2026 MCAS Sample Student Work and Scoring Guide

High School Introductory Physics
Question 19: Constructed-Response

Reporting Category: Energy
Practice Category: Mathematics and Data

Standard: HS.PHY.3.4 - Provide evidence that when two objects of different temperature are in thermal contact within a closed system, the transfer of thermal energy from higher-temperature objects to lower-temperature objects results in thermal equilibrium, or a more uniform energy distribution among the objects and that temperature changes necessary to achieve thermal equilibrium depend on the specific heat values of the two substances.

Item Description: Complete a model to show how heat flows through a system, calculate the amount of thermal energy required for a temperature change, explain why less thermal energy is required to change the temperature of a substance compared with another substance, and explain how the temperature of a substance can remain constant when thermal energy is transferred.

This item can be found in the released item sets on the MCAS Resource Center.

Scoring Guide

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

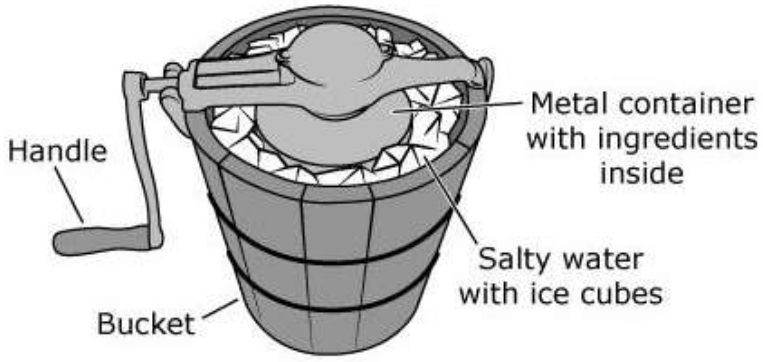
Score*	Description
4A **4B**	The response demonstrates a thorough understanding of thermal energy transfer and specific heat. The response correctly completes a model to show how heat flows through a system. The response correctly calculates the amount of thermal energy transfer required to reduce the temperature of vanilla ice cream ingredients. The response correctly identifies that chocolate ice cream ingredients require less thermal energy transfer than vanilla ice cream ingredients and clearly explains the reasoning. The response also clearly explains how there can be thermal energy transfer to water without changing the water's temperature.
3	The response demonstrates a general understanding of thermal energy transfer and specific heat.
2	The response demonstrates a limited understanding of thermal energy transfer and specific heat.
1	The response demonstrates a minimal understanding of thermal energy transfer and specific heat.
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., 4A and 4B).

Question Introduction

This question has four parts.

Homemade ice cream can be made using a metal container in a bucket. The metal container is filled with the ice cream ingredients (cream, sugar, and flavoring). The bucket is filled with salty water and ice cubes. The ice cream ingredients are stirred using a handle. The diagram shows the ice cream maker.



Score Point 4A

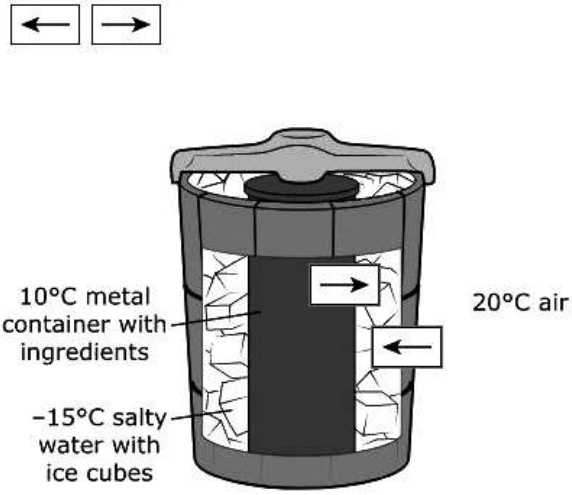
Part A

The parts of the ice cream maker system have different initial temperatures.

- The metal container and the ingredients both have an initial temperature of 10°C.
- The salty water with ice cubes has an initial temperature of –15°C.

The temperature of the air surrounding the bucket is 20°C.

Drag and drop one arrow into each box to show how heat flows through the system. Each arrow may be used once, more than once, or not at all.



Part B

The ingredients for vanilla ice cream have a specific heat of 3.22 J/g • °C and a freezing point of –5.6°C.

Calculate the amount of thermal energy transfer required to reduce the temperature of 1500 g of vanilla ice cream ingredients from 10°C to –5.6°C. Show your calculations and include units in your answer.

Q = $mc\Delta T$, $\Delta T = -5.6 - 10 = -15.6^{\circ}$
$Q = 3.22 \times 1500 \times (-15.6) = -75348,$

75348 Joules transfered

Part C

The ingredients for chocolate ice cream have a specific heat of 3.11 J/g • °C and a freezing point of –5.6°C.

