2022 MCAS Sample Student Work and Scoring Guide

High School Introductory Physics
Question 37: Constructed-Response

Reporting Category: Energy
Practice Category: Evidence, Reasoning, and Modeling
Standard: HS.PHY.3.2 - Develop and use a model to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles and objects or energy stored in fields.
Item Description: Describe how the average molecular motion of molecules changed in two containers, use data to support a claim that energy was conserved, and explain why the average molecular motion of molecules was the same when thermal equilibrium was reached.

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Scoring Guide

Select a score point in the table below to view the sample student response.

Score*	Description
3A	The response demonstrates a thorough understanding of how the transfer of thermal energy between objects of different temperatures results in thermal equilibrium. The response correctly compares the average molecular motion of the water molecules in containers 1 and 2. The response clearly describes how temperature data can be used to show that energy is conserved. The response also correctly compares the average molecular motion of water molecules in containers 1 and 2 when they are in thermal equilibrium and clearly explains the reasoning.
3B	
2	The response demonstrates a partial understanding of how the transfer of thermal energy between objects of different temperatures results in thermal equilibrium.
1	The response demonstrates a minimal understanding of how the transfer of thermal energy between objects of different temperatures results in thermal equilibrium.
0	The response is incorrect or contains some correct work that is irrelevant to the skill or concept being measured.

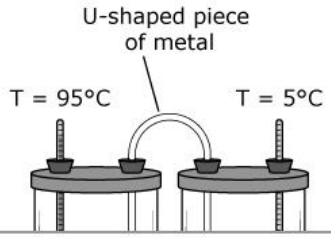
*Letters are used to distinguish between sample student responses that earned the same score (e.g., 3A and 3B).

Score Point 3A

A student conducted two investigations to learn about thermal energy transfer.

Investigation 1

During investigation 1, the student used two insulated containers, container 1 and container 2. The student added 500 g of 95ºC water to container 1 and 500 g of 5ºC water to container 2. The student closed the containers and placed a thermometer in each. The student then placed one end of a U-shaped piece of metal into the water in container 1 and the other end into the water in container 2, as shown.



This question has three parts.

The student analyzed the transfer of thermal energy that took place during investigation 1.

Part A

Select from the drop-down menus to correctly complete the sentence.

During the first 100 s in investigation 1, the average molecular motion of the water molecules in container 1 [decreased ▾], and the average molecular motion of the water molecules in container 2 [increased ▾].

Part B

The student claimed that energy was conserved in the system during the transfer of thermal energy in investigation 1.

Describe how the student could use the data in Table 1 to support the claim.

The Law of Conservation of Energy is shown in the table from investigation 1. As the temperature in conatainer one decresed, the temperature in container two incresed by an equal amount. Since the substances in both containers had the same specific heat and mass and change in temperature, this shows that they also had equal transfers of heat. The heat from container one transferred to container two.

Part C

Eventually thermal equilibrium was reached in investigation 1.

Compare the average molecular motion of the water molecules in both container 1 and container 2 after thermal equilibrium was reached. Explain your reasoning.

The average molecular movement in containers one an two are equal. This is shown because they have equal temperatures and temperature is the measure of the average kinetic energy in a substance. Kinetic energy is the energy of motion, so if there is equal amounts of kinetic energy, there is an equal amount of molecular motion.

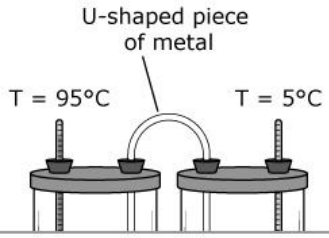
Back to Scoring Guide

Score Point 3B

A student conducted two investigations to learn about thermal energy transfer.

Investigation 1

During investigation 1, the student used two insulated containers, container 1 and container 2. The student added 500 g of 95°C water to container 1 and 500 g of 5°C water to container 2. The student closed the containers and placed a thermometer in each. The student then placed one end of a U-shaped piece of metal into the water in container 1 and the other end into the water in container 2, as shown.



This question has three parts.

The student analyzed the transfer of thermal energy that took place during investigation 1.

Part A

Select from the drop-down menus to correctly complete the sentence.

During the first 100 s in investigation 1, the average molecular motion of the water molecules in container 1 [decreased ▾], and the average molecular motion of the water molecules in container 2 [increased ▾].

Part B

The student claimed that energy was conserved in the system during the transfer of thermal energy in investigation 1.

Describe how the student could use the data in Table 1 to support the claim.

Table 1 shows that energy was conserved in the system during the transfer of thermal energy since the sum of the temperatures for container one and two are equal to the sum of their original temperatures. In the beginning, the sum of container one and two's temperatures is 100 degrees Celsius. As heat is transferred, the sum remains the same. For example, at 200 seconds, 66.6+33.4= 100, at 300 seconds, 60+40= 100, and at 700 second 50+50= 100, the two temperatures always equal 100.

Part C

Eventually thermal equilibrium was reached in investigation 1.

Compare the average molecular motion of the water molecules in both container 1 and container 2 after thermal equilibrium was reached. Explain your reasoning.

The average molecular motion of the water molecules in both containers after thermal equilibrium was reached was the same. Since the two container of water have the same temperature, their molecules will have the same amount of kinetic energy, which mean the molecules movement will be the same.

