Nathan Belcher
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Test Creation Project
CRIN 550: Assessment of Learning

The course for which this assessment is created and will be given is 8th grade Physical Science. Major goals for this course may be broken into three parts: physical science content, the nature of science, and systematic investigation. For the physical science content, this course aims to develop an "in-depth understanding of the nature and structure of matter and the characteristics of energy" and "the technological application of physical science principles." For the nature of science, students continue to grow in their understanding of the nature of science so that they may articulate and internalize basic principles of the nature of science. Some concepts that are included in these basic principles are that "scientific explanations are based on logical thinking; are subject to rules of evidence; are consistent with observational, inferential, and experimental evidence; are open to rational critique; and are subject to refinement and change with the addition of new scientific evidence." For the systematic investigation, this class focuses on variables and repeated trials to validate conclusions with evidence and data. Students also "will plan and conduct research involving both classroom experimentation and literature reviews," and "share their work, using written reports and other presentations" (Virginia Board of Education, 2003a).

The unit for which this assessment is created and will be given is Heat and Temperature, and this unit focuses on how heat affects matter and how heat (and therefore, energy) is transferred between or through objects. The critical scientific concepts developed in this unit are that "atoms and molecules are perpetually in motion," and that "increased temperature means greater average kinetic energy of the substance being measured." In addition, "the transfer of heat occurs in three ways: by conduction, by convection, and by radiation," and "heat and

temperature are not the same thing" (Virginia Board of Education, 2003b). These broad concepts may be broken into intended learning outcomes (ILOs), which are taken from the *Science Standards of Learning (SOL) Curriculum Framework* for Physical Science:

In order to meet this standard, it is expected that students should be able to:
- illustrate and explain the effect of the addition or subtraction of heat energy on the motion of molecules.
- distinguish between heat and temperature.
- compare and contrast Celsius and Kelvin temperature scales and describe absolute zero.
- analyze a time/temperature graph of a phase change experiment to determine the temperature at which the phase change occurs (freezing point, melting point, or boiling point).
- compare and contrast conduction, convection, and radiation and provide and explain common examples.
- explain, in simple terms, how the principle of heat transfer applies to heat engines, thermostats, and refrigerators and heat pumps.
- design an investigation from a testable question related to heat transfer. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis.

I have also added two intended learning outcomes to those provided by the *Curriculum Framework*:
- calculate the heat gained or lost by a system using the equation $Q = mc(T_f - T_i)$.
- convert a temperature in one scale to the temperature in another scale.

These ILOs may be shown graphically in a table of specifications, and the following is a table of specifications for the entire assessment of the unit (red means the ILO will be assessed on the unit test, yellow means the ILO will be assessed in another manner, and orange means the ILO will be assessed multiple times):

Content	K	C	App	An	S	E
The effect of the addition or subtraction of heat energy on the motion of molecules		M explain	M illustrate			
Heat and temperature				M distinguish		
Fahrenheit, Celsius, and Kelvin temperature scales and absolute zero		M describe	M convert	M compare/ contrast		

Content	K	C	App	An	S	E
Time/temperature graph of phase change experiment				M analyze		
Temperature at which phase changes occur		M determine				
Heat gained or lost				M calculate		
Conduction, convection, and radiation with common examples		M explain		M compare/ contrast	M provide	
Principle of heat transfer to heat engines, thermostats, and refrigerators and heat pumps		M explain				
Investigation from a testable question related to heat transfer					M design	

The ILOs that are orange will be assessed with both a quiz and the unit test. The quiz will happen on day 5 of the unit, and the entire unit is 10 days plus 1 extra day for the unit test. Formative assessments consisting of exit slips, employing a personal response system, and other methods will be collected during the unit, and a small project for the ILO in yellow will happen during day nine of the unit. The ILOs that are in red will be assessed in a summative manner on the unit test, because they will be taught after the quiz occurs.

This table of specifications is for the unit test that I am constructing, and the M's mean each ILO is of medium priority. The words in each box are the actual word in the standard, so that when designing the test and during the instruction I may understand how to teach and assess the content. The numbers in each box is the number of the question on the unit test, and MC means multiple-choice and SA means short-answer. The total points for each content and cognitive level are given after the abbreviation TP.

