Creating Rubrics for Science Assessments Aligned with Three-Dimensional Learning of NGSS

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Next Generation Science Assessment

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.

MS-PS1-5

Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

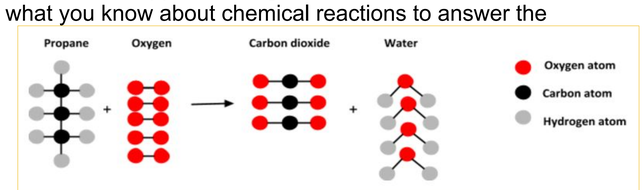
LP C-05
(Learning Performance)

Students use a model to explain that in a chemical reaction atoms are regrouped and why mass is conserved.

DCI	Practice	CCC
PS1.B. Chemical reaction - In a chemical process, the atoms that make up the original substances are regrouped into different molecules. - In chemical reactions, the total number of each type of atom is conserved, and thus the mass does not change.	**Use the model** - **Identify** appropriate elements of the model (and their attributes). - **Describe** the appropriate relationships or interactions among model elements. - **Explain or predict** phenomena using the model.	**Energy and Matter**: Matter is conserved because atoms are conserved in physical and chemical processes. - Determine that mass is conserved. - Describe how mass is conserved in a particular system.

Sample Task

Many people use a propane gas stove to cook when camping. When propane gas burns, a chemical reaction occurs. In this chemical reaction, propane will react with oxygen to form carbon dioxide and water. The model below represents what happens during the chemical reaction. Use the model and what you know about chemical reactions to answer the questions below.



Support your answers using the model to describe what occurs with the atoms that make up propane, oxygen, carbon dioxide, and water. Be sure to include the number and/or types of atoms for each molecule before and after the reaction.

1) How do you know a chemical reaction occurred?
2) How does the model show that the mass is conserved during the reaction?

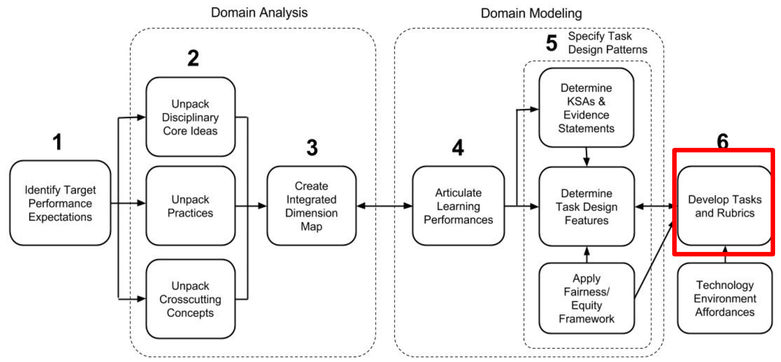
We describe a systematic approach to designing rubrics for scoring equitable physical science assessment items. Rubric design for assessment task design involves unpacking *learning performances (designed in previous project phase)* aligned to NGSS performance expectations (PEs) and designating Focal Knowledge, Skills, and Abilities (FKSAs) that evaluate various dimensions of an item response. The assessment items measure student proficiency related to chemical reactions and energy at the middle school grade band.

FKSA [J: atoms conserved in a model]
Ability to support model use, development, or evaluation by explaining that a chemical reaction conserves atoms and/or mass

Score	Description
2	Student states all of the following: ● Both sides have 10 oxygen atoms ● Both sides have 8 hydrogen atoms ● Both sides have 3 carbon atoms
1	States one or two of the following: ● Both sides have 10 oxygen atoms ● Both sides have 8 hydrogen atoms ● Both sides have 3 carbon atoms AND/OR Student states that there are the same number of oxygen atoms AND hydrogen atoms AND carbon atoms on each side, without stating the numbers
0	One or more of the following: ● Missing or incorrect statement about atom conservation in the reaction ● Student refers only to representational elements (e.g. black/red/grey circles) without referring to atoms ● General statement about the same number of atoms, without referring to specific elements

FKSA [L: how reactions produce new substances]
Ability to support model use, development, or evaluation by explaining that chemical reactions regroup atoms

Score	Description
1	Indicates at least one of the following: ● The reaction involves the regrouping/rearrangement/reordering of atoms ● Reactant molecules/atoms are breaking apart AND forming products, joining together, etc.
0	Any of the following ● Missing or incorrect statement about atoms regrouping or bond breaking ● Refers to breaking apart of reactant OR formation of product, but not both ● Student refers only to representational elements (e.g. black/red/grey circles) without referring to atoms



Student Responses

1. I know a chemical reaction occurred because there is a new molecule (water) || The model shows that mass is conserved during the reaction because most of the molecules are in the new substance.

2. I know that a chemical reaction occurred because the atoms moved around and rearranged so they did not escape or add on. Since the number of atoms stayed the same also the properties changed and there were new substances created.|| The mass was conserved since the same number of atoms stayed in the chemical reaction they just rearranged. Like there were ten oxygen atoms when we started and at the end as well, then we started with eight hydrogen atoms and ended with the same number. Finally there we started with three carbon atoms and ended with the same number.

3. I know a chemical reaction occurred because the molecules rearrange to form a different object.The Carbon atom and Hydrogen atom change to be Oxygen,then it was Oxygen atom with Carbon atom. || The number of atoms do not change it only was arrange in a different ways.

4. because as the chemical was reacting they were going thru transitions and changed || because it come air to water as a mass and it gets bigger

Exemplar Responses

A. A chemical reaction occurs when atoms of the original substances (propane and oxygen) regroup to form new substances (carbon dioxide and water). The model shows that carbon dioxide and water are made of oxygen, carbon, and hydrogen atoms. These atoms are the same as the atoms that make up propane and oxygen. This means carbon dioxide and water are produced by the regrouping of the atoms of propane and oxygen

B. In the model, one molecule of propane and five molecules of oxygen have a total of ten oxygen atoms, three carbon atoms and eight hydrogen atoms. After the reaction, the three carbon dioxide molecules and four water molecules also have a total of ten oxygen atoms, three carbon atoms, and eight hydrogen atoms. The total number of each type of atom before and after the reaction has not changed. Therefore, the mass stays the same.

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