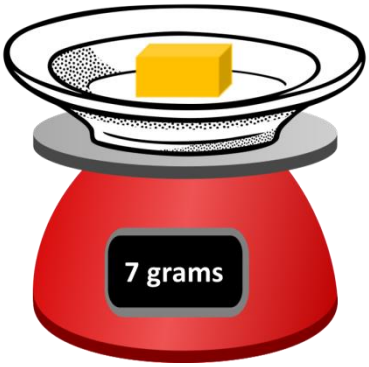
Carol puts a chunk of cold butter into a small bowl. The empty bowl weighs 5 grams.


The bowl with the cold butter weighs 7 grams.




**1) How much does the chunk of cold butter weigh?**

_____ grams

She heats the cold butter until it melts. The butter becomes liquid. None of the butter burns or evaporates.

**2a) How much do you think the bowl with the melted butter weighs?**


_____ grams

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**2b) How do you know? Make an argument. Give your evidence and reasoning.**

_____

_____

_____

_____

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| Question 1 (Scale, Proportion, and Quantity) | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>Uses addition and subtraction to infer the weight of objects in a container. | 2a) 2 grams |
| 0<br>Cannot use addition and subtraction to infer the weight of objects in a container. | 2a) Any number other than 2 g |
| Missing | 2a) and/or 2b) is answered, but 1) is blank. |
| Blank | 1), 2a), and 2b) are all blank. |

| Question 2a (Matter) | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>Understands weight is invariant during phase changes. | 2a) 7 g<br>OR<br>"The same" or any close variant. |
| 0<br>Does not understand weight is invariant during phase changes. | 2a) Any number other than 7 g<br>OR<br>More, less, different, or any close variant. |
| Missing | 1) and/or 2b) is answered, but 2a) is blank. |
| Blank | 1), 2a), and 2b) are all blank. |

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| Question 2b – Engaging in Argument from Evidence | |
|---|---|
| **Correct Principle** | 1 = Correct (the amount of butter is conserved so the weight will stay the same)<br><br>Examples:<br>Nothing escaped from the small bowl or burned.<br>Even though the butter has melted nothing went in or out.<br>It doesn't change the weight just because the volume changes. |
| | 0 = Unclear or missing |
| | -1 = Incorrect (the state of matter changes so the weight will change)<br><br>Examples:<br>The melted butter has more space between the molecules so it will take up more.<br>Usually the liquid form weighs a bit less than the solid chunk of butter. |
| | Missing = 1) and/or 2a) are answered, but 2b) is blank. |
| | Blank = 1), 2a), and 2b) are all blank. |
| **Evidence** | 1 = Provides explicit, relevant evidence in support of a claim.<br>Evidence should be explicit scientific data, which supports a claim. "Scientific data are information, such as observations and measurements…provided to the students" (Berland & McNeill, 2010, p. 772). Evidence should be an observation or measurement of a physical quality of object(s). In this item, evidence is most likely to be a statement about the weight of the butter or the bowl, but it may also include specific statements about the appearance of the butter, or other observable physical attributes of the bowl and/or butter. Personal experience is not valid evidence. Mentioning the "amount" should not be considered evidence, since it does not specify a direct observation; referring to the "amount" can count as reasoning.<br><br>The student's claim is their answer to the previous question, unless the previous answer is missing. Their claim may be repeated within the argument (or, stated for the first time if the previous answer is missing).<br><br>If the student utilizes mathematical expressions containing numbers that represent the weight of the butter and the bowl, these numbers may be considered evidence.<br><br>*Evidence and reasoning may be woven together in one statement, such that they are inextricably linked in the student's argument. Use your best judgment to determine whether evidence and reasoning are present, based on the descriptions above and below. Do not make large inferences about what the student meant; when in doubt, place the burden of proof on the student.* |

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| | |
|---|---|
| | 0 = Does not provide explicit, relevant evidence in support of a claim. |
| | Missing = 1) and/or 2a) are answered, but 2b) is blank. |
| | Blank = 1), 2a), and 2b) are all blank. |
| **Reasoning** | 1 = Provides appropriate reasoning in support of a claim.<br>The reasoning clearly articulates the logic behind the claim. If evidence is present, the reasoning may provide a rationale for why the evidence supports the claim.<br><br>Students often use words like "because," "so," "since," etc. which we may falsely attribute to causal reasoning. If a student uses causal language, carefully evaluate the content of their argument. Students may use these words to repeat a claim or provide evidence. In this case, this causal language should not be taken as an indicator of student reasoning.<br><br>If the student utilizes mathematical expressions to demonstrate the logic behind their argument, this may be considered reasoning.<br><br>Referring to the "amount" can count as reasoning.<br><br>*Evidence and reasoning may be woven together in one statement, such that they are inextricably linked in the student's argument. Use your best judgment to determine whether evidence and reasoning are present, based on the descriptions above. Do not make large inferences about what the student meant; when in doubt, place the burden of proof on the student.* |
| | 0 = Does not provide relevant evidence in support of claim. |
| | Missing = 1) and/or 2a) are answered, but 2b) is blank. |
| | Blank = 1), 2a), and 2b) are all blank. |

| **Example** | **Scores with explanations** |
|---|---|
| I think that the butter will either weigh the same or a little less than the solid butter: I think that the butter will weigh the same (2 grams because tare weight = 5, 7-5=2g) because if none of the butter evaporated, then why would the butter's weight change? | <u>Correct Principle: 0</u> (At the beginning of the response, the student says, "I think that the butter will either weigh the same or a little less than the solid butter." This statement suggests that the student is uncertain about whether the weight of the butter will remain the same. However, at the end of the statement, the student says, "I think that the butter will weigh the same (2 grams because tare weight=5, 7-5=26), because if none of the butter evaporated, then why would the butter's weight change?" Here the students seems to understand the concept, but there is still |

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| | |
|---|---|
| | uncertainty due to the initial statement. Thus, this response should receive the 0 score.)<br><br>Evidence: 1 (The measurements of the solid butter, the tare, and butter combined with the tare represent evidence that supports the student's claim: "I think the butter will weigh the same.")<br><br>Reasoning: 1 (The student provides mathematical reasoning: "2 grams because tare weight=5, 7-5=2g." The student also reasons when saying, "Because if none of the butter evaporated, then why would the butter's weight change?" The rationale for the claim that the weight will be 2 grams, the same as the solid butter, is that the difference between the tare combined with butter and the tare on its own is the weight of the butter AND the weight of the liquid butter will remain the same since none has evaporated.) |
| I think the melted butter weighs 9 grams because the bowl with butter in it was two more than the bowl with no butter. | Correct Principle: -1 (The student does not understand that the weight of the butter will remain constant. Instead, the student seems to rely on patterns observed in the problem.)<br><br>Evidence: 1 (The student's claim is that "The melted butter weighs 9 grams," and the student uses "The bowl with butter in it was two more than the bowl with no butter" as evidence to support the claim. In this example, the student's evidence is measurements provided in the problem.)<br><br>Reasoning: 0 (Although the student uses the word "because," which suggests reasoning, the student only provides evidence. They do not provide any reasoning to explain why this evidence supports their claim.) |
| Only the state changed, the amount hasn't so the weight will stay the same. | Correct Principle: 1 (The student's response indicates that he or she understands that the weight will not change, simply because the state changed.)<br><br>Evidence: 0 (The student does not provide information from measurements or observations in support of the claim that "The weight will stay the same.")<br><br>Reasoning: 1 (The student argues that when the state of matter changes, the weight will stay the same because no matter has been lost. Therefore, this response includes clear logic concerning why the liquid will also weigh 2 grams.) |

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| | |
|---|---|
| Because last year people melted ice and it weighed less (I think). | Correct Principle: -1 (The student's claim is vague, but the student seems to believe that the liquid form of matter will always weigh less than the solid form of that same matter. Thus, the response indicates that the student does not understand the scientific principle.)<br><br>Evidence: 0 (The student does not provide information from measurements or observations in support of the claim. Personal experience does not count as scientific evidence.)<br><br>Reasoning: 0 (The student does not provide reasoning in support of the claim. Although the student used causal language, "because," the student's statement only provides personal experience with no clear scientific logic.) |
| I know this because a liquid does weigh I think 1 grams so it would be 1 gram. | Correct Principle: -1 (The student believes that all liquids weigh 1 gram, which indicates that the student does not understand the scientific principle.)<br>Evidence: 0 (The student does not provide information from measurements or observations in support of the claim that the liquid weighs 1 gram.)<br><br>Reasoning: 0 (The student does not provide reasoning in support of the claim. Although the student used causal language, "because," the student's statement does not provide clear logic concerning why the liquid is 1 gram.) |
| It looks like it. | Correct Principle: -1 (The student believes that the weight of the butter can be determined by looking at it. Thus, the student's response does not indicate that he or she understands the concept.)<br><br>Evidence: 0 ("It looks like it" is not scientific evidence. Although it may appear that the student is basing their answer on a visual observation of the butter, this observation is not concrete enough to support the answer.)<br><br>Reasoning: 0 ("It looks like it" is too vague to suggest any reasoning.) |

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| Scale, Proportion, and Quantity - SCORING | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>(S, P, & Q Level 3: Uses addition and subtraction to infer the weight of liquids in a container.) | 1 on question 1 |
| 0<br>(Below S, P, & Q Level 3: Uses addition and subtraction to infer the weight of liquids in a container.) | 0 |
| . | Blank or missing on question 1 |

| Matter - SCORING | |
|---|---|
| **Score** | **Description of Response** |
| 2<br>(Matter Level 4: Weight is invariant during phase changes) | 1 on question 2a and 1 on Correct physical principles |
| 1<br>(Weak Matter Level 4: Weight is invariant during phase changes) | 1 on question 2a and 0 on Correct physical principles |
| 0<br>(Below Matter Level 4: Weight is invariant during phase changes) | 1 on question 2a and -1 on Correct physical principles<br>OR<br>0 on question 2a |
| . | Blank or missing on question 2a |

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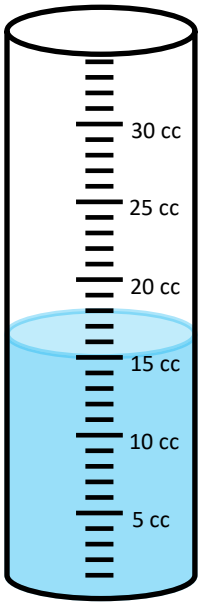
Beth has a rock.

She has a measuring cup. She pours some water into the measuring cup. Then she puts the rock in the measuring cup of water.

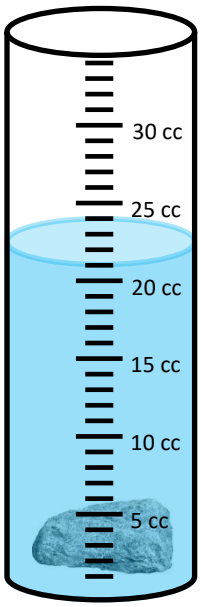
**Picture A**

Picture A shows what the measuring cup looks like before she puts the rock into it.




**Picture B**

Picture B shows what happens after she puts the rock into the measuring cup.




**1a) From the pictures, can you tell what the volume of the rock is?**

**Volume:**
The amount of space that something takes up

☐ Yes, the volume of the rock is _____.

