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**Teaching the Concept of Particle Theory (Grade 7 Science): A Summary**

**Background Information**

Matter refers to anything that has mass and takes up space, and matter is made up of particles. Particle theory is the predominant scientific theory for explaining how particles make up matter and how particles behave in different states. Particle theory states several postulates, or rules, that define the characteristics of particles:

* All matter is made up of particles;
* Particles are in constant motion;
* There are attractive forces between particles that hold them together.

In this unit, students will learn about the behaviour of particles when matter is in different states (solid, liquid, or gas). Temperature is defined as a measurement of the energy of the particles that make up a substance, and higher temperatures are related to increased particle movement. Pure substances (that contain only one type of particle) and mixtures (that contain two or more types of particles) are compared, and types of mixtures (i.e. solutions and mechanical mixtures) are explored.

**Curriculum Expectations**

One of the ‘big ideas’ in the Understanding Matter and Energy: Pure Substances and Mixtures unit is that *the particle theory of matter helps to explain the physical characteristics of matter.* This relates to two of the overall expectations: *Investigate the properties and applications of pure substances and mixtures;* and *Demonstrate an understanding of the properties of pure substances and mixtures, and describe the characteristics using particle theory.*

Three curriculum expectations relate directly to the sequence of lessons described here:

3.2 State the postulates of the particle theory of matter;

3.3 Use the particle theory to describe the differences between pure substances and mixtures.

3.4 Distinguish between solutions and mechanical mixtures.

**Advance Preparation**

Prior to beginning this sequence of lessons, students should be familiar with the physical characteristics of solids, liquids and gases.

A good understanding of particle theory is required before students can successfully work towards meeting other curriculum expectations contained in the Understanding Matter and Energy unit. For example, expectation 3.5 (*describe the processes used to separate mixtures or solutions into their components, an identify some industrial applications of these processes*) or expectation 3.8 (*describe the concentration of a solution in qualitative terms*).

**Lesson Sequence**

This sequence of lessons is intended to present the necessary information to students in a logical order and at an appropriate pace. Lessons may be extended to include additional instructional time to accommodate students’ learning needs (i.e. when additional activities and/or practice in needed for students to master content material). The information presented here is an overview of the key points of each lesson.

Lesson 1: The basic postulates of particle theory.

* All matter is made up of particles.
* All particles are in constant motion.
* There are attractive forces between particles.

Lesson 2: Temperature affects the speed at which particles move.

* Temperature is a measurement of the energy of particles.
* Higher temperatures equal higher energy, therefore particles move faster.

Lesson 3: Particles behave differently when matter is in different states.

* In a gas, there are spaces between the particles, and particles are moving rapidly.
* In liquids and solids, the particles are closer together and have strong forces of attraction between them. In liquids the particles are moving near each other. In solids, the particles vibrate in place.

Lesson 4: Pure substances (all particles are identical) vs. Mixtures (made up of two or more particles).

Lesson 5: Types of mixtures.

* Solutions are mixtures in which the two types of particles mix smoothly into one visible part.
* Mechanical Mixtures (or Heterogeneous Mixtures) are mixtures in which the particles don’t mix well, or mix unevenly. Both types of particles can be observed.

**Teaching Strategies**

A variety of teaching strategies can be implemented in this unit, depending on available time and resources. Teachers may select to use a combination of these, as well as the more traditional lecture and discussion of analysis, which is assumed to support each lesson. A description of alternative tools can be found below.

**Video Presentation**

This is a popular method of instruction for scientific topics involving abstract imagery. Since the physical structure of particles and their behaviours are difficult for most students to visualize, using visual aids such as video/diagrams/images is often an effective form of curriculum delivery.

**Laboratory Investigation**

A hands-on laboratory investigation for this unit allows students to observe the evidence and effects of the theory studied in this unit.

In this lab, students are asked to observe the effect of temperature on water molecules.

In small groups, students will add food coloring to hot, room and ice cold water temperatures to see whether heating or cooling affects the speed of the water molecules.

Students will record their observations and also draw their own molecular model.

Materials:

Hot water in a clear cup/flask

Room temperature water is a clear cup/flask

Cold water in a clear cup/flask

One or two colours of food coloring in small cups

Eye droppers

Safety:

Teacher and students must wear safety goggles

Caution should be exercised when working with hot water

Students can complete a worksheet provided by the teacher where they record their observations and answer questions relating what they observed to the concepts of particle theory.

**Temperature and Particle Motion Gizmo:**

The *Temperature and Particle Motion* Gizmo demonstrates the relationship between the temperature of a gas and the motion of its particles. A sample of moving particles is shown in the Gizmo, along with corresponding Maxwell-Boltzmann distribution. The temperature and type of gas can be changed.

As a teacher-led projector demonstration, students can observe the particle effects of increasing and decreasing temperature and selecting light versus heavy gases.

The teacher guide associated with this Gizmo offers some useful discussion questions:

* Do all of the molecules in a gas move at the same velocity?
* How does the temperature of a gas relate to the average velocity of its

molecules?

