Extensive and intensive properties worksheet with answers

Properties of matter can be classified as either extensive or intensive and as either physical or chemical. Recognize the difference between physical and chemical, and intensive and extensive, properties Key Takeaways Key Points All properties of matter are either physical or chemical properties and physical properties are either intensive or extensive. Extensive properties, such as mass and volume, depend on the amount of matter being measured. Intensive properties, such as density and color, do not depend on the amount of the substance present. Physical properties can be measured without changing a substance’s chemical identity. Chemical properties can be measured only by changing a substance’s chemical identity. Key Terms intensive property: Any characteristic of matter that does not depend on the amount of the substance present. extensive property: Any characteristic of matter that depends on the amount of matter being measured. physical property: Any characteristic that can be determined without changing the substance’s chemical identity. chemical property: Any characteristic that can be determined only by changing a substance’s molecular structure. All properties of matter are either extensive or intensive and either physical or chemical. Extensive properties, such as mass and volume, depend on the amount of matter that is being measured. Intensive properties, such as density and color, do not depend on the amount of matter. Both extensive and intensive properties are physical properties, which means they can be measured without changing the substance’s chemical identity. For example, the freezing point of a substance is a physical property: when water freezes, it’s still water (H_2O)—it’s just in a different physical state. Solid, liquids, and gases: Water can exist in several states, including ice (solid), water (liquid), and water vapor (gas). A chemical property, meanwhile, is any of a material’s properties that becomes evident during a chemical reaction; that is, any quality that can be established only by changing a substance’s chemical identity. Chemical properties cannot be determined just by viewing or touching the substance; the substance’s internal structure must be affected for its chemical properties to be investigated. Physical Properties Physical properties are properties that can be measured or observed without changing the chemical nature of the substance. Some examples of physical properties are: color (intensive) density (intensive) volume (extensive) mass (extensive) boiling point (intensive): the temperature at which a substance boils melting point (intensive): the temperature at which a substance melts Physical properties: Matter has mass and volume, as demonstrated by this concrete block. You can observe its mass by feeling how heavy it is when you try to pick it up; you can observe its volume by looking at it and noticing its size. Mass and volume are both examples of extensive physical properties. Chemical Properties Remember, the definition of a chemical property is that measuring that property must lead to a change in the substance’s chemical structure. Here are several examples of chemical properties: Heat of combustion is the energy released when a compound undergoes complete combustion (burning) with oxygen. The symbol for the heat of combustion is ΔH_c. Chemical stability refers to whether a compound will react with water or air (chemically stable substances will not react). Hydrolysis and oxidation are two such reactions and are both chemical changes. Flammability refers to whether a compound will burn when exposed to flame. Again, burning is a chemical reaction—commonly a high-temperature reaction in the presence of oxygen. The preferred oxidation state is the lowest-energy oxidation state that a metal will undergo reactions in order to achieve (if another element is present to accept or donate electrons). There are two types of change in matter: physical change and chemical change. Identify the key features of physical and chemical changes Key Takeaways Key Points Physical changes only change the appearance of a substance, not its chemical composition. Chemical changes cause a substance to change into an entirely new substance with a new chemical formula. Chemical changes are also known as chemical reactions. The “ingredients” of a reaction are called reactants, and the end results are called products. Key Terms chemical change: A process that causes a substance to change into a new substance with a new chemical formula. chemical reaction: A process involving the breaking or making of interatomic bonds and the transformation of a substance (or substances) into another. physical change: A process that does not cause a substance to become a fundamentally different substance. There are two types of change in matter: physical change and chemical change. As the names suggest, a physical change affects a substance’s physical properties, and a chemical change affects its chemical properties. Many physical changes are reversible (such as heating and cooling), whereas chemical changes are often irreversible or only reversible with an additional chemical change. Physical & Chemical Changes: This video describes physical and chemical changes in matter. Physical change: Blending a smoothie involves physical changes but no chemical changes. Physical Changes Another way to think about this is that a physical change does not cause a substance to become a fundamentally different substance but a chemical change causes a substance to change into something chemically new. Blending a smoothie, for example, involves two physical changes: the change in shape of each fruit and the mixing together of many different pieces of fruit. Because none of the chemicals in the smoothie components are changed during blending (the water and vitamins from the fruit are unchanged, for example), we know that no chemical changes are involved. Cutting, tearing, shattering, grinding, and mixing are further types of physical changes because they change the form but not the composition of a material. For example, mixing salt and pepper creates a new substance without changing the chemical makeup of either component. Phase changes are changes that occur when substances are melted, frozen, boiled, condensed, sublimated, or deposited. They are also physical changes because they do not change the nature of the substance. Boiling water: Boiling water is an example of a physical change and not a chemical change because the water vapor still has the same molecular structure as liquid water (H_2O). If the bubbles were caused by the decomposition of a molecule into a gas (such as $H_2O \rightarrow H_2$ and O_2), then boiling would be a chemical change. Chemical Changes Chemical changes are also known as chemical reactions. The “ingredients” of a reaction are called the reactants, and the end results are called the products. The change from reactants to products is signified by an arrow: Reactants → Products The formation of gas bubbles is often the result of a chemical change (except in the case of boiling, which is a physical change). A chemical change might also result in the formation of a precipitate, such as the appearance of a