☐ No. What other information do you need? _____

**1b) Why or why not? Make an argument. Give your evidence and reasoning.**

_____

_____

_____

_____

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**2a) From the pictures, can you tell what the weight of the rock is?**

☐ Yes, the weight of the rock is _____.

☐ No. What other information do you need? _____

**2b) Why or why not? Make an argument. Give your evidence and reasoning.**

_____

_____

_____

_____

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| Question 1a (Matter) | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>Recognizes that displacement is related to volume. | 1a) Yes, the volume of the rock is anything. |
| 0<br>Does not recognize that displacement is related to volume. | 1a) No. What other information do you need? Anything. |
| Missing | 1a) is blank, but 1b), 2a), or 2b) are answered. |
| Blank | 1a), 1b), 2a), and 2b) are blank. |

| Question 1a YES [only if answer to 1a) is YES] (Scale, Proportion, and Quantity) | |
|---|---|
| **Score** | **Description of Response** |
| 2<br>Can measure volume by displacement. | 1a) Yes, the volume of the rock is 6 cubic centimeters.<br>Accept other units or no units. |
| 1<br>Can measure volume by displacement, imprecisely. | 1a) Yes, the volume of the rock is 5 cubic centimeters, 7 cubic centimeters, or some other obvious subtraction error.<br>Accept other units or no units. |
| 0<br>Cannot measure volume by displacement. | 1a) Yes, the volume of the rock is an obvious misunderstanding of how to calculate volume. (Ex: 21 cc) |
| Missing | Checked yes, but no answer. |
| Blank | 1a), 1b), 2a), and 2b) are blank. |

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| Question 1b – Engaging in Argument from Evidence | |
|---|---|
| **Correct Principle** | 1 = Correct (water displacement is a result of the rock's volume)<br><br>Examples:<br>The water goes up because of the rock's volume.<br>Displacement is caused by how much space the rock takes up.<br>The rock takes up some of the space that the water was taking up before. |
| | 0 = Unclear or missing |
| | -1 = Incorrect (water displacement is caused by weight, or they don't know what causes water displacement)<br><br>Examples:<br>The weight of the rock is 6 cc.<br>I can't tell how much the rock takes up. |
| | Blank = 1a), 2a), 1b), and 2b) are all blank. |
| **Evidence** | 1 = Provides explicit, relevant evidence in support of a claim.<br>Evidence should be explicit scientific data, which supports a claim. "Scientific data are information, such as observations and measurements…provided to the students" (Berland & McNeill, 2010, p. 772). Evidence should be an observation or measurement of a physical quality of object(s). In this item, evidence is most likely to be a statement about the water level, but it may also include specific statements about the size or appearance of the rocks, or other observable physical attributes of the rocks and containers. Personal experience is not valid evidence. Mentioning the "amount" should not be considered evidence, since it does not specify a direct observation; referring to the "amount" can count as reasoning.<br><br>The student's claim is their answer to the previous question, unless the previous answer is missing. Their claim may be repeated within the argument (or, stated for the first time if the previous answer is missing).<br><br>If the student utilizes mathematical expressions containing numbers that represent the weight of the butter and the bowl, these numbers may be considered evidence.<br><br>*Evidence and reasoning may be woven together in one statement, such that they are inextricably linked in the student's argument. Use your best judgment to determine whether evidence and reasoning are present, based on the descriptions above and below. Do not make large inferences about what the student meant; when in doubt, place the burden of proof on the student.* |
| | *0 = Does not provide explicit, relevant evidence in support of a claim.* |

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| | |
|---|---|
| | *Missing = 1a) and/or 2a) are answered, but 1b) is blank.* |
| | *Blank = 1a), 1b), 2a), and 2b) are all blank.* |
| **Reasoning** | 1 = Provides appropriate reasoning in support of a claim.<br>The reasoning clearly articulates the logic behind the claim. If evidence is present, the reasoning may provide a rationale for why the evidence supports the claim.<br><br>Students often use words like "because," "so," "since," etc. which we may falsely attribute to causal reasoning. If a student uses causal language, carefully evaluate the content of their argument. Students may use these words to repeat a claim or provide evidence. In this case, this causal language should not be taken as an indicator of student reasoning.<br><br>Referring to the "amount" can count as reasoning.<br><br>If the student utilizes mathematical expressions to demonstrate the logic behind their argument, this may be considered reasoning.<br><br>*Evidence and reasoning may be woven together in one statement, such that they are inextricably linked in the student's argument. Use your best judgment to determine whether evidence and reasoning are present, based on the descriptions above. Do not make large inferences about what the student meant; when in doubt, place the burden of proof on the student.* |
| | *0 = Does not provide relevant evidence in support of claim.* |
| | *Missing = 1a) and/or 2a) are answered, but 1b) is blank.* |
| | *Blank = 1a), 1b), 2a), and 2b) are all blank.* |

| **Example** | **Scores with explanations** |
|---|---|
| The weight of the rock is 6cc because in her picture the water rose higher. Also the rock has mass so when it's in mass it takes more space. | <u>Correct Principle: -1</u> (In this example, the student attributes the change in the water level to weight rather than volume, which suggests that the student does not understand the scientific concept.)<br><br><u>Evidence: 1</u> (The student's claim is that "the weight of the rock is 6cc." The student supports this claim with the observation that "the water rose higher.")<br><br><u>Reasoning: 1</u> (The student provides reasoning in support of the claim that "the weight of the rock is 6cc." The student explains |

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| | |
|---|---|
| | that "the rock has mass so when it's in mass it takes more space." Thus, the student believes that the water level increased, because of the mass of the rock. Although incorrect, the student provides appropriate reasoning.) |
| The water rises 6 cc so that is the amount of space the rock takes up. | Correct Principle: 1 (This student reports that "The water rises 6cc so that is the amount of space the rock takes up." His or her statement indicates that he or she understands that water rises depending on the volume of the object placed in the water. Thus, the student's response suggests that he or she understands the scientific principle.)<br><br>Evidence: 1 (The student's claim is that the volume of the rock is 6cc. To support his or her claim, the student provides evidence in the form of an observation: "The water rises 6cc.")<br><br>Reasoning: 1 (The student provides reasoning in the form of an explanation for why the water level rose 6cc: when the rock was placed in the water, the rock took up volume.) |
| Because the water level went up by 6cc, but I'm actually kind of confused, because I know they didn't add water and but I understand the arithmetic concept, so I don't know actually. | Correct Principle: 0 (From this response, it is unclear whether the student understands the scientific principle. The student seems to understand that there is some connection between the 6cc increase in the water level and the volume. At the same time, the student says, "But I'm actually kind of confused, because I know they didn't add water and but I understand the arithmetic concept, so I don't know actually." The student seems to somehow know that he or she needs to subtract the volume with the rock from the volume without the rock, but does not seem to understand that the rock caused the volume to increase. Since it is unclear whether the student understands the scientific principle, this response receives a 0 score for Correct Principle.)<br><br>Evidence: 1 (In this example, the student actually makes two claims. Although not stated explicitly, the student's first claim is that the volume of the rock is 6cc. The second claim is that the student doesn't know what the volume is. The student provides evidence in the form of an observation to support the first claim: "the water level went up by 6cc.")<br><br>Reasoning: 0 (As noted earlier, this student makes two claims. The student does not provide any reasoning regarding why the volume of the rock is 6cc. The statement explaining why they "don't know" the answer does not count as reasoning. ) |
| I need to know how wide it is and how tall it is. | Correct Principle: -1 (Since the student reports that he or she is missing measurements needed to calculate the volume, the student does not appear to understand the relationship between volume and water displacement.) |

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| | |
|---|---|
| | Evidence: 1 (Although not explicitly stated, the student's claim is that the volume cannot be determined. In this example, the student's evidence is that there is not enough information to solve the problem: "I need to know how wide it is and how tall it is.")<br><br>Reasoning: 0 (The student does not provide reasoning in this example.) |
| How much the water level rises is how much space it takes up, volume. | Correct Principle: 1 (This student reports that "How much the water level rises is how much space it takes up, volume." His or her statement indicates that he or she understands that water rises depending on the volume of the object placed in the water. Thus, the student's response suggests that he or she understands the scientific principle.)<br>Evidence: 0 (The student does not provide evidence.)<br><br>Reasoning: 1 (The student's reasoning is that the volume of the rock can be calculated by observing the water displacement.) |
| I think the volume of the rock is 6 cubic centimeters because in picture B it shows that the rock is roughly 6 cubic cm. | Correct Principle: 0 (The student seems to believe that you can determine the volume of the rock by simply looking at the picture. Ordinarily, this would not be true, but in this case, the rock actually does reach the 6 cubic centimeters mark. Thus, it is unclear whether the student understands the scientific concept.)<br><br>Evidence: 0 (The student's claim is that "the volume of the rock is 6 cubic centimeters," but the student does not provide evidence in support of this claim.)<br><br>Reasoning: 0 (In this example, the student provides tautological reasoning, meaning circular logic. The student's claim is that the "rock is 6 cubic centimeters" and the reasoning is a restatement of the claim.) |

| **Question 2a (Matter)** | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>Recognizes that displacement is not related to weight. | 2a) No. What other information do you need? Anything. |
| 0<br>Does not recognize that displacement is not related to weight. | 2a) Yes, the weight of the rock is anything. |
| Missing | 2a) is blank, but 1a), 1b), or 2b) are answered. |
| Blank | 1a), 1b), 2a), and 2b) are blank. |

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| Scale, Proportion, and Quantity - SCORING | |
|---|---|
| **Score** | **Description of Response** |
| 2<br>(S, P, & Q Level 4: Uses addition and subtraction to mathematically reason about volume.) | 1 on Question 1a AND 2 on Question 1a YES |
| 1<br>(Weak S, P, & Q Level 4: Uses addition and subtraction to mathematically reason about volume.) | 1 on Question 1a AND 1 on Question 1a YES |
| 0<br>(Below S, P, & Q Level 4: Uses addition and subtraction to mathematically reason about volume.) | 1 on Question 1a AND 0 on Question 1a YES<br>missing on Question 1a YES |
| . | Blank or missing on Question 1a YES |

| Matter - SCORING | |
|---|---|
| **Score** | **Description of Response** |
| 2<br>(Matter Level 3: Understands water displacement depends upon volume of submerged object.) | 1 on Question 1a AND 1 on Correct Physical Principles AND 1 on Question 2a |
| 1<br>(Weak Matter Level 3: Understands water displacement depends upon volume of submerged object.) | 1 on Question 1a AND 0 on Correct Physical Principles AND 1 on Question 2a |
| 0<br>(Below Matter Level 3: Understands water displacement depends upon volume of submerged object.) | 0 on Question 1a AND 0 on Correct Physical Principles (and any answer on Question 2a)<br>OR<br>0 on Question 1a and -1 on Correct Physical Principles<br>OR<br>1 on Question 1a AND 1 on Correct Physical Principles AND 0 on Question 2a<br>OR<br>1 on Question 1a AND 0 on Correct Physical Principles AND 0 on Question 2a<br>OR<br>1 on Question 1a AND -1 on Correct Physical Principles AND 0 on Question 2a |
| . | Blank or missing on question 1a or question 2a |

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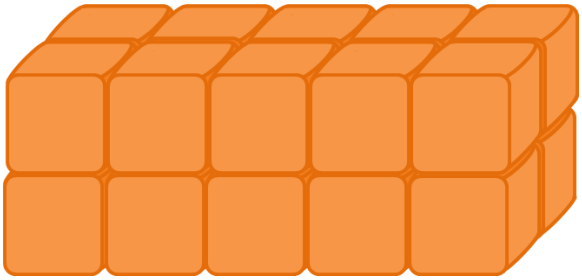
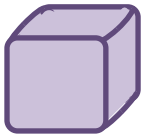
Ana has a block of clay. The block of clay is marked so that it can be divided into smaller pieces. Each smaller piece is 1 cubic centimeter.