Identify whether reducing the temperature of 1500 g of chocolate ice cream ingredients from 10°C to –5.6°C will require more, less, or the same amount of thermal energy transfer as is required to reduce 1500 g of vanilla ice cream ingredients from 10°C to –5.6°C. Explain your reasoning.

As stated in Part B, the specific heat of vanilla ice cream ingredients is 3.22 J/g * C, which is greater than that of chocolate ice cream. This means it would require more energy to change the temperature of vanilla ice cream ingredients by the same amount as chocolate ice cream ingredients, which is required in the problem. Therefore, less thermal energy must be transfered to change the temperature of the chocolate ice cream ingredients.

Part D

As the ice cream is being made, the temperature of the salty water with ice cubes is constant.

Explain how there can be thermal energy transfer between the metal container and the salty water without the temperature of the salty water changing.

The thermal energy can be transfered without temperature change if the energy is instead be used to melt the ice, as during melting the temperature of the ice does not change, although it takes in thermal energy, which is instead used to change the state of matter from solid ice to liquid water.

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Score Point 4B

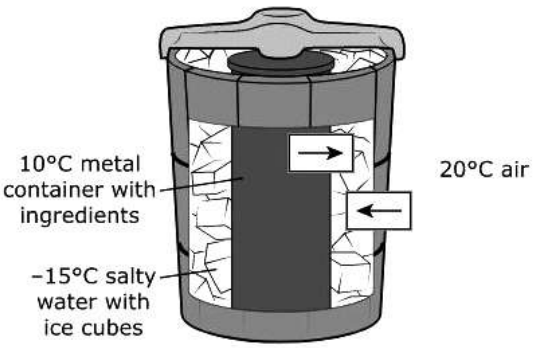
Part A

The parts of the ice cream maker system have different initial temperatures.

- The metal container and the ingredients both have an initial temperature of 10°C.
- The salty water with ice cubes has an initial temperature of –15°C.

The temperature of the air surrounding the bucket is 20°C.

Drag and drop one arrow into each box to show how heat flows through the system. Each arrow may be used once, more than once, or not at all.



Part B

The ingredients for vanilla ice cream have a specific heat of 3.22 J/g • °C and a freezing point of –5.6°C.

Calculate the amount of thermal energy transfer required to reduce the temperature of 1500 g of vanilla ice cream ingredients from 10°C to –5.6°C. Show your calculations and include units in your answer.

$Q = (1500) \times (3.22) \times (15.6)$

$m = 1500 \text{ g}$

$c = 3.22 \ \frac{J}{g}{}^{\circ}C$

$\Delta T = 15.6^{\circ}C$

The thermal energy transfer is 75348 Joules.

Part C

The ingredients for chocolate ice cream have a specific heat of 3.11 J/g • °C and a freezing point of –5.6°C.

Identify whether reducing the temperature of 1500 g of chocolate ice cream ingredients from 10°C to –5.6°C will require more, less, or the same amount of thermal energy transfer as is required to reduce 1500 g of vanilla ice cream ingredients from 10°C to –5.6°C. Explain your reasoning.

Reducing the temperature of chocolate ice cream ingriedients will take less thermal energy transfer than vanilla ice cream ingredients because the specific heat of chocolate ice cream is lower meaning that it takes less energy to change the temperature.

Part D

As the ice cream is being made, the temperature of the salty water with ice cubes is constant.

Explain how there can be thermal energy transfer between the metal container and the salty water without the temperature of the salty water changing.

The salty water with ice cubes does not change temperature because it is in the process of melting, or changing phase. When an object is changing phases, the temperature cannot change therefore the salty water with ice cubes will not change temperature when thermal energy is transferred.

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Score Point 3

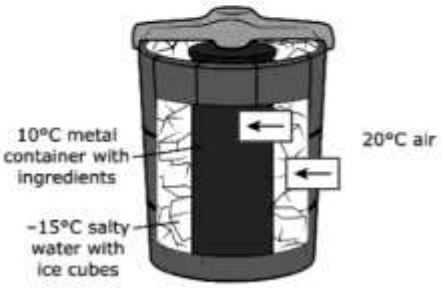
Part A

The parts of the ice cream maker system have different initial temperatures.

- The metal container and the ingredients both have an initial temperature of 10°C.
- The salty water with ice cubes has an initial temperature of -15°C.

The temperature of the air surrounding the bucket is 20°C.

Drag and drop one arrow into each box to show how heat flows through the system. Each arrow may be used once, more than once, or not at all.



Part B

The ingredients for vanilla ice cream have a specific heat of 3.22 J/g • °C and a freezing point of -5.6°C.