Content	K	C	App	An	S	E
The effect of the addition or subtraction of heat energy on the motion of molecules		M explain MC: 1, 9, 17 TP: 9	M illustrate MC: 2, 7, 14 TP: 9			
Heat and temperature				M distinguish SA: 29 TP: 5		
Fahrenheit, Celsius, and Kelvin temperature scales and absolute zero		M describe MC: 3, 8, 13, 22 TP: 12	M convert MC: 18, 20, 24 TP: 9	M compare/ contrast SA: 31 TP: 3		
Time/temperature graph of phase change experiment				M analyze SA: 26 TP: 3		
Temperature at which phase changes occur		M determine MC: 4, 10, 12, 19 TP: 12				

Content	K	C	App	An	S	E
Heat gained or lost				M calculate SA: 27, 30 TP: 4		
Conduction, convection, and radiation with common examples		M explain MC: 6, 15, 21, 23, 25 TP: 15		M compare/ contrast SA: 28 TP: 7	M provide SA: 28 TP: 3	
Principle of heat transfer to heat engines, thermostats, and refrigerators and heat pumps		M explain MC: 5, 11, 16 TP: 9				
Totals		57	18	22	3	

The school's ethnic and gender breakdown is as follows: out of 296 students in 2007, 72% are Caucasian, 19% African-American, 5% Hispanic, and 3% other ethnicities. Fifty-three percent of the students are male, and 47% are female (Berkeley Middle School Data). In one of my classes, about half (12 out of 28) students have individualized education plans, so the unit test and other assessments must conform to these plans. If the plans call for reduced number of items, the table of specifications will guide my elimination of certain items so that I maintain a relatively high degree of reliability for making inferences about student learning.

The purpose of this test is to assess the students' acquisition of the ILOs for the unit, and I will use the results to determine the amount of students' acquisition of the ILOs and whether I need to re-teach any part of the unit.

The unit test itself is 31 questions long, with 25 multiple-choice worth 3 points apiece and 6 short-answer questions worth varying points apiece. When designing the test, I referred

directly to the ILOs to ensure that the content in the curriculum is assessed at the proper level of Bloom's taxonomy, which increases the construct validity of the test. "Construct validity asks, 'Does the assessment measure what it purports to measure?'" (Gareis & Grant, 2008), and through the direct reference of the ILOs for test questions I believe this test has high construct validity. This may be seen in the table of specifications by observing that all questions are asked at the same content and cognitive level that are in the ILOs and will be instructed on, and the table of specifications also helps with content validity. This validity is "concerned with how adequately an assessment samples the intended learning outcomes, standards, or objectives of an instructional unit" (Gareis & Grant, 2008). This test has at least three multiple-choice questions for each ILO in the comprehension and application cognitive levels, to ensure these ILOs are adequately sampled. There is at least one question each of the ILOs in the analysis and synthesis cognitive levels, which will be enough to give a reasonable amount of content validity. These short-answer questions take the students longer to answer, so due to time constraints I am unable to include more questions at these cognitive levels.

I have chosen questions with multiple-choice and short-answer to cover the content in a reasonably efficient manner while still reaching the higher levels of Bloom's taxonomy. The multiple-choice questions allow this test to cover much content in a shorter amount of time, and the short-answer questions cover the higher cognitive levels. The multiple-choice questions are also a familiar format for the students, and continue to help the students become more comfortable with the SOL questions (which for science are multiple-choice). I also want students to understand the content in a deeper manner, and one way with which this may be tested is through supply-response items. Therefore, the six short-answer questions force the students to create an answer on their own, and place more of the onus on the students to provide a cogent

answer. The following table shows where I have taken some test items and used them in this unit test:

Question #	Source
5	Vicki Lewis' "The Heat Is On" Unit Test
9	Vicki Lewis' "The Heat Is On" Unit Test
13	Vicki Lewis' "The Heat Is On" Unit Test
18	Vicki Lewis' "The Heat Is On" Unit Test
21	Vicki Lewis' "The Heat Is On" Unit Test
22	Vicki Lewis' "The Heat Is On" Unit Test
25	Vicki Lewis' "The Heat Is On" Unit Test

As with any test, there are reliability issues with this unit test. One issue is that time may become a factor for some students, especially for those with IEPs. Therefore, using the table of specifications, I will work with the paraprofessional in my class to eliminate some questions or perform any other modification mandated by the IEPs. I will have the students answer the multiple-choice questions on a Scantron sheet, so another issue with reliability is the students' ability to transfer the answers from the test to their Scantron sheet. They have much practice during the year with this already, but it always remains a reliability issue. For each of the short-answer questions, I have tried to leave adequate space for the students to respond. But, for those with poor or large handwriting, there may be issues regarding my ability to read their answer or have them fit their answer in the given space. To alleviate this, I will check on those students that I know have interesting handwriting, and give them extra paper if necessary. Another issue with reliability is the individual test items, but through creating a larger sample for each content and cognitive level this threat is reduced. When I perform my item analysis, I will check for test items

that either many students answer incorrectly and those that all students answer correctly. This will alert me to any individual test item that was poorly worded or gave away an answer in the question and allow me to still draw inferences from this assessment.