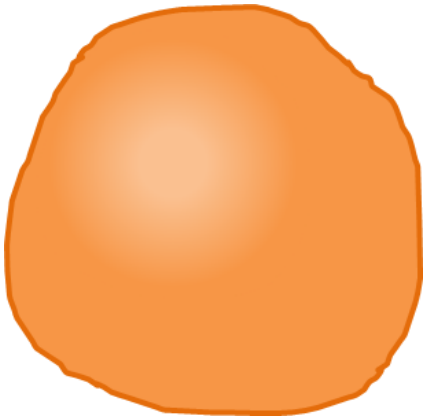
1 cubic centimeter

**1) What is the volume of the block of clay?**

**Volume:**
The amount of space that something takes up

_____

Ana takes the block of clay and molds it into a ball. She is careful not to get any air inside of the ball of clay.



**2a) What is the volume of the ball of clay?**

_____

**2b) Why do you think so? Make an argument. Give your evidence and reasoning.**

_____

_____

_____

_____

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| Question 1 (Scale, Proportion, and Quantity) | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>Can use centimeter cubes to measure volume. | 1) 20 cubic centimeters<br>Accept other units (cm, square centimeters) or no unit. |
| 0<br>Cannot use centimeter cubes to measure volume. | 1) Any other answer, besides 20. |
| Missing | 2a) and/or 2b) are answered, but 1) is blank. |
| Blank | 1), 2a), and 2b) are all blank. |

| Question 2a (Matter) | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>Understands volume of solid objects is invariant with reshaping. | Answers to 1) and 2a) are the same.<br>OR<br>"The same" or any close variant. |
| 0<br>Does not understand volume of solid objects is invariant with reshaping. | Answers to 1) and 2a) are different.<br>OR<br>Bigger, smaller, different, or any close variant. |
| Missing | 1) and/or 2b) is answered, but 2a) is blank. |
| Blank | 1), 2a), and 2b) are all blank. |

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| Question 2b – Engaging in Argument from Evidence | |
|---|---|
| **Correct Principle** | 1 = Correct (Volume is invariant with reshaping)<br><br>Examples:<br>Changing the shape doesn't change the volume.<br>It's the same material just a different shape.<br>It's still the same material.<br>She didn't add anything or take anything away. |
| | 0 = Unclear or missing |
| | -1 = Incorrect (Volume may change with reshaping)<br><br>Examples:<br>The block is longer so it takes up more space.<br>Crumpling things up makes them bigger.<br>[Estimates the height and length of the ball.] |
| | Blank = 1a), 2a), 1b), and 2b) are all blank. |
| **Evidence** | 1 = Provides explicit, relevant evidence in support of a claim.<br>Evidence should be explicit scientific data, which supports a claim. "Scientific data are information, such as observations and measurements…provided to the students" (Berland & McNeill, 2010, p. 772). Evidence should be an observation or measurement of a physical quality of object(s). In this item, evidence is most likely to be a statement about the volume of the clay block, but it may also include specific statements about the shape of the clay, or other observable physical attributes of the clay. Personal experience is not valid evidence. Mentioning the "amount" should not be considered evidence, since it does not specify a direct observation; referring to the "amount" can count as reasoning.<br><br>The student's claim is their answer to the previous question, unless the previous answer is missing. Their claim may be repeated within the argument (or, stated for the first time if the previous answer is missing).<br><br>If the student utilizes mathematical expressions containing numbers that represent the weight of the butter and the bowl, these numbers may be considered evidence.<br><br>*Evidence and reasoning may be woven together in one statement, such that they are inextricably linked in the student's argument. Use your best judgment to determine whether evidence and reasoning are present, based on the descriptions above and below. Do not make large inferences about what the student meant; when in doubt, place the burden of proof on the student.* |
| | *0 = Does not provide explicit, relevant evidence in support of a claim.* |
| | *Missing = 1a) and/or 2a) are answered, but 1b) is blank.* |

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| | |
|---|---|
| | *Blank = 1a), 2a), 1b), and 2b) are all blank.* |
| **Reasoning** | 1 = Provides appropriate reasoning in support of a claim.<br>The reasoning clearly articulates the logic behind the claim. If evidence is present, the reasoning may provide a rationale for why the evidence supports the claim.<br><br>Students often use words like "because," "so," "since," etc. which we may falsely attribute to causal reasoning. If a student uses causal language, carefully evaluate the content of their argument. Students may use these words to repeat a claim or provide evidence. In this case, this causal language should not be taken as an indicator of student reasoning.<br><br>Referring to the "amount" can count as reasoning.<br><br>If the student utilizes mathematical expressions to demonstrate the logic behind their argument, this may be considered reasoning.<br><br>*Evidence and reasoning may be woven together in one statement, such that they are inextricably linked in the student's argument. Use your best judgment to determine whether evidence and reasoning are present, based on the descriptions above. Do not make large inferences about what the student meant; when in doubt, place the burden of proof on the student.* |
| | *0 = Does not provide relevant evidence in support of claim.* |
| | *Missing = 1a) and/or 2a) are answered, but 1b) is blank.* |
| | *Blank = 1a), 2a), 1b), and 2b) are all blank.* |

| **Example** | **Scores with explanations** |
|---|---|
| On #1 it says each square is one centimeter. So I counted by fours and I got twenty because I multiplied 5x4=20 and if Ana takes the clay and molds it into a ball it is still the same volume=20. | <u>Correct Principle: 1</u> (In this example, the student says "If Ana takes the clay and molds it into a ball it is still the same volume=20." This statement suggests that the student understands that changing the shape of the object will not change its volume.)<br><br><u>Evidence: 1</u> (The student's claim is that the volume of the ball of clay is 20 centimeters. The student's evidence is in the form of a mathematical expression: "5x4=20.")<br><br><u>Reasoning: 1</u> (The student provides two forms of reasoning. The student first provides mathematical reasoning "So I counted by fours and I got twenty because I multiplied 5x4=20." Then the student explains that changing the shape will not change the volume of an object: "If Ana takes the clay and molds it into a ball |

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| | |
|---|---|
| | it is still the same volume=20.”) |
| Because the ball is taller than the block so it takes up more space. | Correct Principle: -1 (This student’s response indicates that he or she thinks that if you change the shape of an object, its volume will also change: “The ball is taller.” Thus, the student does not seem to understand that the volume will remain the same regardless of shape.)<br><br>Evidence: 1 (Although not explicitly stated, the student’s claim is that the volume of the ball will be greater than the volume of the block. Thus, in this case, the student’s evidence is in the form of an observation about the shape of the ball compared to the block: “The ball is taller than the block.”)<br><br>Reasoning: 1 (Although the student’s claim and reasoning are incorrect, the student does provide reasoning. The student argues that taller objects will take up more space, and therefore, have more volume. |
| Changing the shape won’t change the volume. | Correct Principle: 1 (From this response, it seems clear that the student understands that the volume of an object will not change just because its shape has changed. Thus, the student seems to understand the scientific principle.)<br><br>Evidence: 0 (In this example, the claim is implied: the volume of the ball of clay is the same as the volume of the block of clay. However, the student does not provide any evidence to support this claim.)<br><br>Reasoning: 1 (The student provides the following explanation for why the volume of the ball of clay will be the same as the block of clay: “Changing the shape won’t change the volume.”) |
| I think the ball is 4 wide, 3 height, and 2 for length. | Correct Principle: -1 (In this example, the student estimates the measurements of the rock, which suggests that he or she does not understand that the volume of the ball will be the same as the volume of the block. Thus, the student does not seem to understand the Correct Principle.)<br><br>Evidence: 1 (Although not explicitly stated, the student’s claim is that the volume will be 24 (or 4 x 3 x 2). The student’s provides evidence in the form of an observation concerning the estimated dimensions of the ball of clay.)<br><br>Reasoning: 0 (The student does not provide reasoning in this example.) |
| Because there is still the same amount of clay and the clay still weighs the same. | Correct Principle: 0 (In the first part of the student’s response--“there is still the same amount of clay”--the student seems to |

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| | |
|---|---|
| | understand that if the amount of the clay does not change, the volume will not change simply because the shape changed. If this was all the student said, then we could assume that the student understands the Correct Principle. However, the student also says that "the clay still weighs the same." It is unclear here whether the student is confusing weight with volume. Thus, in this example, there is also some evidence to believe that the student does not understand the Correct Principle, so the student will receive a 0.)<br>Evidence: 0 (The student's implicit claim is that the volume of the clay will still be the same. However, the student does not provide evidence in support of this claim. Although some students may associate volume with "amount of clay," this is considered an indicator of their conceptual understanding of matter, not a direct observation. The same goes for the weight of the clay. We can assume that the student's mention of weight is an indicator of their conceptual understanding, since weight is not mentioned in the item.)<br><br>Reasoning: 1 (Although not explicitly stated, the student's claim is that the volume of the ball of clay will be the same as the volume of the block of clay. The student's reasoning is that the amount and weight of the clay are still the same.) |
| I think Ana's ball of clay is 80g because 1 cubic centimeter of sugar is 2g and there is 40g + 40g = 80g. | Correct Principle: -1 (The provides false evidence and reasoning that is unrelated to the ball of clay question. The student does not seem to understand the scientific concept.)<br><br>Evidence: 0 (The student's claim is that the "ball of clay is 80g." The student supports this claim with false/irrelevant evidence: "1 cubic centimeter of sugar is 2g." )<br><br>Reasoning: 0 (In this example, the student provides mathematical reasoning, but the reasoning is irrelevant and based on false evidence.) |

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| Scale, Proportion, and Quantity - SCORING | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>(S, P, & Q Level 3: Can use centimeter cubes to measure volume by comparison.) | 1 on Question 1 |
| 0<br>(Below S, P, & Q Level 3: Can use centimeter cubes to measure volume by comparison.) | 0 |
| . | Blank or missing on Question 1 |

| Matter - SCORING | |
|---|---|
| **Score** | **Description of Response** |
| 2<br>(Matter Level 3: Understands volume of solid objects and liquids is invariant with reshaping.) | 1 on Question 2a AND 1 on Correct Physical Principles |
| 1<br>(Weak Matter Level 3: Understands volume of solid objects and liquids is invariant with reshaping.) | 1 on Question 2a AND 0 on Correct Physical Principles |
| 0<br>(Below Matter Level 3: Understands volume of solid objects and liquids is invariant with reshaping.) | 0 on Question 2a AND 0 on Correct Physical Principles<br>OR<br>0 on Question 2a AND -1 on Correct Physical Principles |
| . | Blank or Missing on question 2a) and 2b) |

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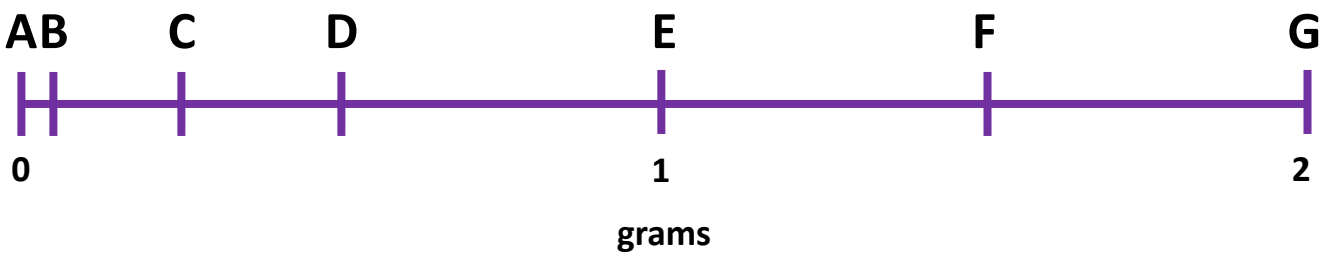
20 drops of water weigh 1 gram.