Calculate the amount of thermal energy transfer required to reduce the temperature of 1500 g of vanilla ice cream ingredients from 10°C to -5.6°C. Show your calculations and include units in your answer.

Q = $mc\Delta T$

$\Delta T = T_f - T_i$

$\Delta T = -5.6 - 10 = -15.6^{\circ}C$

$Q = (1500)\ (3.22)\ (15.6)$

The amount of thermal energy transfer required to reduce the temperature of vanilla ice cream ingredients from 10°C to -5.6°C is 75348 J.

Part C

The ingredients for chocolate ice cream have a specific heat of 3.11 J/g • °C and a freezing point of –5.6°C.

Identify whether reducing the temperature of 1500 g of chocolate ice cream ingredients from 10°C to –5.6°C will require more, less, or the same amount of thermal energy transfer as is required to reduce 1500 g of vanilla ice cream ingredients from 10°C to –5.6°C. Explain your reasoning.

To reduce the temperature of vanilla ice cream its 75,348 J and to reduce the temperature of chocolate ice cream its 72,774 J. Chocolate ice cream requires less thermal energy transfer than vanilla ice cream. This is because chocoate ice cream has a smaller specific heat so it requires less thermal energy transfer.

Part D

As the ice cream is being made, the temperature of the salty water with ice cubes is constant.

Explain how there can be thermal energy transfer between the metal container and the salty water without the temperature of the salty water changing.

There can be thermal energy transfer between the metal container and the salty container without the temperature of the salty water changing. This is because during this transfer there is a phase change occuring. The ice cubes are solid, and as the thermal energy is being transfered the ice cubes are going through a phase change and they are melting. When a phase change is occuring the temperature wont change.

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Score Point 2

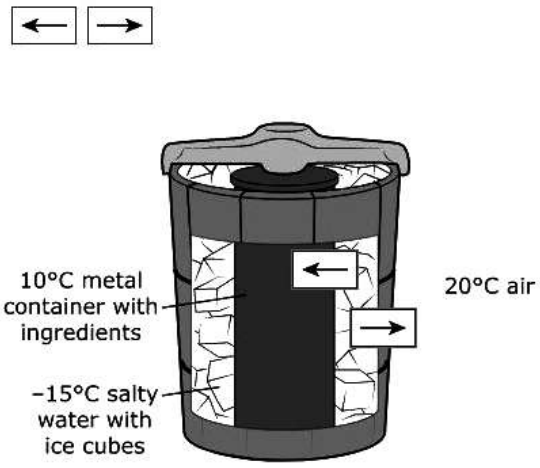
Part A

The parts of the ice cream maker system have different initial temperatures.

- The metal container and the ingredients both have an initial temperature of 10°C.
- The salty water with ice cubes has an initial temperature of –15°C.

The temperature of the air surrounding the bucket is 20°C.

Drag and drop one arrow into each box to show how heat flows through the system. Each arrow may be used once, more than once, or not at all.



Part B

The ingredients for vanilla ice cream have a specific heat of 3.22 J/g • °C and a freezing point of –5.6°C.

Calculate the amount of thermal energy transfer required to reduce the temperature of 1500 g of vanilla ice cream ingredients from 10°C to –5.6°C. Show your calculations and include units in your answer.

$$-5.6 - 10 = -15.6^{\circ}C$$

$$Q = mc \triangle T$$

$$Q = 1500\,(3.22)\ (-15.6)$$

$$Q = -75348J$$

Part C

The ingredients for chocolate ice cream have a specific heat of 3.11 J/g • °C and a freezing point of –5.6°C.

Identify whether reducing the temperature of 1500 g of chocolate ice cream ingredients from 10°C to –5.6°C will require more, less, or the same amount of thermal energy transfer as is required to reduce 1500 g of vanilla ice cream ingredients from 10°C to –5.6°C. Explain your reasoning.

Q = 1500(3.11)(-15.6)
Q = -72774 J

Reducing the temperature of the 1500 g of chocolate ice cream will require less the amount of thermal energy compared to the 1500 g of vanilla ice cream

Part D

As the ice cream is being made, the temperature of the salty water with ice cubes is constant.

Explain how there can be thermal energy transfer between the metal container and the salty water without the temperature of the salty water changing.

The cold temperatures from the salty water transfers over to the metal container because it is being turned inside of it. Meanwhile there is no other source of heat or cold that is changing the salty water, so that is how it remains its constant temperature.

