Pattern Analysis of Student Thinking (PAST)

7-MS-PS1-2 – Chemical Reaction - Assessment Task

PE: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

DCI: **Chemical Reactions:**

- Substances react chemically in characteristic ways.
- In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

TASK 1 – *Look for patterns in a set of experimental data indicating evidence of a chemical reaction.*

Purpose	Student Response Themes	Examples of Student Responses	Possible Teacher Instructional Moves
In this task, students look for patterns in a set of data showing the results of chemical reactions between various metals and a solution of copper sulfate. They should observe that the appearance of the metal and the solution change in some way (e.g. color or texture), providing evidence of a chemical change. They should be able use the production of bubbles and the mass data as evidence to explain that a product of some reactions is a gas that escapes the system.	**Question 1A** • The students needed a way to see if something happened when the metal was added. • A control is needed to compare to the tubes with reactions.	• *So you can see how much the ones with metal changed.* • *You need a control to compare with the others.* • *They wanted to see what it would do without metal.* • *Because metal might change the substance.*	A **control** is something that is used as a standard of comparison for checking the results of an experiment. If students do not understand the purpose of the unreacted tube in this experiment, they may need more experience with using controls to verify experimental changes. In general, the more experience students have with observing chemical changes, the better they will be at identifying the types of evidence that indicate a chemical change (unexpected color or texture change, gas production, emission of heat, etc.). Chemical changes can be presented as videos, demonstrations, hands-on experiments, or engagement with specific phenomena that can be explained as a chemical change. The production of gas not only indicates a chemical change, it also results in the apparent loss of mass from an open system. If this is confusing to students, they may need to have experiences reminding them that gas has mass, such as weighing
	Question 1B • Color changed in all reactions. • Metal texture changed in all reactions. • Solution color changed. • Bubbles were produced in some tubes.	• *Both solution color and metal color changed in all of the tubes.* • *Metal color and texture changed.* • *The solution went from blue to clear or light blue or blue-green.* • *All the metals changed to reddish colors.* • *Most of the tubes made gas bubbles.*	

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	Question 1C • The tube in which the mass did not change was the only one that did not produce bubbles (gas). • The tubes that produced bubbles were producing gas. This means that some mass left the system.	• *The tubes with bubbles had a reaction that gave off gas, so mass was lost.* • *There were bubbles present and that is a chemical reaction.* • *The mass gassed away.* • *It really didn't change because of the gas going out.*	balloons or balls before and after air is added. They may also need to see gas-producing reactions conducted in a closed system, where the mass is measured before and after the reaction. A classic is baking soda and vinegar in a tightly closed baggie.
Focus SEP/CCC: Students are analyzing and interpreting data for patterns that provide evidence of the presence of a chemical reaction.			

TASK 2 – Look for patterns in a set of data to explain how new substances form in a displacement reaction.

Purpose	Student Response Themes	Examples of Student Responses	Possible Teacher Instructional Moves
In this task, students draw a model of one of the reactions from the data and identify physical properties of the reactants and products to see that they have changed. They complete chemical sentences to indicate that new substances have been created in a displacement reaction between copper sulfate and various metals. They construct a simple explanation of what happens at the molecular level of a chemical reaction. Students do not necessarily need to know chemical symbols or use ball and stick representations to see the pattern in this type of reaction.	**Question 2A** A model is drawn showing the reactants and products of the displacement reaction. Note: Various oxidation states are beyond the scope of this assessment (e.g. iron II, iron III, copper I, copper II).	$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$ Responses may use chemical symbols, shapes shown in the assessment, or other variations that illustrate displacement of the two metals.	The types and complexity of models that students might draw here is related to their prior understanding of chemical symbols and chemical equations. Since the purpose of this task is for students to discover patterns occurring in chemical reactions (displacement reactions in this case), it is only necessary that they see how the metals switch out to form new substances. Learning the chemical symbols might be helpful for some, but it might over-complicate the basic idea of chemical change for some students. If students are unable to draw a representative model, one strategy to help them see the pattern is to have them physically act out the rearrangement of
	Question 2B Students should identify the properties of the metals and sulfate solutions of the reactants and products. (Scaffolding question)	*Reactants*: Iron - dark gray & dull and copper sulfate solution – blue *Products:* Copper – reddish brown & rough and iron sulfate solution – light yellow-green	