**1a) Will 10 drops of water weigh anything?**

☐ Yes.

☐ No.

**1b) Circle the letter that marks the weight of 10 drops of water on the number line.**

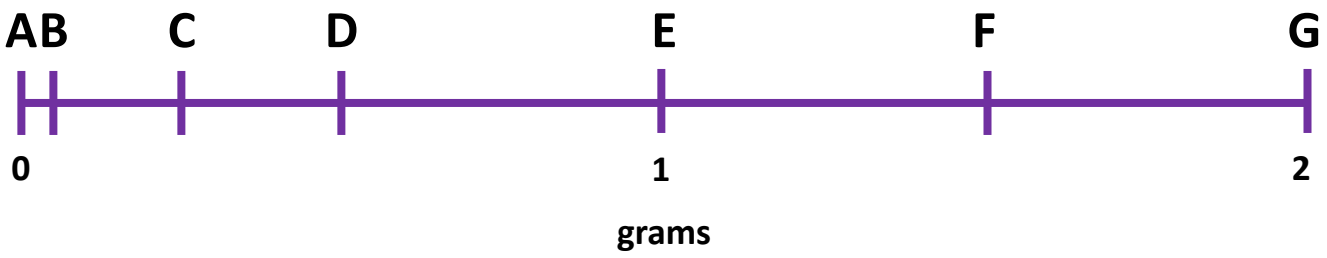



**2a) Does 1 drop of water weigh anything?**

☐ Yes

☐ No

**2b) Circle the letter that marks the weight of 1 drop of water on the number line.**




**3) Why did you choose your answers? Make an argument. Give your evidence and reasoning.**

_____

_____

_____

_____

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| Question 1a (Matter) | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>Recognizes that very small things have weight. | Yes |
| 0<br>Does not recognize that very small things have weight. | No |
| Missing | 1a) is blank, but 1b), 1c), 2a), 2b), and/or 2c) are answered. |
| Blank | 1a), 1b), 1c), 2a), 2b), and/or 2c) are all blank. |

| Question 1b (Scale, Proportion, and Quantity) | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>Recognizes that the weight of 10 drops of water will be half of the weight of 20 drops of water. | D |
| 0<br>Does not recognize that the weight of 10 drops of water will be half the weight of 20 drops of water. | Any other letter |
| Missing | 1b) is blank, but 1a), 1c), 2a), 2b), and/or 2c) are answered. |
| Blank | 1a), 1b), 1c), 2a), 2b), and/or 2c) are all blank. |

| Question 2a (Matter) | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>Recognizes that very small things have weight. | Yes |
| 0<br>Does not recognize that very small things have weight. | No |
| Missing | 2a) is blank, but 1a), 1b), 1c), 2b), and/or 2c) are answered. |
| Blank | 1a), 1b), 1c), 2a), 2b), and/or 2c) are all blank. |

| Question 2b (Scale, Proportion, and Quantity) | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>Recognizes that the weight of 1 drop of water will be 1/20 of the weight of 20 drops of water. | B |
| 0<br>Does not recognize that the weight of 1 drop of water will be 1/20 the weight of 20 drops of water. | Any other letter |
| Missing | 2b) is blank, but 1a), 1b), 1c), 2a), and/or 2c) are answered. |
| Blank | 1a), 1b), 1c), 2a), 2b), and/or 2c) are all blank. |

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| Question 3 – Engaging in Argument from Evidence | |
|---|---|
| **Correct Principle** | 2 = Completely correct (the weight of one drop and/or ten drops is proportional to the weight of the whole 20 drops)<br><br>Examples:<br>20 drops = 1 g so 10 drops = ½ g.<br>Half of 20 is 10 and half of 1 is ½. |
| | 1 = Partially correct (all matter has weight)<br><br>Examples:<br>Even though it is less it still weighs something.<br>Even a tiny bit weighs something.<br>1 of anything has an amount of weight. |
| | 0 = Unclear, missing, or inconsistent<br><br>Examples:<br>10 is half of 20 so it would be D. But if you put a drop of water on a scale, it would not weigh anything. |
| | -1 = Incorrect (10 drops and 1 drop are too small to weigh anything at all)<br><br>Examples:<br>10 drops and 1 drop both equal 0.<br>It is very small and it will not weigh anything. |
| | Blank = 1a), 1b), 1c), 2a), 2b), and/or 2c) are all blank. |
| **Relative weight** | 1 = Answer to 2b is less than answer to 1b. |
| | 0 = Answer to 2b is greater than or equal to answer to 1b. |
| **Evidence** | 1 = Provides explicit, relevant evidence in support of a claim.<br>Evidence should be explicit scientific data, which supports a claim. "Scientific data are information, such as observations and measurements…provided to the students" (Berland & McNeill, 2010, p. 772). Evidence should be an observation or measurement of a physical quality of object(s). In this item, evidence is most likely to be a statement about the weight of twenty drops of water, but it may also include statements about the size of water drops or other specific observable physical attributes of the water. Personal experience is not valid evidence. Mentioning the "amount" should not be considered evidence, since it does not specify a direct observation; referring to the "amount" can count as reasoning.<br><br>The student's claim is their answer to the previous question, unless the previous answer is missing. Their claim may be repeated within the argument (or, stated for the first time if the previous answer is missing).<br><br>If the student utilizes mathematical expressions containing numbers that represent the weight of 20, 10, or 1 drop(s) of water, these numbers may be considered evidence.<br><br>*Evidence and reasoning may be woven together in one statement, such that they are inextricably linked in the student's argument. Use your best judgment to determine whether evidence and reasoning are* |

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| | |
|---|---|
| | *present, based on the descriptions above and below. Do not make large inferences about what the student meant; when in doubt, place the burden of proof on the student.*<br><br>*Note: If a student provides evidence for at least one of their claims (i.e., about the weight of ten drops, or about the weight of one drop), this is sufficient for a score of 1.* |
| | 0 = Does not provide explicit, relevant evidence in support of a claim. |
| | Missing = 1a), 1b), 2a), 2b), and/or 2c) are answered, but 1c) is blank. |
| | Blank = 1a), 1b), 1c), 2a), 2b), and/or 2c) are all blank. |
| **Reasoning** | 1 = Provides appropriate reasoning in support of a claim.<br>The reasoning clearly articulates the logic behind the claim. If evidence is present, the reasoning may provide a rationale for why the evidence supports the claim.<br><br>Students often use words like "because," "so," "since," etc. which we may falsely attribute to causal reasoning. If a student uses causal language, carefully evaluate the content of their argument. Students may use these words to repeat a claim or provide evidence. In this case, this causal language should not be taken as an indicator of student reasoning.<br><br>If the student utilizes mathematical expressions to demonstrate the logic behind their argument, this may be considered reasoning.<br><br>Referring to the "amount" can count as reasoning.<br><br>*Evidence and reasoning may be woven together in one statement, such that they are inextricably linked in the student's argument. Use your best judgment to determine whether evidence and reasoning are present, based on the descriptions above. Do not make large inferences about what the student meant; when in doubt, place the burden of proof on the student.*<br><br>*Note: If a student provides reasoning for at least one of their claims (i.e., about the weight of ten drops, or about the weight of one drop), this is sufficient for a score of 1.* |
| | 0 = Does not provide relevant evidence in support of claim. |
| | Missing = 1a), 1b), 2a), 2b), and/or 2c) are answered, but 1c) is blank. |
| | Blank = 1a), 1b), 1c), 2a), 2b), and/or 2c) are all blank. |

| **Example** | **Scores with explanations** |
|---|---|
| I chose my answer because each drop of water weighs something for 20 drops of water to weigh 1 gram. | <u>Correct Principle: 1</u> (The student states that each drop of water must weigh something, but does not use proportional reasoning to determine the exact weight of 1 drop.)<br><br><u>Evidence: 1</u> (The student gives a measurement for the weight of 20 drops of water.)<br><br><u>Reasoning: 1</u> (The student states that the each drop of water must weigh something in order for the evidence to be true. This |

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| | |
|---|---|
| | provides the rationale supporting why the evidence about weight is relevant to their argument.) |
| I chose no, for both because if 20 drops of water equals 1 gram then 10 and 1 drops of water will equal less than 1 gram. That is a weight but really really light weight. | Correct Principle: 1 (The student states that each drop of water must weigh something, but does not use proportional reasoning to determine the exact weight of 1 drop.)<br><br>Evidence: 1 (The student gives a measurement for the weight of 20 drops of water.)<br><br>Reasoning: 1 (The student states that 10 drops and 1 drops of water will weigh something less than 20 drops of water. This provides the rationale supporting why the evidence about weight is relevant to their argument.) |
| I chose my answers because if 20 drops equals 1 g then 10 equals nothing because it is not a gram yet. It would need 10 more drops of water. | Correct Principle: -1 (The student states that anything less than a gram does not have any weight. This is incorrect.)<br><br>Evidence: 1 (The student gives a measurement for the weight of 20 drops of water.)<br><br>Reasoning: 1 (The student provides a rationale supporting why the evidence about weight is relevant to their argument. Since 10 drops is less than 20 drops, which is equal to 1 gram, 10 drops will not weigh anything.) |
| 10 drops is ½ 20 drops so ½ gram. 1 drop is 1/20 20 drops so 1/20 gram. | Correct Principle: 2 (The student uses proportional reasoning to determine the exact weight of 10 drops and 1 drop.)<br><br>Evidence: 1 (The student utilizes mathematical expressions containing numbers that represent the weight of 20, 10, or 1 drop(s) of water.)<br><br>Reasoning: 1 (The student utilizes mathematical expressions to demonstrate the logic behind their argument.) |
| I chose this answer because 20 drops equals one so that's why. | Correct Principle: 0 (The student does not provide a claim, so it is unclear whether they think that 10 drops and/or 1 drop of water have weight.)<br><br>Evidence: 1 (The student gives a measurement for the weight of 20 drops of water.)<br><br>Reasoning: 0 (Although the student uses causal language, "because", they do not provide any rationale behind their argument – only evidence.) |
| If a drop of water weighed something, then raindrops would hurt. | Correct Principle: -1 (The student seems to believe that a drop of water has no weight, which is incorrect.)<br><br>Evidence: 0 (The student does not provide any information about the weight of the water drops from measurement or observation.) |