This assessment has both potential for and cautions against predictive validity, because whereas this test contains ILOs that may be assessed on the Virginia SOLs, this test assesses in a much more thorough manner than the SOLs. The SOLs are designed to cover much content in a few questions, so any part of the standards that are assessed are usually done so in a surface manner. Therefore, this test may or may not ask questions at the same cognitive level as the 8th grade SOL, so it is wise to be cautious when considering predictive validity.

I have chosen three points for each multiple-choice question because there is a relatively large amount of content that needs to be covered, but I still wanted to leave some points for the short-answer part. Three points times 25 multiple-choice questions gives 75 points for this part of the test, and leaves 25 points for the short-answer questions. The multiple-choice questions will be graded using the Scantron grading machine, and the short-answer questions will be graded with the scoring rubrics that I have developed for each short-answer question. The scoring rubrics helps guard against my biases by providing a set way to grade the question as opposed to simply looking at the answer, and contributes to the overall reliability and validity of the scoring. This test comprises the largest part of the unit grade, though there are other components. These include laboratory activities, daily classwork, homework, and a quiz, so there are other opportunities for students to show their learning throughout the unit.

Heat and Temperature Unit Test

Multiple Choice (3 points each):
Total Questions: 25
On the Scantron sheet, bubble in the choice that best completes the statement or answers the question.

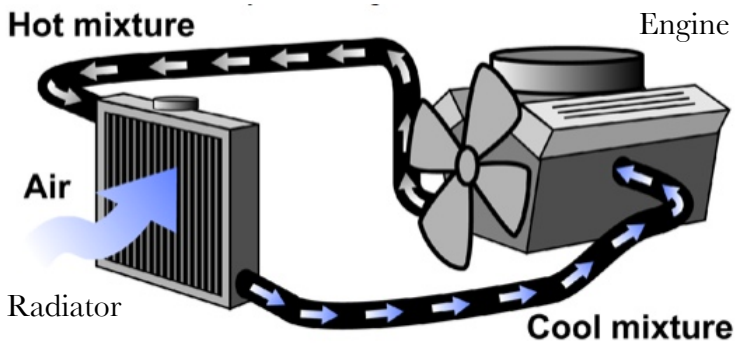
1. In which phase of matter do the molecules that make up the substance have the **least** motion?
   A. Gas.
   B. Liquid.
   C. Plasma.
   D. Solid.

2. Ten degree Celsius water is poured together with water at other temperatures to make water at a different temperature. Which other water temperature will give the **greatest** motion to the molecules after they are poured together?
   A. 30 degree Celsius water
   B. 50 degree Celsius water
   C. 70 degree Celsius water
   D. 90 degree Celsius water

3. Which is the correct equation that is used to change from Celsius units to Kelvin units?
   A. Add 273
   B. Subtract 273
   C. Multiply by 9/5 and add 32
   D. Subtract 32 and multiply by 5/9

4. Which phase change occurs at the *lowest* temperature?
   A. Evaporation
   B. Ionization
   C. Melting
   D. Vaporization

5. All of the following are good conductors **except** _____.
   A. air
   B. aluminum
   C. copper
   D. silver



6. The figure above show the movement of a liquid in a car from the engine through the radiator and back to the engine. The purpose of this is to _____.
   A. cool the engine down
   B. heat the engine up
   C. provide the engine with fuel
   D. provide the engine with a spark

7. A 3 liter bottle of water is placed in refrigerator, and heat is removed from the water. The number of collisions that occur between the water molecules _____.
   A. decreases
   B. disappears
   C. increases
   D. stays the same

8. What is the theoretical temperature when all motion stops?
   A. -273 Kelvins.
   B. 0 degrees Celsius.
   C. 0 degrees Fahrenheit.
   D. 0 Kelvins.

