Competitive Exams: Matter

One of the main quests of science throughout the ages has been to discover what matter is made of-and what holds it together. All matter is made out of many tiny particles called atoms. The study of how these atoms interact is called chemistry. Modern physics has discovered how atoms are made up of smaller particles and how these particles interact to build atoms into molecules and larger objects of matter.

The philosopher Democritus came very close to our modern understanding when he proposed that everything is made up of very small particles, which he called atoms, from the Greek atomus, for 'indivisible'

In the 1600s, Sir Isaac Newton and other scientists experimented with materials, light, and heat, and developed many basic laws of physics. By the early 1800s, the theory of the atom became popular. By the 1900s, scientists had discovered that atoms are themselves made of even smaller particles. This century research in particle physics has taken us deep into the heart of the atom, far beyond the limits of the most powerful conventional microscopes.

The Building Blocks of Matter

What is matter made of? If you could see the smallest piece of matter, what would it look like? If you cut a piece of material into halves, and cut one of the halves into halves, and then continued cutting halves into halves-assuming you had a very fine blade and a very powerful microscope-could you continue cutting forever?

Until very recently, there was no microscope powerful enough to see the 'building blocks' of matter. But scientists were able to deduce that there were fundamental particles, which they called atoms (for indivisible), by performing experiments such as firing electrons into targets and seeing how the pieces came out:

Atoms are extremely small particles, out of which all matter is made. They are the smallest particles of a chemical element that still have the properties of that element.

A typical atom is about one millionth of a millimetre across-a million of them laid in a line would measure one millimetre across. The lightest atom is that of hydrogen, while one of the heaviest is that of uranium-about 200 times heavier than hydrogen.

Splitting large atoms into smaller ones or 'fusing' small ones to create larger ones, releases energy-this is what happens inside nuclear reactors and atom bombs (fission) and inside hydrogen bombs and the sun (fusion).

SI Base Units

Matter consists of atoms held together by electromagnetic forces. How tight these bonds are determines which of the four states: Solid, liquid, gas or plasma, matter exists as. Plasmas are only found naturally in the coronae and cores of stars. They can also be created experimentally in laboratories such as JET.

As the atoms move faster, the distances between them increases. Heating increases the motion of atoms and causes the matter to go from solid (ice) to liquid (water) to gas (vapor).

Heat and temperature is explained in atomic theory as the motion of the atoms (faster = hotter).

Pressure is explained as the momentum transfer of those moving atoms on the walls of the container (faster atoms = higher temperature = more momentum/hits = higher pressure).

In the physical sciences, a phase is a set of states of a macroscopic physical system that have relatively uniform chemical composition and physical properties (i.e.. Density, crystal structure, index of refraction, and so forth).

The most familiar examples of phases are solids, liquids, and gases. Less familiar phases include: Plasmas and quark-gluon plasmas; Bose-Einstein condensates and fermionic condensates; strange matter; liquid crystals; superfluids and supersolids; and the paramagnetic and ferromagnetic phases of magnetic materials.

Phases are sometimes called states of matter, but this term can lead to confusion with thermodynamic states. For example, two gases maintained at different pressures are in different thermodynamic states, but the same “state of matter”

Fluids and Gases

A subset of the phases of matter, fluids include liquids, gases, plasmas and, to some extent, plastic solids. Fluids are divided into liquids and gases.

- Liquids form a free surface (that is, a surface not created by their container) while gases do not.
- A gas is one of the four main phases of matter (after solid and liquid, and followed by plasma), that subsequently appear as a solid material is subjected to increasingly higher temperatures. Thus, as energy in the form of heat is added, a solid (e. g. Ice) will first melt to become a liquid (e. g. Water), which will then boil or evaporate to become a gas (e. g. Water vapor). In some circumstances, a solid (e. g. “dry ice”) can directly turn into a gas: This is called sublimation. If the gas is further heated, its atoms or molecules can become (wholly or partially) ionized, turning the gas into a plasma.

Surface Tension

Certain substances can break down surface tension in a liquid. In this experiment, the surface tension of the milk initially holds the drops of food colouring in place. However, what will happen lo the drops of food colouring when you add washing-up liquid to the dish? You will need: Shallow dish; milk; two eye-droppers; food colouring; washing-up liquid.

- Pour milk into a shallow dish and leave it to warm up to room temperature. Using an eye-dropper, carefully squeeze a few drops of different food colourings onto the surface. Notice that the drops of food colouring form separate circles on the surface. The food colouring does not break the surface tension of the milk.
- Using a different dropper, squeeze some washing-up liquid onto the milk. Watch the colours spread as the flexible skin on the milk starts to break down where the drops of washing-up liquid fall. The stronger surface tension around the edge of the dish then pulls the milk and food colouring outwards.

Air Streams

Another aspect of fluid flow is that the pressure in a fluid drops as it moves faster. This is known as the Bernoulli effect, named after the Swiss mathematician Daniel Bernoulli (1700 – 82). We can use this theory to explain how we are able to make a ping-pong ball hover in the air. You will need: a hairdryer set to “cool” a ping-pong ball.

- Hold a hairdryer so that it points upwards. Place the ping-pong ball in the middle of the airstream.
- You'll find that the ball will stay put. In the middle, the air flows faster (less pressure) than it does at the edges (higher pressure). The higher pressure always pushes the ball back.