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| | |
|---|---|
| | Reasoning: 1 (The student provides a statement of logic to support their claim, in spite of a lack of evidence.) |
| Because for the 1st it was ten, in the middle of C and D. For the 2nd it was A. | Correct Principle: 1 (The student states that each drop of water weighs something, but incorrectly uses proportional reasoning to determine the weight of 10 drops – in between C and D.)<br><br>Evidence: 0 (The student does make reference to an observation or measurement.)<br><br>Reasoning: 0 (Even though the student uses causal language, "because", they do not provide a rationale supporting their claim.) |

| **Scale, Proportion, and Quantity: Relative Weight [answer only if 1b and 2b have answers]** | |
|---|---|
| **Score** | **Description of Response** |
| 1 | Answer to 2b is less than answer to 1b. |
| 0 | Answer to 2b is greater than or equal to answer to 1b. |

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| Scale, Proportion, and Quantity (Questions 1b and 2b) | |
|---|---|
| **Score** | **Description of Response** |
| 2<br>(S, P, & Q Level 3: Has generalized knowledge of fractions (there are an infinite number of fractions between any two integers); number and measure line is a dense, and quantities form a continuum.) | 1 on Question 1b AND 1 on Question 2b |
| 1<br>(S, P, & Q Level 2: Has knowledge of a few special fractions (1/2, 1/4); number and measure line is spotty.)<br>OR can describe weight qualitatively but not quantitatively. | 1 on Question 1b AND 0 on Question 2b<br>OR<br>Incorrect answer on either Question 1b or Question 2b, but Answer to 2b is less than answer to 1b |
| 0<br>(Below S, P, & Q Level 2: Has knowledge of a few special fractions (1/2, 1/4); number and measure line is spotty.) | 0 on Question 1b AND 0 on Question 2b AND answer to 2b is greater than or equal to answer to 1b |
| . | Blank or Missing on Question 1b and/or Question 2b |

| Matter - SCORING | |
|---|---|
| **Score** | **Description of Response** |
| 2<br>(Matter Level 3: Knows tiny things have weight.) | 1 on Question 1a AND 1 on Question 2a<br>AND<br>1 or 2 on Correct Physical Principles (3) |
| 1<br>(Weak Matter Level 3: Knows tiny things have weight.) | 1 on Question 1a AND 1 on Question 2a<br>AND<br>0 (or greater) on Correct Physical Principles (3) |
| 0<br>(Below Matter Level 3: Knows tiny things have weight.) | 1 on Question 1a AND 0 on Question 2a<br>OR<br>0 on Question 1a AND 1 on Question 2a<br>OR<br>0 on Question 1a AND 0 on Question 2a<br>OR<br>1 on Question 1a AND 1 on Question 2a<br>AND<br>-1 on Correct Physical Principles (3) |
| . | Blank or Missing on Question 1a and/or Question 2a |

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| Argument – SCORING | |
|---|---|
| **Score** | **Description of Response** |
| 3 | 3 on Question 3 |
| 2 | 2 on Question 3 |
| 1 | 1 on Question 3 |
| 0 | 0 |
| . | Blank or missing on Question 3 |

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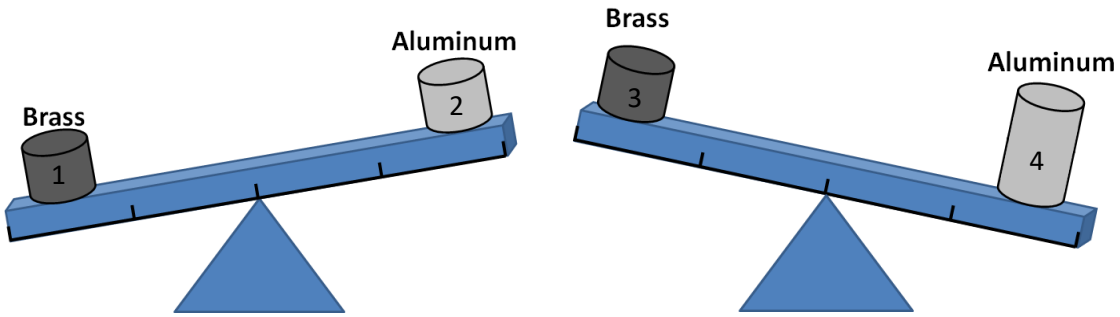
There are four cylinders on two balance scales. They are made of two different materials. Two cylinders are made of a material called brass. Two cylinders are made of a material called aluminum.

On Scale 1, cylinders 1 and 2 have the same volume.

On Scale 2, cylinders 3 and 4 have different volumes.

**Volume:** The amount of space that something takes up




Scale 1 Scale 2

**1a) What can you tell about the weight of cylinders 1 and 2?**

- ☐ Cylinder 1 weighs more.
- ☐ Cylinder 2 weighs more.
- ☐ The cylinders weigh the same amount.
- ☐ You cannot tell which one weighs more.

**1b) What can you tell about the weight of cylinders 3 and 4?**

- ☐ Cylinder 3 weighs more.
- ☐ Cylinder 4 weighs more.
- ☐ The cylinders weigh the same amount.
- ☐ You cannot tell which one weighs more.

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A very small piece of brass is the exact same size and shape as another very small piece of aluminum.


**2a) What can you tell about the weight of these small pieces of brass and aluminum?**

- ☐ The brass piece will weigh more.
- ☐ The aluminum piece will weigh more.
- ☐ They will both weigh the same tiny bit.
- ☐ They will both weigh nothing at all.
- ☐ You cannot tell anything about their weight.

**2b) How can you tell? Make an argument. Give your evidence and reasoning.**

_____

_____

_____

_____

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| Question 1a (Scale, Proportion, and Quantity) | |
|---|---|
| **Score** | **Description of Response** |
| 1 | 1a) Cylinder 1 weighs more |
| 0 | Any other response |
| Missing | 1a) is blank, but 1b), 2a), or 2b) are answered. |
| Blank | 1a), 1b), 2a), and 2b) are blank. |

| Question 1b (Scale, Proportion, and Quantity) | |
|---|---|
| **Score** | **Description of Response** |
| 1 | 1b) Cylinder 4 weighs more |
| 0 | Any other response |
| Missing | 1b) is blank, but 1a), 2a), or 2b) are answered. |
| Blank | 1a), 1b), 2a), and 2b) are blank. |

| Question 2a (Matter) | |
|---|---|
| **Score** | **Description of Response** |
| 1 | 2a) The brass piece will weigh more. |
| 0 | 2a) The aluminum piece will weigh more<br>They will both weigh the same tiny bit<br>They will both weigh nothing at all.<br>You cannot tell anything about their weight.<br>OR<br>Multiple responses |
| Missing | 1b) is blank, but 1a), 2a), or 2b) are answered. |
| Blank | 1a), 1b), 2a), and 2b) are blank. |

| Question 2b – Engaging in Argument from Evidence | |
|---|---|
| **Correct Principle** | 1 = Correct (Brass will be heavier because it is the heavier material when the two objects are the same size)<br><br>Examples:<br>Brass is heavier than aluminum.<br>When they were the same size, brass was heavier. |
| | 0 = Unclear or missing |
| | -1 = Incorrect (One of the following: (1) Either of the objects will be heavier because of the way they look, or some other quality of the objects other than weight when size is held constant; (2) Aluminum will be heavier because it is heavier on scale 2; (3) They will both weigh the same (or nothing) because they are so small; or (4) The student says, “I don’t know.”) |

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| | |
|---|---|
| | Examples:<br>Aluminum weighs more.<br>They are just two same size pieces sitting there.<br>There is no scale. |
| | Blank = 1a), 1b), 2a), and 2b) are all blank. |
| **Evidence** | 1 = Provides explicit, relevant evidence in support of a claim.<br>Evidence should be explicit scientific data, which supports a claim. "Scientific data are information, such as observations and measurements…provided to the students" (Berland & McNeill, 2010, p. 772). Evidence should be an observation or measurement of a physical quality of object(s). In this item, evidence is most likely to be a statement about the volume (size) and/or weight of the two objects, but it may also include specific statements about the appearance of the objects, or other observable physical attributes. Personal experience is not valid evidence. Mentioning the "amount" should not be considered evidence, since it does not specify a direct observation; referring to the "amount" can count as reasoning.<br><br>The student's claim is their answer to the previous question, unless the previous answer is missing. Their claim may be repeated within the argument (or, stated for the first time if the previous answer is missing).<br><br>*Evidence and reasoning may be woven together in one statement, such that they are inextricably linked in the student's argument. Use your best judgment to determine whether evidence and reasoning are present, based on the descriptions above and below. Do not make large inferences about what the student meant; when in doubt, place the burden of proof on the student.* |
| | *0 = Does not provide explicit, relevant evidence in support of a claim.* |
| | *Missing = 1a), 1b), and/or 2a) are answered, but 2b) is blank.* |
| | *Blank = 1a), 1b), 2a), and 2b) are all blank.* |
| **Reasoning** | 1 = Provides appropriate reasoning in support of a claim.<br>The reasoning clearly articulates the logic behind the claim. If evidence is present, the reasoning may provide a rationale for why the evidence supports the claim.<br><br>Students often use words like "because," "so," "since," etc. which we may falsely attribute to causal reasoning. If a student uses causal language, carefully evaluate the content of their argument. Students may use these words to repeat a claim or provide evidence. In this case, this causal language should not be taken as an indicator of student reasoning.<br><br>Referring to the "amount" can count as reasoning. |

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| | |
|---|---|
| | Statements such as “Brass is heavier than aluminum” or, although incorrect, “Aluminum is heavier” count as reasoning.<br><br>*Evidence and reasoning may be woven together in one statement, such that they are inextricably linked in the student’s argument. Use your best judgment to determine whether evidence and reasoning are present, based on the descriptions above. Do not make large inferences about what the student meant; when in doubt, place the burden of proof on the student.* |
| | *0 = Does not provide relevant evidence in support of claim.* |
| | *Missing = 1a), 1b), and/or 2a) are answered, but 2b) is blank.* |
| | *Blank = 1a), 1b), 2a), and 2b) are all blank.* |

| **Example** | **Scores with explanations** |
|---|---|
| When brass and aluminum were the same size, the brass was heavier. Now they are the same size again so brass will be heavier. | Correct Principle: 1 (In this example, the student argues that the relative relationship between the weight and size of two objects will remain constant. Thus, the student seems to understand the scientific principle.)<br><br>Evidence: 1 (The student’s claim is that “brass will be heavier.” To support this claim, the student provides evidence in the form of an observation: “When brass and aluminum were the same size, the brass was heavier.”)<br><br>Reasoning: 1 (The student reasons by connecting information obtained from a prior observation to the current situation: “Now they are the same size again.”) |
| They are both small, so they will probably weigh about the same. | Correct Principle: -1 (This student’s response indicates that he or she believes that all objects of the same size will “probably weigh about the same.” Thus, the student’s response suggests that he or she does not understand the scientific principle.)<br><br>Evidence: 1 (The student’s claim is that both materials will weigh the same. To support his or her claim, the student provides evidence in the form of an observation: “They are both small.”)<br><br>Reasoning: 0 (Although the student used “so,” which suggests causal language, the part of the sentence that comes after “so” is simply a restatement of the claim.) |
| In the last picture brass weighed more. | Correct Principle: 1 (The student’s response clearly indicates that he or she understands that brass is heavier than aluminum.) |