cloudy material when dissolved substances are mixed. Rotting, burning, cooking, and rusting are all further types of chemical changes because they produce substances that are entirely new chemical compounds. For example, burned wood becomes ash, carbon dioxide, and water. When exposed to water, iron becomes a mixture of several hydrated iron oxides and hydroxides. Yeast carries out fermentation to produce alcohol from sugar. An unexpected color change or release of odor also often indicates a chemical change. For example, the color of the element chromium is determined by its oxidation state; a single chromium compound will only change color if it undergoes an oxidation or reduction reaction. The heat from cooking an egg changes the interactions and shapes of the proteins in the egg white, thereby changing its molecular structure and converting the egg white from translucent to opaque. The best way to be completely certain whether a change is physical or chemical is to perform chemical analyses, such as mass spectroscopy, on the substance to determine its composition before and after a reaction. This activity has students collect mass and volume data for different samples of the same substance and develop a formula for density based on slope calculations. The procedure fosters the development of a model for density based on the relationship between mass and volume instead of simple formula use. In addition, students assign different substances to groups so they can establish the periodic nature of density through quantitative data. Save & Print Teacher Notes Save & Print Student Worksheet This activity has students collect mass and volume data for different samples of the same substance and develop a formula for density based on slope calculations. The procedure fosters the development of a model for density based on the relationship between mass and volume instead of simple formula use. In addition, students assign different substances to groups so they can establish the periodic nature of density through quantitative data. Save & Print Teacher Notes Save & Print Student Worksheet How can characteristic properties of substances be related to their structure? Investigation Objectives Analyze and interpret data to develop a mathematical relationship between mass and volume. Using particle diagrams, construct a model for density that represents the relative densities for all substances tested. PE MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. Science and Engineering Practices Analyzing and Interpreting Data Analyze and interpret data to determine similarities and differences in findings. Disciplinary Core Ideas PS1.A: Stucture and Properties of Matter Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. Crosscutting Concepts Patterns Macroscopic patterns are related to the nature of microscopic and atomic-level structure. Make certain students are slowly dropping each sample into the cylinder. Tilt the cylinder and let the sample slowly slide down the wall of the cylinder to avoid breakage or water splashing out. Do not force a sample into a graduated cylinder. Assign each group a substance for testing. Dry all samples after use. Once samples are dry, they may be reused for subsequent classes. Generate a Class Density Data Table for students to contribute group data. Class Density Data Table Group Substance Density (g/mL) Student: Obtain 4 or 5 samples of the same element or pure substance. Teacher: Groupings of metals that tend to give good results include: Fe, Cu, and Al; Fe, Cu, and Pb; or Cu, Al, and Pb. Choose samples of different sizes or shapes. Sample size must be large enough to show a change in volume in the cylinder. Find the volume of each sample by displacement of water or calculation. If your samples are regularly shaped geometric solids, like cylinders, spheres, cubes, or rectangular solids, then calculate the volume using the appropriate formula. Remind students to mass all samples before calculating volume by displacement of water. The mass is not accurate if the sample is wet. Review with students how to calculate volume using displacement of water. VolA = Volwater2 – Volwater1 Graph the data with volume on the x-axis and mass on the y-axis. Formulas for regular solids: Cube or rectangle = l × w × h Cylinder = πr2 × h Sphere = 4/3πr3 Draw the line of best fit. Check students’ work to ensure mass is recorded on the y-axis and volume is on the x-axis. Calculate the slope of the line. Remind students of the slope formula: Calculate the density of each sample. Go over how to draw the line of best fit. Students can also use a calculator or computer program to get the line of best fit. Calculate the average density of all samples for a substance. Density formula: D = M(g)/V(mL) Data will vary by substance and sample size. Density(Cu) Sample Mass (g) Volume by displacement (mL) Volume by calculation (cm3) optional Calculated density (g/mL) 1 22.8 2.6 2.59 8.8 2 4.2 0.5 .75 8.4 3 10.9 1.2 1.20 9.1 4 30.3 3.4 3.37 8.9 5 15.9 1.8 1.81 8.8 Analysis & Discussion How do the densities of each sample compare? There should be a fairly narrow range of densities among the samples. Use your data to support or refute the statement that density is an intensive property of matter. Density is an intensive property because there is a narrow range of densities across the samples. No matter what the initial mass was, densities were essentially the same. Since intensive properties do not depend on the amount of material, the data indicate that density is an intensive property of matter. How does the average density compare to the slope of the line? Use your data to construct a model for density. The average density is 8.8 g/mL and the slope of the line is 9.0 g/mL. The two values are essentially the same so we know that density is a ratio between mass and volume. Density is an intensive property of matter that illustrates how much mass a substance has in a given amount of volume. Translate the slope equation into the density equation. Show the steps with all units. How are the slope and formula for density related? D = Mass (g)/Volume (mL) The two formulas are the same. Your teacher will give you the standard value for the density of the metal or other substance you used. At 22° C: Al = 2.70 g/mL Cu = 8.96 g/mL Fe = 7.87 g/mL Pb = 11.3 g/mL Calculate the percent error using the slope. Calculate the percent error using the average. % error = (standard value – experimental value)/standard value Compare the two values. The two values should be close and percent error should be around 10% or less. Larger values usually indicate poor measurement technique, classroom temperature or water temperature substantially different than 22° C, or flaws in manufacturing. Check the substances yourself before students complete the lab. Sketch a particle diagram that models the concept of density for each substance. Remind students that density is recorded as mass per 1 unit of volume. Suggest to them that they use the same size and shape area to represent the same unit of volume. Only the “mass” of the particles will have to change. *Next Generation Science Standards® is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards were involved in the production of, and do not endorse, these products.