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It is also important to note that this assessment utilizes only one type of chemical reaction (displacement). Its purpose is to have students look for patterns in similar types of chemical reactions, rather than providing a definition of a displacement reaction. They should have experiences with many types of reactions in which the atoms and atom groups rearrange to form new substances such as: combination (synthesis), decomposition, and combustion.	**Question 2C and 2D** Student answers should indicate displacement (switching) of the metals. • The reactant metal "changes places" with the copper and combines with the sulfate ion. • Each of the products is a new substance with the atoms arranged in a different way.	Products: • aluminum sulfate & copper • magnesium sulfate & copper • zinc sulfate & copper • *The metals change places.* • *The copper is by itself and the other metal combines with sulfate.* • *Everything breaks apart. The metal hooks up with the sulfate and the copper breaks away from it.* • *The copper comes off the sulfate and the other metals go on.* • *All of the molecules get scrambled and make new ones.*	atoms and atom groups in a chemical reaction as small or whole-class groups. Asking students (individually or in groups) to draw and share models of this and other reactions can also increase their understanding of how atoms regroup in a chemical change. Having students explain their models to others can be very powerful and encourages scientific dialogue in the classroom for sense-making purposes.

Focus SEP/CCC: Students are drawing models to describe unobservable mechanisms and constructing explanations from data show that new substances are formed in a chemical reaction.

TASK 3 – Look for patterns in a set of data to explain how new substances form in a displacement reaction.

Purpose	Student Response Themes	Examples of Student Responses	Possible Teacher Instructional Moves
This task is designed to confirm that students understand how a specific type of chemical reaction (displacement) results in new substances. They do this by using previous data and reaction patterns as evidence to show that copper sulfate and copper metal cannot react because copper cannot displace itself.	**Question 3A** • There will be no reaction and/or changes when copper metal is mixed with copper sulfate. • Copper metal cannot change places with itself when it is mixed with copper sulfate. There is nothing to replace so no reaction will occur.	• *When the other metals were added, they changed places with the copper in the copper sulfate. Copper can't change places with itself. Nothing will happen.* • *It has to be a different metal than copper because copper is in copper sulfate already.* • *The data show that all the metals replace the copper in the copper sulfate to make a new sulfate. There is no way to do that with copper.*	If students are unable to see why copper metal and copper sulfate do not react, ask them, "What are the new substances in the reaction?" The teacher can also have them try to write a sentence or draw a model of what they think the reaction would be. This might help them to see that nothing actually changes on either side of the sentence or model.

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They also make a supported argument that copper and copper sulfate are two different substances, even though both contain copper atoms.	**Question 3B** • The data show that a new substance is made when copper and sulfate combine so the properties (colors) can be different. • Copper is reddish-brown but the other atoms from sulfate in iron sulfate make it a new substance with a different color.	• *The reaction made a different substance. One is plain copper and the other is copper with sulfate.* • *Copper and copper sulfate are two different substances.* • *The table shows that copper is reddish-brown without the sulfate.* • *Copper itself does not have the yellow because sulfur is not in there.*	Students may say (correctly) that copper and copper sulfate have different properties because copper sulfate "contains" sulfate and not "just copper." However, it is important that they understand that these are two completely different substances. Many students forget to use the data as evidence in their explanation to show that changes in physical properties indicate a chemical reaction.
Focus SEP/CCC: Students are constructing supported arguments to support a claim related to the formation of new substances in a chemical reaction .			

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