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| | |
|---|---|
| | Evidence: 1 (Although not explicitly stated, the student's claim is that the brass will weigh more. The student provides evidence in the form of an observation about the weight of brass in a previous scenario. *Please note the contrast between this example and the one directly below: "Brass is a heavier material." Although both responses are similar, this example counts as evidence because the student refers to a specific observation. In the example below, the student refers to the general relationship between the two materials.*)<br><br>Reasoning: 0 (The student does not provide reasoning to support his or her response.) |
| Brass is a heavier material. | Correct Principle: 1 (The student's response clearly indicates that he or she understands that brass is heavier than aluminum.)<br><br>Evidence: 0 (Although not explicitly stated, the student's claim is that the brass will weigh more. However, the student does not provide evidence to support this claim. )<br><br>Reasoning: 1 (The student explains that the brass will weigh more because "brass is a heavier material." In this case, the reasoning is in the form of a fact concerning the relative weights of the two materials.) |
| They did not put a scale to help us decide what the weight is. | Correct Principle: -1 (The student thinks that a scale is needed to answer the question, which suggests that the student does not understand that a brass object will always be heavier than an aluminum object of the same size.)<br>Evidence: 1 (Although not explicitly stated, the student's claim is that there is not enough information to determine the relative weights of the two materials. Thus, the evidence is in the form of an observation that there is not a scale.)<br><br>Reasoning: 0 (The student does not provide reasoning.) |
| I can tell cause I did in second grade with brass and aluminum. | Correct Principle: 0 (In this example, it is unclear whether the student understands the principle, since the student is relying on personal experience.)<br><br>Evidence: 0 (The student uses personal experience as evidence. Personal experiences do not count as scientific observations).<br><br>Reasoning: 0 (Although the student says "cause," which suggests causal reasoning, the student does not provide reasoning.) |

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| Scale, Proportion, and Quantity - SCORING | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>(S, P, & Q Level 2: Knows how to measure weight with balance scale, length with rulers, and area with tiles) | 1 on 1a AND 1 on 1b |
| 0<br>(Below S, P, & Q Level 2: Knows how to measure weight with balance scale, length with rulers, and area with tiles) | 0 on 1a AND 0 on 1b<br>OR<br>0 on 1a AND 1 on 1b<br>OR<br>1 on 1a AND 0 on 1b |
| . | Blank or Missing on 1a and/or 1b |

| Matter - SCORING | |
|---|---|
| **Score** | **Description of Response** |
| 2<br>(Matter Level 3: Integrates weight, volume, and heaviness for size in compositional model of materials AND Knows tiny things have weight) | 1 on 2a and 1 on Correct Physical Principles |
| 1<br>(Weak Matter Level 3: Knows tiny things have weight) | 1 on 2a and 0 on Correct Physical Principles |
| 0<br>(Below Matter Level 3: Integrates weight, volume, and heaviness for size in compositional model of materials) | 1 on 2a and -1 on Correct Physical Principles<br>OR<br>0 on 2a |
| . | Blank or Missing on 2a |

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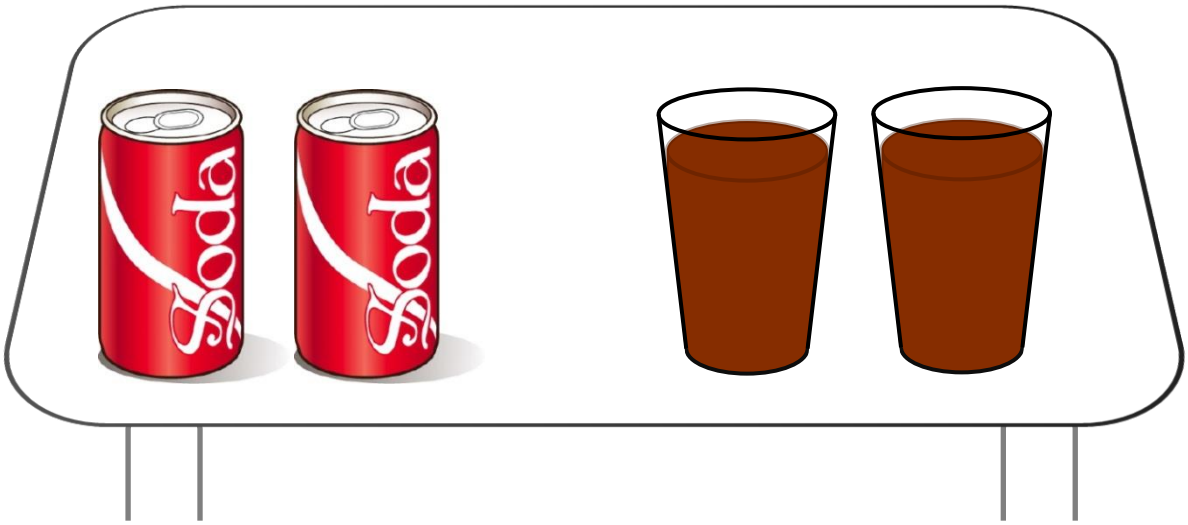
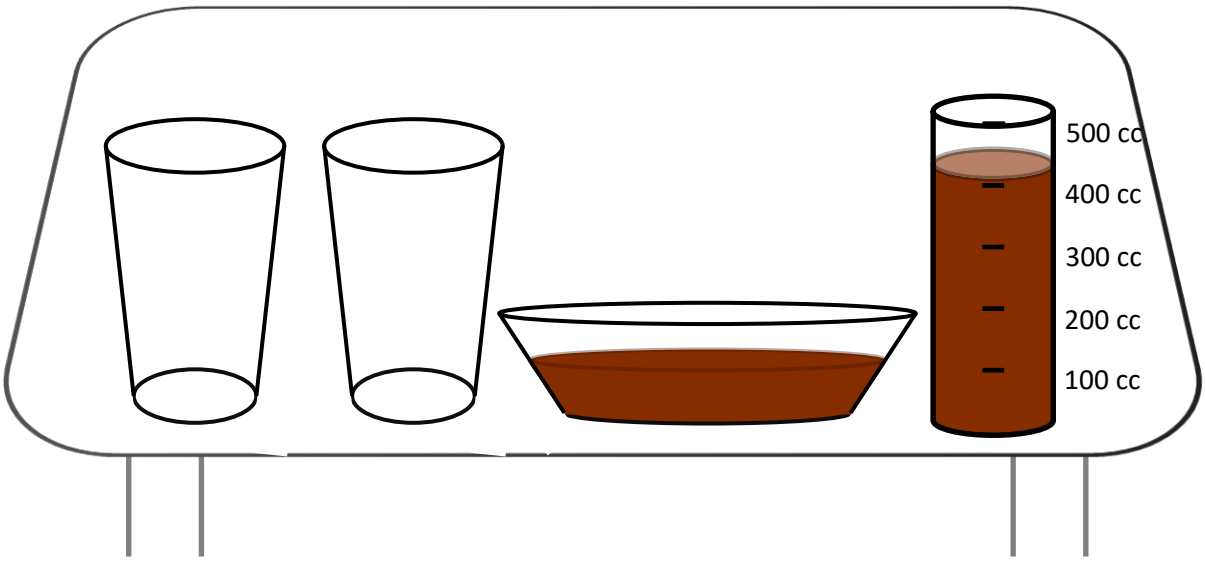
Nate pours two cans of soda into two glasses.




He pours all of the soda from one glass into a shallow bowl. He pours the other glass into a tall measuring cup.




**1a) Is the volume of soda in the bowl and the measuring cup the same, or different?**

- ☐ Same.
- ☐ Different.

**Volume:**
The amount of space that something takes up

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**1b) Why do you think so? Make an argument. Give your evidence and reasoning.**

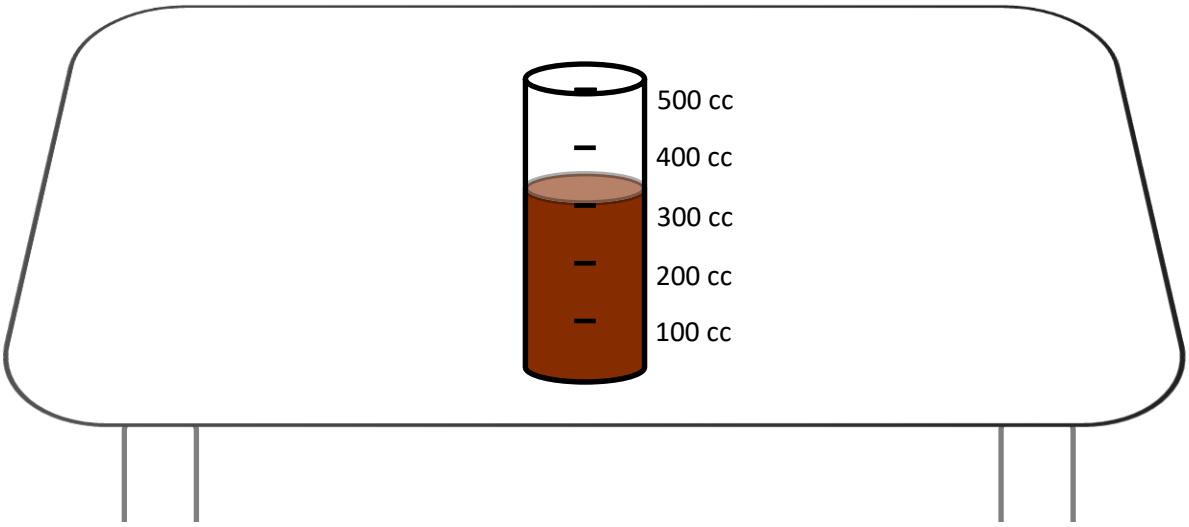
_____

_____

_____

_____

Nate pours some soda out of the measuring cup.




