higher to exert a force on that small area big enough to hold up the bicycle and rider. The car has much bigger tires and a much larger area over which the tire pressure is exerted. This causes the overall force (weight) of the car to be distributed over a larger area, so each piece of that area only needs to carry a fraction of taht weight. See example below.

Person + Bike = 200 lbs
<u>(total force due to gravity)</u>

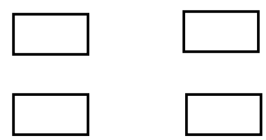
bike tires only touch the ground
in two small areas

each area is 1 in^2

so that small total area has to support about 200 lbs. If the pressure is $100\,\frac{lbs}{in^2}$ then the two areas above with a total area of 2 in^2 can support 200 lbs.

Person + Car = 4000 lbs
<u>(total force due to gravity)</u>

car tires touch the ground
in a much larger area



each area is 25 in^2

so the larger total area will support about 4000 lbs. If the pressure is $40\,\frac{lbs}{in^2}$ then the four areas above with a total area of 100 in^2 can support 4000 lbs.