* What would you see if the temperature was absolute zero? [Note: absolute zero

is not shown in the Gizmo because at low temperatures gases change phase to

liquids and/or solids. Helium has the lowest boiling point, 4 K.]

* Why do heavier gases move more slowly than lighter gases at the same

temperature? [Temperature is a measure of average kinetic energy. If the same

amount of energy is added to lighter and heavier molecules, the lighter molecules

will move more quickly.]

* What does the Maxwell-Boltzmann distribution indicate about molecular

velocities?

The activities associated with this gizmo are intended for more senior science courses, however it does address several curriculum expectations for this unit. As a suggestion, if students are working with this gizmo as a hands-on activity, the support material should be appropriately modified. Alternatively, keeping this activity as a teacher-led exercise leading to a whole-class discussion can satisfy similar learning outcomes.

**Potential Areas of Difficulty and Solutions**

***Area of difficulty:***

Students may have difficulty imagining the abstract nature of particle structure and movement.

***Solution:***

Using a variety of visual aids/resources such as: videos, images, etc may help students familiarize themselves with the particle theory model.

***Area of difficulty:***

Students may struggle with the difference between pure substances vs. mixtures and the associated scientific terminology.

***Solution:***

Students can draw and study diagrams that illustrate each substance. In class discussion, teacher (and students) can regularly use correct scientific vocabulary and examples when referring to these substances.

***Area of difficulty:***

Students may have difficulty applying these concepts to a substance undergoing state changes (eg. water being converted to ice or vapour).

***Solution:***

The teacher can perform a lab demonstration explaining what is happening at each stage of state transition. As a follow-up, students can create a diagrams in the form of a storyboard that illustrate the state changes.

**Practical Applications**

Throughout the unit, the real-life practical applications of the particle theory of matter will be regularly discussed as part of each lesson. In addition, students can choose a practical application as a research project, or select several applications as topics for their culminating assessments (see below).

Some practical applications for this unit are:how a thermometer works, coal gasification, the water cycle in weather, medicines and their heats of sublimation, mixture separation in the food industry, water purification, hot-air balloons, diffusion and osmosis - just to name a few!

**Differentiated Assessment**

As a culminating task, students can select four activities from a choice board that addresses each type of multiple intelligence. There is also flexibility in choosing a theoretical concept or a practical application as their topic. The teacher can encourage the class to select a combination of both. Any alternative assignments must be reviewed by the teacher.

*Verbal/Linguistic* - Write a story about a particle’s journey through the three states of matter.

*Logical/Mathematical* - Compare and contrast the types of mixtures that we have studied.

*Interpersonal* - Write and conduct an interview/survey for particles (students) in the class.

*Musical Rhythmic* - Write and record a song relating a topic studied in this unit.

*Naturalist* - Draw a diagram illustrating the water cycle.

*Visual/Spatial* - Create a poster illustrating the three states of matter on a particle level.

*Body Kinesthetic* - Construct a model showing the varying attractive forces for each state.

*Intrapersonal* - Write a summary report relating to a topic studied in this unit.

**Annotated References and Resources**

American Chemical Society (2011). Middle School Chemistry. Ch 1, lesson 2. Retrieved 11 July 2012 from <http://www.middleschoolchemistry.com/lessonplans/>

* *This website by the American Chemical Society provides lesson plans that adhere to the American middle school curriculum expectations.*

Chemistry for Kids. (Unknown). Particle Model. Retrieved 11 July 2012 from <http://www.chemistryforkids.net/help/particle-model>

* *This website, directed at students, provides simple explanations, with charts and visuals, for scientific concepts related to the principles of chemistry. By clicking forward or back through the pages, information can also be found on solutions and mixtures, states of matter, as well as particle theory.*

Explore Learning, Gizmos (Unknown). Temperature and Particle Motion. Retrieved 11 July 2012 from <http://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=555&ClassID=0> and <http://cs.explorelearning.com/materials/TempParticleTG.pdf>

* *This website provides a library of interactive online simulations for math and science education in grades 3-12.*

Jones, R. (2000). Particle Theory. Retrieved 11 July 2012 from <http://www.le.ac.uk/se/centres/sci/selfstudy/particle01.html#particletheory>

* *This website, from the University of Leicester, provides a simple and easy-to-read overview of particle theory for adults. Useful reading for teachers preparing lessons.*

[kosasihiskandarsjah](http://www.youtube.com/user/kosasihiskandarsjah) (2008). States of Matter [video]. Retrieved 11 July 2012 from <http://www.youtube.com/watch?v=s-KvoVzukHo>

Plumb, D., Ritter, B., James, E. & Bloch, M. (1999). Nelson Science 9. Scarborough, ON: Nelson Thomson Learning.

* *Though this text is intended for grade nine students (and is an older edition, prior to recent curriculum changes), it contains excellent visuals (i.e. charts, diagrams) and activity ideas that can be modified for grade seven students.*