**2) Does the volume of soda in the measuring cup change?**

☐ Yes. How much did it change? _____

☐ No. Why not? _____

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| **Question 1a (Matter)** | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>Differentiates volume from area and understands volume of liquids is invariant with reshaping. | Same |
| 0<br>Does not differentiate volume from area/ understand volume of liquids is invariant with reshaping. | Different |
| Missing | 2) and/or 1b) is answered, but 1a) is blank. |
| Blank | 1a), 1b), and 2) are all blank. |

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| **Question 1b – Engaging in Argument from Evidence** | |
|---|---|
| **Correct Principle** | 1 = Correct (the amount of liquid is conserved)<br><br>Examples:<br>There is an equal amount of soda.<br>The containers are different shapes but the volume is the same. |
| | 0 = Unclear, missing, or inconsistent |
| | -1 = Incorrect (the shape of the liquid affects the volume)<br><br>Examples:<br>The bowl is wider so it is bigger.<br>They are different because the bowl takes up more space than the cup. |
| | Blank = 1), 2), 3), 4a), and 4b) are all blank. |
| **Evidence** | 1 = Provides explicit, relevant evidence in support of a claim.<br>Evidence should be explicit scientific data, which supports a claim. "Scientific data are information, such as observations and measurements…provided to the students" (Berland & McNeill, 2010, p. 772). Evidence should be an observation or measurement of a physical quality of object(s). In this item, evidence is most likely to be a statement about the volume of the original cans of soda or height/width of the containers. It may also include specific statements about other observable physical attributes of the containers. Personal experience is not valid evidence. Mentioning the "amount" should not be considered evidence, since it does not specify a direct observation; referring to the "amount" can count as reasoning.<br><br>The student's claim is their answer to the previous question, unless the previous answer is missing. Their claim may be repeated within the argument (or, stated for the first time if the previous answer is missing).<br><br>*Evidence and reasoning may be woven together in one statement, such that they are inextricably linked in the student's argument. Use your best judgment to determine whether evidence and reasoning are present, based on the descriptions above and below. Do not make large inferences about what the student meant; when in doubt, place the burden of proof on the student.* |
| | *0 = Does not provide explicit, relevant evidence in support of a claim.* |
| | *Missing = 4b) is blank, but 1), 2), 3), and/or 4a) have answers.* |
| | *Blank = 1), 2), 3), 4a), and 4b) are all blank.* |
| **Reasoning** | 1 = Provides appropriate reasoning in support of a claim.<br>The reasoning clearly articulates the logic behind the claim. If evidence is present, the reasoning may provide a rationale for why the evidence supports the claim.<br><br>Students often use words like "because," "so," "since," etc. which we may falsely attribute to causal reasoning. If a student uses causal language, carefully evaluate the content of their argument. Students may use these words to repeat a claim or provide evidence. In this case, this causal language should not be taken as an indicator of student reasoning. |

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| | |
|---|---|
| | Referring to the "amount" can count as reasoning.<br><br>*Evidence and reasoning may be woven together in one statement, such that they are inextricably linked in the student's argument. Use your best judgment to determine whether evidence and reasoning are present, based on the descriptions above. Do not make large inferences about what the student meant; when in doubt, place the burden of proof on the student.* |
| | *0 = Does not provide relevant evidence in support of claim.* |
| | *Missing = 4b) is blank, but 1), 2), 3), and/or 4a) have answers.* |
| | *Blank = 1), 2), 3), 4a), and 4b) are all blank.* |

| **Example** | **Scores with explanations** |
|---|---|
| They are always going to be the same no matter where you pour it, because it started the same. | Correct Principle: 1 (The student's answer suggests that they think the volume of liquids is invariant based on the container.)<br><br>Evidence: 1 (The student observes that the volume of the two cans of soda was the same, before they were poured.)<br><br>Reasoning: 1 (The student states that the volume will be the same "no matter where you pour it" because it started as the same amount which provides a rationale for their argument.) |
| Because they're not in the same container then how flat it lies or how wide it is would be different. | Correct Principle: -1 (The answer suggests that the student thinks that volume is dependent on the shape of the container.)<br><br>Evidence: 1 (The student provides an observation that the containers have different shapes.)<br><br>Reasoning: 1 (The student says "how flat it lies or how wide it is would be different." This statement provides the logic that connects their observation about the shape of the container to their implicit claim that the volume is different.) |
| I think so because the soda is just in a different form. | Correct Principle: 1 (The student states that the "form" (shape) of the liquid does not impact its volume.)<br><br>Evidence: 1 (The student observes that the shape of the soda is different.)<br><br>Reasoning: 0 (The student does not provide any rationale linking the observation to their implicit claim that the volume would be the same.) |
| They will be about the same because the can is thinner and the shallow bowl is wider. | Correct Principle: 0 (The student thinks that the volume will be the same, but suggests that they might just be visually comparing the amount of space occupied by the liquid in the picture.) |

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| | |
|---|---|
| | Evidence: 1 (The student provides observations about the containers: “the can is thinner and the shallow bowl is wider.”)<br><br>Reasoning: 0 (The student does not provide any rationale linking the observation to their claim that the volume would be the same.) |
| I think the volume of the soda in the bowl is different from the soda in the cup because I believe the volume can change by being positioned differently. | Correct Principle: -1 (The student explicitly states a belief that volume varies with the position of a liquid.)<br><br>Evidence: 0 (The student does not provide any observation about the shape of the containers, or the volume of the liquid.)<br><br>Reasoning: 1 (Despite a lack of evidence to support their claim, the student clearly articulates a rationale for their argument.) |
| Because I looked at them both and the bowl looks like it holds more. | Correct Principle: -1 (The student seems to believe that the volume of the containers is unequal, which is incorrect.)<br><br>Evidence: 0 (The student provides an observation that it “looks like it holds more.” This observation is not concrete enough to be considered valid evidence.)<br><br>Reasoning: 0 (The student does not provide any rationale beyond the observation that it “looks like it holds more.”) |

| **Question 2 (Scale, Proportion, and Quantity)** | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>Uses addition and subtraction to mathematically reason about volume. | Yes. How much did it change? 100 cubic centimeters.<br>(Accept abbreviations, other units of measurement, no unit of measurement. Do not accept from 400 cc to 300 cc.) |
| 0<br>Cannot use addition and subtraction to mathematically reason about volume. | Yes. How much did it change? Any other answer.<br>OR<br>No. Why not? Any answer. |
| Missing | 1a) and/or 1b) is answered, but 2) is blank. |
| Blank | 1a), 1b), and 2) are all blank. |

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| Scale, Proportion, and Quantity - SCORING | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>(S, P, & Q Level 4: Uses addition and subtraction to mathematically reason about volume.) | 1 on Question 2 |
| 0<br>(Below S, P, & Q Level 4: Uses addition and subtraction to mathematically reason about volume.) | 0 on Question 2 |
| . | Blank or Missing on Question 2 |

| Matter - SCORING | |
|---|---|
| **Score** | **Description of Response** |
| 2<br>(Matter Level 3: Differentiates volume from area and understands volume of solid objects and liquids is invariant with reshaping.) | 1 on Question 1a AND 1 on Correct Physical Principles |
| 1<br>(Weak Matter Level 3: Differentiates volume from area and understands volume of solid objects and liquids is invariant with reshaping.) | 1 on Question 1a AND 0 on Correct Physical Principles |
| 0<br>(Below Matter Level 3: Differentiates volume from area and understands volume of solid objects and liquids is invariant with reshaping.) | 0 on Question 1a<br>OR<br>1 on Question 1a AND -1 on Correct Physical Principles |
| . | Blank or Missing on Question 1a and 1b |

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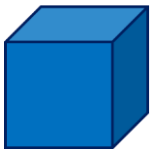
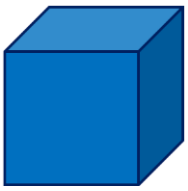
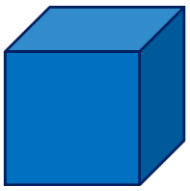
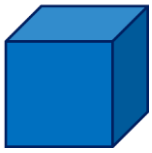
Here are four blocks. All of the blocks are solid, with no air inside of them. The chart shows the weight and volume of each block.

| | A | B | C | D |
|---|---|---|---|---|
| |  |  |  |  |
| **Weight (grams)** | 5 g | 15 g | 10 g | 10 g |
| **Volume (cubic centimeters)** | 5 cc | 10 cc | 10 cc | 5 cc |

**1) Which block takes up the most space? (You can pick more than one block if there is a tie.)**

_____

**Volume:** The amount of space that something takes up

**2) Which block is heaviest? (You can pick more than one block if there is a tie.)**

_____

**3) Which blocks are heaviest for their sizes?**

_____

**4a) Do you think any of the blocks could be made of the same material?**

☐ Yes. Which ones? _____

☐ No, none of the blocks could be made of the same material.

**Material:** Glass, sand, and different types of wood and metal are examples of different materials

**4b) Why do you think so? Make an argument. Give your evidence and reasoning.**

_____

_____

_____

_____

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| Question 1 (Scale, Proportion, and Quantity) | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>Can evaluate relative volume, given measurements. | B and C |
| 0<br>Cannot evaluate relative volume, given measurements. | Any other answer |
| Missing | 1) is blank, but 2), 3), 4a), and/or 4b) have answers |
| Blank | 1), 2), 3), 4a), and 4b) are all blank |

| Question 2 (Scale, Proportion, and Quantity) | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>Can evaluate relative weight, given measurements. | B |
| 0<br>Cannot evaluate relative weight, given measurements. | Any other answer |
| Missing | 2) is blank, but 1), 3), 4a), and/or 4b) have answers |
| Blank | 1), 2), 3), 4a), and 4b) are all blank |

| Question 3 (Scale, Proportion, and Quantity) | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>Can evaluate relative density when volume is held constant. | B and D<br>OR<br>D |
| 0<br>Cannot evaluate relative density when volume is held constant. | Any other answer |
| Missing | 3) is blank, but 1), 2), 4a), and/or 4b) have answers |
| Blank | 1), 2), 3), 4a), and 4b) are all blank |

| Question 4a (Matter + Scale, Proportion, and Quantity) | |
|---|---|
| **Score** | **Description of Response** |
| 1<br>Integrates information about weight and volume; and recognizes density (heaviness for size) is a constant property of materials. | 4a) Yes. Which one? <u>A and C</u> |
| 0<br>Does not integrate information about weight and volume; does not recognize density (heaviness for size) is a constant property of materials. | 4a) Yes. Which one? <u>Any other answer</u> or <u>no answer</u><br>OR<br>4a) No, none of the blocks could be made of the same material. |
| Missing | 4a) is blank, but 1), 2), 3), and/or 4b) have answers |
| Blank | 1), 2), 3), 4a), and 4b) are all blank |

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| Question 4b – Engaging in Argument from Evidence | |
|---|---|
| **Correct Principle** | 2 = Completely correct<br>A and C have the same ratio between their weight and volume (5 g: 5 cc = 10 g: 10 cc). A response can state this principle a couple of different ways, but most commonly will include a statement that A is half of C (or C is twice A) in weight and volume. Overall, the response should indicate that the student is thinking about density as involving a *quantitative* proportional relationship between weight and volume. (This is very different from the kids who notice a pattern that A and C have volumes that are equal to their weights, but don't articulate any explicit quantitative proportional reasoning - just pattern matching. See category -1.)<br><br>Examples<br>If you shrunk C, it would be the same as A.<br>A is 1/3 the size and weight of C.<br>Block A is ½ of Block C. If Block A doubles its size, it will be the same as Block C. |
| | 1 = Partially correct<br>Students recognize that the relationship between weight and volume is an essential aspect of materials, but their description of the relationship is *qualitative* rather than *quantitative*. In order to receive a score of 1, the student's response should talk about BOTH volume (size, etc.) and weight (heaviness, etc.) in a manner that suggests that they are wrestling with the concepts of weight and volume (rather than only recognizing patterns in the data). This may manifest in a few different types of responses.<br>In one type of response, students recognize that in order to be made of the same material, two objects that have the same volume should also have the same weight (or vice versa), but are confused because none of the objects in the problem have the same volume AND same weight. These students have a more basic understanding that if two objects are the same material, there is a relationship between weight and volume that needs to be constant, but they aren't able to engage in the quantitative proportional reasoning needed to recognize when objects of DIFFERENT volumes might be made of the same material.<br>A slight variant of this response is an imprecise recognition of the relationship between weight and volume by students who argue that two of the blocks are made of the same material because their weight and/or volume are close enough that they are basically equal.<br>Student responses that justify picking two blocks based on their relative "heaviness for size" should also fall into this category.<br><br>Examples<br>Cube A and cube D are the same size but cube D weighs as much as cube C and cube C is the same size as cube B so therefore they are all made of different material.<br>A and D has different weights but has the same volume. B and C also has the same volume but weighs differently. And C and D weigh the same, but have different volume.<br>Because none of them have the same weight and volume.<br>B and C have the same volume and their weights are close enough.<br>B and D are both the heaviest for their size. |
| | 0 = Unclear or missing |
| | -1 = Incorrect |

