

Overview of learning progression for matter and atomic-molecular theory from Smith *et al.*, 2006 mapped onto items of the CPCA

Questions & Big Ideas	Components of Big Ideas	6-8 Elaboration of Big Ideas	Item on CPCA		
			<i>α-version</i>	<i>β-version</i>	<i>γ-version</i>
<p>1. What are things made of and how can we explain their properties?</p> <p>1. Objects¹ are constituted of matter, which exists as many different material kinds. Objects have properties that can be measured and depend on amount of matter and on the material kinds they are made of.</p>	Existence of matter and diversity of material kinds	<p>Matter has mass, volume, and weight (in a gravitational field), and exists in three general phases, solids, liquids, and gas.</p> <p>Materials can be elements, compounds or mixtures.</p>	<p>1*</p> <p>11</p> <p>13</p> <p>19</p> <p>25</p>	<p>-</p> <p>6</p> <p>8</p> <p>14</p> <p>20</p>	<p>-</p> <p>6</p> <p>8</p> <p>14</p> <p>19</p>
		<p>All matter is made of a limited number of different kinds of atoms, which are commonly bonded together in molecules and networks. Each atom takes up space, has mass, and is in constant motion.</p>			
	Objects have properties that can be measured and explained. Three important properties are mass, weight, and volume.	<p>Mass is a measure of amount of matter and is constant across location; weight is a force, proportional to mass and varies with gravitational field.</p> <p>Solids, liquids, & gases have different properties.</p>	<p>14</p> <p>15</p>	<p>9</p> <p>10</p>	<p>9</p> <p>10</p>
		<p>The mass and weight of an object is explained by the masses and weights of its atoms. The different motions & interactions of atoms in solids, liquids, and gases help explain their different properties.</p>			
	Material kinds have characteristic properties that can be measured and explained.	<p>Materials have characteristic properties independent of size of sample (Extends knowledge to include boiling/freezing points and to elaborate on density)</p> <p>The properties of materials are determined by the nature, arrangement and motion of the molecules that they are made of.</p>	16	11	11

<p>2. What changes and what stays the same when things are transformed?</p> <p>2. Matter can be transformed, but not created or destroyed, through physical and chemical processes.</p>	<p>Mass and weight are conserved across a broad range of transformations</p>	<p>Mass and weight (but not volume) are conserved across chemical changes, dissolving, phase change & thermal expansion.</p> <p>Mass and weight are conserved in physical and chemical changes because atoms are neither created nor destroyed.</p>	<p>3*</p> <p>10</p> <p>13</p> <p>20</p>	<p>-</p> <p>5</p> <p>8</p> <p>15</p>	<p>-</p> <p>5</p> <p>8</p> <p>15</p>
	<p>Material kinds stay the same across some transformations and change across others.</p>	<p>Some transformations involve chemical change (e.g., burning, rusting) in which new substances, as indicated by their different properties, are created.</p> <p>In other changes (e.g., phases change, thermal expansion) materials may change appearance but the substances in them stay the same.</p> <p>In chemical changes new substances are formed as atoms are rearranged into new molecules. The atoms themselves remain intact.</p> <p>In physical changes, molecules change arrangement and/or motion but remain intact, so the chemical substance remains the same.</p>	<p>4*</p> <p>5*</p> <p>6</p> <p>7</p> <p>9</p> <p>13</p> <p>17</p> <p>18</p> <p>21*</p> <p>22</p> <p>24</p>	<p>-</p> <p>-</p> <p>1</p> <p>2</p> <p>4</p> <p>8</p> <p>12</p> <p>13</p> <p>-</p> <p>17</p> <p>19</p>	<p>-</p> <p>-</p> <p>1</p> <p>2</p> <p>4</p> <p>8</p> <p>12</p> <p>13</p> <p>-</p> <p>16</p> <p>18</p>

<p>3. How do we know?</p> <p>3. We can learn about the world through measurement, modeling, and argument.</p>	<p>Good measurements provide more reliable and useful information about object properties than common sense impressions.</p>	<p>Our senses respond to combinations of physical properties, rather than isolated ones. For this reason, they are not good measures of those physical properties.</p> <p>Sources of measurement error can be examined and quantified.</p> <p>We can learn about the properties of things through indirect measurement (e.g., water displacement) as well as using powerful tools (microscopes).</p> <p>Atoms are too small to see directly with commonly available tools.</p>	12	7	7
	<p>Modeling is concerned with capturing key relations among ideas rather than surface appearance.</p>	<p>Models can propose unseen entities to explain a pattern of data.</p> <p>The properties of and changes in atoms and molecules have to be distinguished from the macroscopic properties and phenomena for which they account.</p>	<p>2*</p> <p>8</p> <p>23</p>	<p>-</p> <p>3</p> <p>18</p>	<p>-</p> <p>3</p> <p>17</p>
	<p>Arguments use reasoning to connect ideas and data.</p>	<p>Good arguments involve getting data that helps distinguish between competing explanations.</p> <p>We learn about properties of atoms and molecules indirectly, using hypothetico-deductive reasoning.</p>			

¹ Any bounded material entity, not just solids

*Items removed from final instrument (γ-version)