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Score Point 1

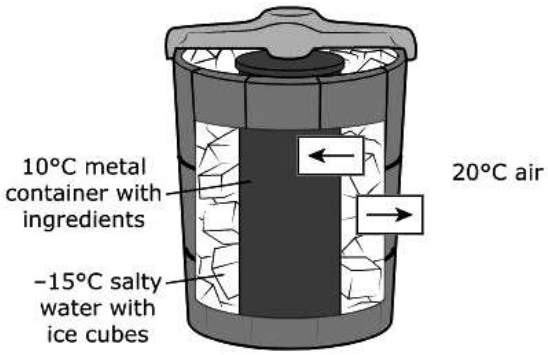
Part A

The parts of the ice cream maker system have different initial temperatures.

- The metal container and the ingredients both have an initial temperature of 10°C.
- The salty water with ice cubes has an initial temperature of –15°C.

The temperature of the air surrounding the bucket is 20°C.

Drag and drop one arrow into each box to show how heat flows through the system. Each arrow may be used once, more than once, or not at all.



Part B

The ingredients for vanilla ice cream have a specific heat of 3.22 J/g • °C and a freezing point of –5.6°C.

Calculate the amount of thermal energy transfer required to reduce the temperature of 1500 g of vanilla ice cream ingredients from 10°C to –5.6°C. Show your calculations and include units in your answer.

$Q = mc\Delta t$

$15.6 = 1.5 * 0.00322 * \Delta T$

$\Delta T = 3230$

3230 J of thermal energy transfer

Part C

The ingredients for chocolate ice cream have a specific heat of 3.11 J/g • °C and a freezing point of –5.6°C.

Identify whether reducing the temperature of 1500 g of chocolate ice cream ingredients from 10°C to –5.6°C will require more, less, or the same amount of thermal energy transfer as is required to reduce 1500 g of vanilla ice cream ingredients from 10°C to –5.6°C. Explain your reasoning.

Reducing the temperature of 1500 g of chocolate ice cream ingredients will require less thermal energy transfer as the specific heat is lower.

Part D

As the ice cream is being made, the temperature of the salty water with ice cubes is constant.

Explain how there can be thermal energy transfer between the metal container and the salty water without the temperature of the salty water changing.

The salty water will not change temperatures because the ice cubes in it will instead. They have a lower temperature so they will be first to expend their lower temperature to the metal container.

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Score Point 0

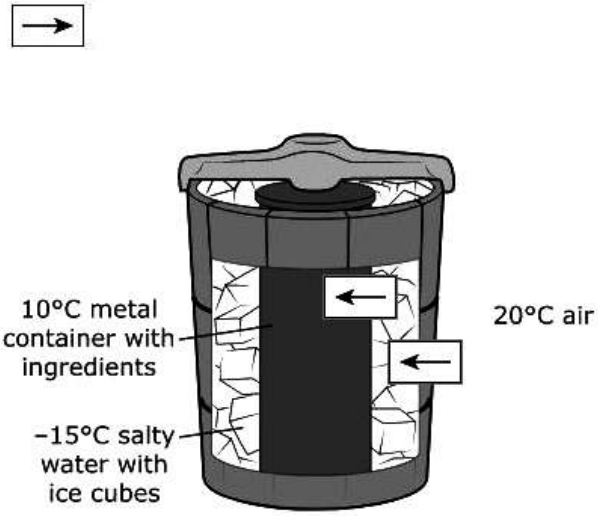
Part A

The parts of the ice cream maker system have different initial temperatures.

- The metal container and the ingredients both have an initial temperature of 10°C.
- The salty water with ice cubes has an initial temperature of –15°C.

The temperature of the air surrounding the bucket is 20°C.

Drag and drop one arrow into each box to show how heat flows through the system. Each arrow may be used once, more than once, or not at all.



Part B

The ingredients for vanilla ice cream have a specific heat of 3.22 J/g • °C and a freezing point of –5.6°C.

Calculate the amount of thermal energy transfer required to reduce the temperature of 1500 g of vanilla ice cream ingredients from 10°C to –5.6°C. Show your calculations and include units in your answer.

$$Q = mc \triangle t$$

Part C

The ingredients for chocolate ice cream have a specific heat of 3.11 J/g • °C and a freezing point of –5.6°C.

Identify whether reducing the temperature of 1500 g of chocolate ice cream ingredients from 10°C to –5.6°C will require more, less, or the same amount of thermal energy transfer as is required to reduce 1500 g of vanilla ice cream ingredients from 10°C to –5.6°C. Explain your reasoning.

The amount of energy will be more because dark colors attract thermal energy so the chocolate will not be able to cool down as fast because it is attracts heat easier.

Part D

As the ice cream is being made, the temperature of the salty water with ice cubes is constant.

Explain how there can be thermal energy transfer between the metal container and the salty water without the temperature of the salty water changing.

The salty water has a much more extreme temperature so it does not change. Also metal changes temperature much faster than liquid does so the ice would cool down the metal container quickly.

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