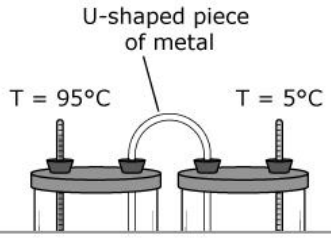
Back to Scoring Guide

Score Point 2

A student conducted two investigations to learn about thermal energy transfer.

Investigation 1

During investigation 1, the student used two insulated containers, container 1 and container 2. The student added 500 g of 95°C water to container 1 and 500 g of 5°C water to container 2. The student closed the containers and placed a thermometer in each. The student then placed one end of a U-shaped piece of metal into the water in container 1 and the other end into the water in container 2, as shown.



This question has three parts.

The student analyzed the transfer of thermal energy that took place during investigation 1.

Part A

Select from the drop-down menus to correctly complete the sentence.

During the first 100 s in investigation 1, the average molecular motion of the water molecules in container 1 [decreased ▾], and the average molecular motion of the water molecules in container 2 [increased ▾].

Part B

The student claimed that energy was conserved in the system during the transfer of thermal energy in investigation 1.

Describe how the student could use the data in Table 1 to support the claim.

The student could say that for the final two seconds the temperature stayed the same so that is how the energy was conserved.

Part C

Eventually thermal equilibrium was reached in investigation 1.

Compare the average molecular motion of the water molecules in both container 1 and container 2 after thermal equilibrium was reached. Explain your reasoning.

The average molecular motion of molecules would be the same in both container 1 and container 2 because they are both equal in temperature.

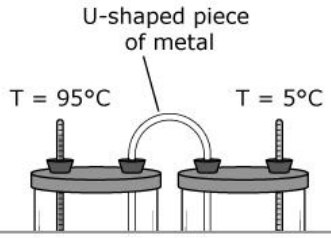
Back to Scoring Guide

Score Point 1

A student conducted two investigations to learn about thermal energy transfer.

Investigation 1

During investigation 1, the student used two insulated containers, container 1 and container 2. The student added 500 g of 95ºC water to container 1 and 500 g of 5ºC water to container 2. The student closed the containers and placed a thermometer in each. The student then placed one end of a U-shaped piece of metal into the water in container 1 and the other end into the water in container 2, as shown.



This question has three parts.

The student analyzed the transfer of thermal energy that took place during investigation 1.

Part A

Select from the drop-down menus to correctly complete the sentence.

During the first 100 s in investigation 1, the average molecular motion of the water molecules in container 1 [decreased ▾], and the average molecular motion of the water molecules in container 2 [increased ▾].

Part B

The student claimed that energy was conserved in the system during the transfer of thermal energy in investigation 1.

Describe how the student could use the data in Table 1 to support the claim.

The student could use data from investigation 1 because the heat is being transfered by both containeer 1 and container 2, making both the containers transfer thermal energy.

Part C

Eventually thermal equilibrium was reached in investigation 1.

Compare the average molecular motion of the water molecules in both container 1 and container 2 after thermal equilibrium was reached. Explain your reasoning.

In container 1 the temperature started to drop from 95.0 and eventually got down to 50.0, The temperature in container 2 began to increase from 5.0 and eventually got to 50.0. Because the heat was stronger in container 1 that heat got transfered into container 2 and made the heat go up, and containers two's temperature go down because all the heat from container 1 qas being extracted by container 2. Thermal equilibrium was being reached because heat was coming out of container 1 and being transfered into container 2 so both containers got to the same temperature which ended up being 50.0.

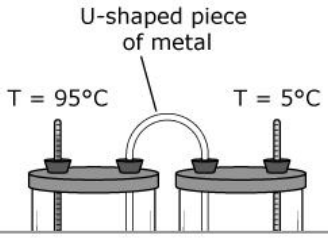
Back to Scoring Guide

Score Point 0

A student conducted two investigations to learn about thermal energy transfer.

Investigation 1

During investigation 1, the student used two insulated containers, container 1 and container 2. The student added 500 g of 95°C water to container 1 and 500 g of 5°C water to container 2. The student closed the containers and placed a thermometer in each. The student then placed one end of a U-shaped piece of metal into the water in container 1 and the other end into the water in container 2, as shown.



This question has three parts.

The student analyzed the transfer of thermal energy that took place during investigation 1.

Part A

Select from the drop-down menus to correctly complete the sentence.

During the first 100 s in investigation 1, the average molecular motion of the water molecules in container 1 [decreased ▾], and the average molecular motion of the water molecules in container 2 [remained the same ▾].

Part B

The student claimed that energy was conserved in the system during the transfer of thermal energy in investigation 1.

Describe how the student could use the data in Table 1 to support the claim.

well data one shows how the tempertuture statred off as 95.0 anc i feel like it is being divided by the top of the tempertuture.

Part C

Eventually thermal equilibrium was reached in investigation 1.

Compare the average molecular motion of the water molecules in both container 1 and container 2 after thermal equilibrium was reached. Explain your reasoning.

My reasoning for this is contanier two is not the same because it goes lower than the first one

Back to Scoring Guide