9. The addition of heat causes particles to _____ their motion.
   A. counteract
   B. decrease
   C. increase
   D. stay the same

10. Water at 450 Kelvins is a _____.
   A. Bose-Einstein condensate
   B. liquid
   C. gas
   D. solid

11. A device that removes heat from a small, enclosed area is a(n) _____.
    A. heat engine
    B. heat pump
    C. insulator
    D. refrigerator

12. The freezing point of a substance is the same as its _____.
    A. boiling point
    B. condensation point
    C. evaporation point
    D. melting point

13. What is the boiling point of water?
    A. 0 degrees Celsius.
    B. 100 degrees Celsius.
    C. 100 degrees Fahrenheit.
    D. 100 Kelvins.

14. To change from a solid to a liquid at 1337 Kelvins, gold atoms are given an increase in heat. The motion of the gold atoms _____.
    A. decreases
    B. disappears
    C. increases
    D. stays the same

15. Which of the following is **NOT** a way of transferring heat?
    A. Conduction
    B. Convection
    C. Insulation
    D. Radiation

16. Dial thermostats have bimetallic strips in them to regulate the temperature. Bimetallic strips are made of two pieces of metal that have _____ of expansion.
    A. different rates
    B. high rates
    C. rigid rates
    D. the same rates

17. One gram of _____ has the most energy.
    A. ice
    B. ice water
    C. steam
    D. tap water

18. "It was so cold yesterday that the temperature only reached 275!" Which temperature scale is being used?
    A. Celsius.
    B. Centigrade.
    C. Fahrenheit.
    D. Kelvin.

19. Water at 60 degrees Celsius is a _____.
    A. gas
    B. liquid
    C. plasma
    D. solid

20. When a weather forecaster in Williamsburg predicts that the high for today will be 76 degrees, which temperature scale is she using?
    A. Celsius.
    B. Centigrade.
    C. Fahrenheit.
    D. Kelvin.

21. Through which of the following will convection most likely occur?
    A. Liquids and gases.
    B. Liquids and solids.
    C. Solids and gases.
    D. Solids and plasmas.

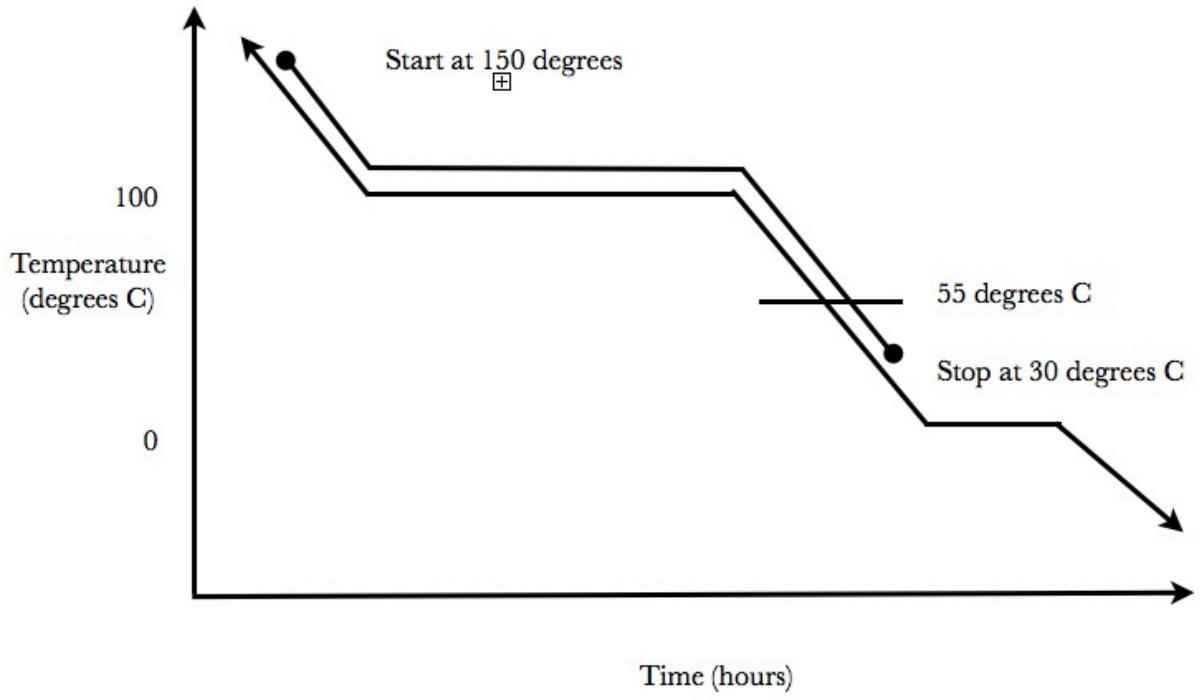
22. Which of the following temperatures are **NOT** possible?
    A. -274 degrees Fahrenheit.
    B. -5 Kelvins.
    C. 2 degrees Celsius
    D. 45 degrees Celsius

