Chapter 4 – Viscosity

**States of Matter**

The essentials of life – food, water, and air – are examples of substances that occur in the three different states of matter: solid, liquid, and gas.

**Solid**: Solid is the state of matter of a substance that has a definite shape and volume (for example, a sugar cube).

**Liquid:** Liquid is the state of matter of a substance that has a definite volume, but no definite shape (for example, water).

**Gas:** Gas is the state of matter of a substance that has neither a definite shape nor a definite volume (for example, oxygen).

By using the particle theory, you can explain why liquids and gases flow but solids do not.

**The five major points of the particle theory of matter are:**

1. All matter is made up of very small particles.

2. All particles in a pure substance are the same. Different substances are made of different particles.

3. There is space between the particles.

4. The particles are always moving. As the particles gain energy, they move faster.

5. The particles in a substance are attracted to one another. The strength of the attractive force depends on the type of particle.

Draw the picture from page 111 in the box below. (Be neat! You’ll need this picture to study for your test!)

Gas Liquid Solid

The liquid is held in a container. You have probably notices that liquids take the shape of the container in which they are placed.

This solid cube of sugar does not need a container to keep its shape.

According to particle theory, the particles of a gas will completely fill a container. If you removed the stopper in this flask, what would happen to the gas.

**Particles in Solids**

According to the particle theory we can think of solids as being made up of particles that are tightly packed together, like bees in a hive. This way of thinking about the particles of a solid can explain why solids are greatly affected by gravity. It explains why a solid will tumble toward the lowest surface when suspended in the air and then dropped. The particle theory suggests that the particles of a solid are so close together that they cannot move around freely – they can only vibrate.

Many solids can be ground together into such small pieces that they can slip past each other when they are poured out of their containers. Sugar, salt, flour, powdered cleansers and detergents, and many other crystals and powders that we use every day are examples of solids that can be poured. However, according to the particle theory, each tiny fragment of these solids contains billions of even smaller particles that are tightly packed together. Thus, each tiny fragment is also like a miniature solid in itself. This explains why solids form a pile when they are poured and why they do not keep flowing apart from each other.

**Particles in Liquids**

Again, according to the particle theory, the particles that make up liquids have enough energy to pull away from each other and slide around each other, while at the same time vibrating close together in small clusters. Another way to think about what is happening on the level of the particles is to imagine groups of guests talking and dancing at a party. The party guests can move around by shifting as a group, or by flowing in between the other groups of party goers. Similarly, liquid particles can slip past each other. Unlike the particles in solids, they do not form rigid clumps. As a result, the particles of a liquid cannot hold their shape; instead, they fill a container and take the shape of that container.

As in solids, liquid particles are so tightly packed together that they are easily affected by the downward pull of gravity. Therefore, liquids always flow to the lowest possible level, like the water flowing over a waterfall. As well, liquids form a level surface when they are at rest. Some foods, like chocolate and ice-cream, can be melted to form a gooey liquid. Many other substances, such as water, oil, syrup, and perfume, are liquids at room temperature.

**Particles in Gases**

All liquids can be transformed into their gaseous states when the liquids are heated. Many substances are gases at room temperature; for example, the air around you is gas. According to the particle theory, gas particles are so far apart from each other that there is an enormous amount of empty space between them. Imagine that you and a friend are as far apart from each other as possible in a baseball stadium, and no one else is there. This is similar to what it would be like to be a gas particle. In fact, the particle theory explains that most gases seem invisible to you because you are observing mostly unique space. The particle theory also explains why gas particles have no difficulty moving past each other, and why they flow very easily.

**Particles in Gases**

All liquids can be transformed into their \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ states when the liquids are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Many substances are gases at room temperature; for example, the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ around you is gas. According to the particle theory, gas particles are so \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ from each other that there is an \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ amount of empty space between them. Imagine that you and a friend are as far apart from each other as possible in a baseball stadium, and no one else is there. This is similar to what it would be like to be a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. In fact, the particle theory explains that most gases seem \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to you because you are observing mostly empty space. The particle theory also explains why gas particles have no \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ moving past each other, and why they flow \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

The \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ suggest that gas particles are so free to move that they do so in every \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and they have a great deal of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to move extremely far apart. Therefore, gas particles spread out so much that in a brief time, they fill up the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of an entire \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. For this reason, gases, like liquids, take on the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of the container in which they are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. However, gases do not flow to the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ possible level as do liquids. Because gas particles are not \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or tightly packed together, the energy of gas particles allows them to move in all directions, sometimes against \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and to remain \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. For example, water vapour forms \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ that float in the sky. Unlike what happens to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, when the lid is taken off a container of gas, the gas particles will start to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ apart again, until they have \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the entire room or building. The particle theory can be used to explain how gases \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ all the space that they can fill – up, down, or sideways.

We have learned that the behavior of \_\_\_\_\_\_\_\_\_\_\_\_\_ particles as they spread out in all directions is known as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Diffusion is the movement of particles from an area of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ concentration to an area of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ concentration of the same substance. For example, the particles in perfume vapour begin to move away from the perfume bottle (where there is a high concentration of perfume particles) when it is opened, until the perfume can be smelled across the room (where there is a low concentration of perfume). As we know, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ can occur in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ as well. You have probably seen cream added to coffee. In seconds, without stirring. Stirring with a spoon simply allow the cream to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ more quickly.

**Changes of State**

As you may recall from earlier studies, the process of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is an example of a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, which occurs when the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ state of a substance is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ into another state. The change from \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is called melting, and the change from liquid to gas in called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. These changes of state occur when the substance is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and the particles of the substance gain \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. If you were to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the substance, the reverse changes of state would occur because the particles \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ energy. The change from gas to liquid is called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and the change from liquid to solid is called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

An unusual change of state occurs when a solid turns into its \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ state \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ going through the liquid state. This change of state is known as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. An example of sublimation occurs when dry ice is used at a rock concert – a chunk of frozen carbon dioxide (a solid) gains energy and gives off a thick cloud of fog (carbon dioxide gas). The change from a gas directly to a solid is called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ as well. An example of this is when \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ forms on windows on bitterly cold days (water vapour in the air loses energy rapidly and forms snowy ice).

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is slow vaporization. It occurs over a wide range of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. A wet towel will dry even if the air temperature is not high. On a cool day it will simply take \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ for the water to evaporate from the towel.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ vaporization. It occurs at a specific temperature, called the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ point. The boiling point of water is 100˚C (at sea level). Similarily, every substance has its own \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ point and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ point. The freezing point of water for example, is 0˚C (at sea level). This is the temperature at which liquid water freezes. It is also the temperature at which ice melts – its melting point.