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| | |
|---|---|
| | Answer mentions or implies an incorrect physical principle, or the student says “I don’t know,” which is a direct admission of a lack of understanding.<br>This category includes responses that rely on pattern-matching. In this case, the respondent recognizes that the weight is equal to the volume, but does not provide evidence that they are thinking of weight and volume as physical concepts, but only as entities in the table.<br><br>Examples:<br>The weight and volume are the same as each other, while B and D both have 5 more grams than the number of cc’s.<br>I think that they are the same because they are all solid and how similar the size is. |
| | Missing = 4b) is blank, but 1), 2), 3), and/or 4a) have answers. |
| | Blank = 1), 2), 3), 4a), and 4b) are all blank. |
| **Evidence** | 1 = Provides explicit, relevant evidence in support of a claim.<br>Evidence should be explicit scientific data, which supports a claim. “Scientific data are information, such as observations and measurements…provided to the students” (Berland & McNeill, 2010, p. 772). Evidence should be an observation or measurement of a physical quality of object(s). In this item, evidence is most likely to be a statement about the weight or volume (size) of one or more blocks, but it may also include specific statements about other observable physical attributes like height, width, or appearance. Personal experience is not valid evidence. Mentioning the “amount” should not be considered evidence, since it does not specify a direct observation; referring to the “amount” can count as reasoning.<br><br>The student’s claim is their answer to the previous question, unless the previous answer is missing. Their claim may be repeated within the argument (or, stated for the first time if the previous answer is missing).<br><br>If the student utilizes mathematical expressions containing numbers that represent the weight and volume of the blocks, these numbers may be considered evidence.<br><br>*Evidence and reasoning may be woven together in one statement, such that they are inextricably linked in the student’s argument. Use your best judgment to determine whether evidence and reasoning are present, based on the descriptions above and below. Do not make large inferences about what the student meant; when in doubt, place the burden of proof on the student.* |
| | 0 = Does not provide explicit, relevant evidence in support of a claim. |
| | Blank = 1), 2), 3), 4a), and 4b) are all blank. |
| **Reasoning** | 1 = Provides appropriate reasoning in support of a claim.<br>The reasoning clearly articulates the logic behind the claim. If evidence is present, the reasoning may provide a rationale for why the evidence supports the claim.<br><br>Students often use words like “because,” “so,” “since,” etc. which we may falsely attribute to causal reasoning. If a student uses causal language, carefully evaluate the content of their argument. Students may use these words to repeat a claim or provide evidence. In this case, this causal language should not be taken as an indicator of student reasoning.<br><br>If the student utilizes mathematical expressions to demonstrate the logic behind their argument, this may be considered reasoning. |

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| | If the student uses the phrase “heavier material” or “heavier for size” to describe any block, this may be taken as an indicator of reasoning.<br><br>Referring to the “amount” can count as reasoning.<br><br>*Evidence and reasoning may be woven together in one statement, such that they are inextricably linked in the student’s argument. Use your best judgment to determine whether evidence and reasoning are present, based on the descriptions above. Do not make large inferences about what the student meant; when in doubt, place the burden of proof on the student.* |
| | 0 = Does not provide relevant evidence in support of claim. |
| | Missing = 4b) is blank, but 1), 2), 3), and/or 4a) have answers. |
| | Blank = 1), 2), 3), 4a), and 4b) are all blank. |

| **Example** | **Scores with explanations** |
|---|---|
| C and D have the same weight in grams and they don’t need the same volume in cc. | Correct Principle: -1 (The student suggests that only weight determines what material an object is made out of, and that volume does not matter.)<br><br>Evidence: 1 (The student’s claim, although not explicitly stated, is that C and D are the same material. This is supported by their observation about the measurement of blocks C and D, in grams.)<br><br>Reasoning: 1 (The student states that the blocks “don’t need the same volume in cc.” This provides the rationale supporting why the evidence about weight is relevant to their claim.) |
| I don’t think any of the blocks could be made out of the same material. I think this because blocks B and C seem to have the exact same volume, but they both have different weights. The material for B is probably metal and C is probably wood. | Correct Principle: 1 (The student recognizes that both volume and weight are relevant to material, and understands that if two objects are the same material, there is a relationship between weight and volume that needs to be constant. However, they aren't able to engage in the quantitative proportional reasoning needed to recognize when objects of different volumes might be made of the same material.)<br><br>Evidence: 1 (The student’s claim is that no two blocks are the same material. This is supported by their observation about the weight and volume measurements of blocks B and C.)<br><br>Reasoning: 1 (The student says “the material for B is probably metal and C is probably wood,” providing a specific hypothetical example of two different materials that would account for the pattern of weight and volume observed. This reasoning is not a statement of a scientific principle, or a belief held by the student. However, it still serves as an illustration of the logic behind the student’s evidence, that when 2 objects are the same size and |

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| | different weight, one must be made of a heavier material than the other.) |
| Possible because A weighs less than C but it is 2 times bigger. With A, it's 2 times smaller than C, and it weighs double the amount as A. | Correct Principle: 2 (The student's response indicates that they understand that the proportional relationship between weight and volume is a defining characteristic of materials.)<br><br>Evidence: 1 (The student provides information about the weight and volume of 2 of the blocks, in support of their implicit claim that A and C are made of the same material.)<br><br>Reasoning: 0 (The student does not provide reasoning in support of their claim. There is no explanation of why A and C's weight and volume measurements are relevant to their argument. Although they do use causal language, "because", the student's statement only provides evidence.) |
| No, A, D are the same and B, C. That shows one material may be heavier or lighter. | Correct Principle: 0 (The student's claim is that none of the objects are made of the same material. However, their evidence and reasoning are vague. Therefore, it is unclear whether or not the student understands that a relationship between volume and weight is a defining characteristic of materials.)<br><br>Evidence: 0 (The student does provide an observation in support of the claim: "A,D are the same and B,C." However, this observation is so vague that it is unclear whether the student is referring to weight, volume, or some other attribute of objects A and D. Therefore, this evidence is so weak that it merits a score of 0.)<br><br>Reasoning: 1 (The student gives a statement that provides rationale for their claim: "That shows one material may be heavier or lighter.") |
| I think A and D because they look the same and all of them are the same so there is only size difference that makes it heavy. | Correct Principle: -1 (The student's claim is unclear. At one point they say that "A and D" are the same material, and then later they say that "all of them are the same." Regardless, the student's statement that "there is only size difference that makes it heavy" suggests that weight is not a defining characteristic of materials – an incorrect assertion.)<br><br>Evidence: 0 (The student provides the observation that "they look the same." This is not sufficiently detailed to be considered evidence.)<br><br>Reasoning: 0 (The student provides a statement that "there is only size difference that makes it heavy," which might be considered reasoning. However, this statement is not linked to their observation, where they stated that A and D could be made of the same material. Blocks A and D are the same size, so their statement that "only size difference" makes it heavy does not clearly support their claim.) |

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| No because they all weigh different besides blocks C and D. But, some objects are little and weigh a lot, or big and weigh a small amount of weight. I remember in folk tales, they sometimes say that the brick weighs more than the mountain of feathers but they are wrong. | Correct Principle: 0 (The student's claim is that none of the objects are made of the same material. However, their reasoning is vague. Therefore, it is unclear whether or not the student understands that a relationship between volume and weight is a defining characteristic of materials.)<br><br>Evidence: 1 (The student provides an observation about the weight of the blocks.)<br><br>Reasoning: 0 (The student provides a large statement that they intended as support for their evidence. However, this statement is not clearly linked to the evidence. Their evidence refers only to the weight of the blocks, but then their explanation draws in volume, and goes into a tangential explanation about folk tales.) |
| I think they're all made of the same materials, but the bigger they are they weigh more. | Correct Principle: 1 (The student recognizes that weight and volume are both factors in defining a material, even though they are unable to perform the exact proportional reasoning required to compare objects with different volumes.)<br><br>Evidence: 0 (The student does make reference to an observation – "the bigger they are they weigh more," however, they make no reference to weight and volume of specific blocks. Therefore, this statement is not specific enough to be considered evidence.)<br><br>Reasoning: 1 ("the bigger they are they weigh more" is a statement that describes the relationship between weights of different-size objects made of the same material. This statement provides a rationale for why different-size blocks might weigh the same, although it would be more effective in the presence of clear evidence.) |

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| Scale, Proportion, and Quantity - SCORING | |
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| **Score** | **Description of Response** |
| 3<br>(S, P, & Q Level 4: Quantifies and compares object characteristics based on proportional relationships) | 1 on question 4a.<br>AND<br>1 on question 3<br>AND<br>1 on question 2<br>1 on question 1<br>AND<br>2 on Correct measurement principle |
| 2<br>(S, P, & Q Level 3: Beginning understanding of measured characteristics that involve proportional relationships) | 1 on question 3<br>AND<br>1 on question 2 AND 1 on question 1<br>AND<br>0 on question 4a OR missing on question 4a AND Below 2 on Correct measurement principle<br>OR----------<br>1 on question 3<br>AND<br>1 on question 2 AND 1 on question 1 |
| 1<br>(S, P, & Q Level 2: Can use measures to evaluate relative scale for weight and volume) | 1 on question 2 AND 1 on question 1<br>AND<br>0 on question 4a OR missing on question 4a<br>AND<br>0 on question 3 OR missing on question 3 |
| 0<br>(S, P, & Q Level 1) | 0 on question 1 OR 0 on question 2<br>AND<br>0 on question 4a OR missing on question 4a<br>AND<br>0 on question 3 OR missing on question 3 |
| . | Blank<br>OR<br>Missing on one or more of questions 1, 2, 3, and 4a, such that it is impossible to make a minimum inference (see below) |

[Note: If students get question 4a correct without getting question 1 or question 2 or question 3 correct, give them the score that corresponds to the **minimum** inference that we can make about their ability – either 0 or 1, depending on the specific pattern of responses.]

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| Matter - SCORING | |
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| **Score** | **Description of Response** |
| 2<br>(Matter Level 3: Integrates weight, volume, and heaviness for size in compositional model of materials.) | 1 on question 4a AND 2 on Correct measurement principles<br>OR<br>0 on question 4a AND 2 on Correct measurement principles |
| 1<br>(Weak Matter Level 3: Integrates weight, volume, and heaviness for size in compositional model of materials.) | 1 on question 4a AND 1 on Correct measurement principles<br>OR<br>0 on question 4a AND 1 on Correct measurement principles |
| 0<br>(Below Matter Level 3: Integrates weight, volume, and heaviness for size in compositional model of materials.) | 0 on question 4a and 0 on Correct measurement principles<br>OR<br>0 on question 4a and -1 on Correct measurement principles<br>OR<br>1 on question 4a AND 0 on Correct measurement principles<br>OR<br>1 on question 4a and -1 on Correct measurement principles |
| . | Blank or Missing on question 4a |

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