23. A material that easily transfers the flow of heat is a(n) _____.
    A. collector
    B. condenser
    C. conductor
    D. insulator

24. A temperature of 30 degrees Celsius is equal to _____ Kelvins.
    A. -303
    B. -243
    C. 243
    D. 303

25. Transfer of energy that does **NOT** require matter is _____.
    A. conduction
    B. convection
    C. insulation
    D. radiation

Short Answer:
Write your response to each question clearly so that you will receive full credit for your answer. Show all work including the initial equation for any calculation.



The above time versus temperature graph represents 20 grams of water cooling from 150 degrees Celsius to 30 degrees Celsius. Answer the following questions, with the specific heat of water given by

$$c = 1.00 \frac{calorie}{(gram)\,(degrees\,Celsius)}$$

and the equation as

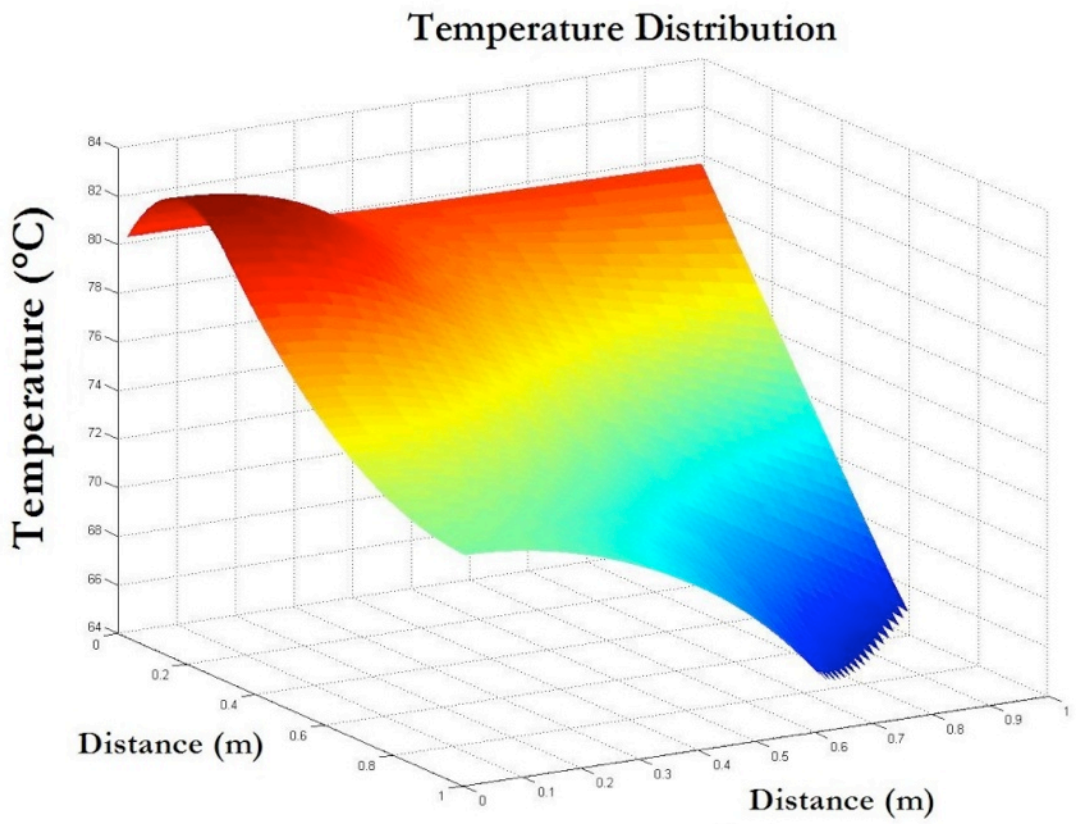
$$Q = mc\Delta T$$

26. List the phases of matter that the water passed through as it cooled from 150 degrees Celsius to 30 degrees Celsius. (Worth 3 points.)

27. Calculate the heat gained or lost as the water cools from 55 degrees Celsius to 30 degrees Celsius. Use the equation below as your starting point, and show all work including units (meaning, show me where you plugged in the values for each variable). (Worth 2 points.)

$$Q = mc\Delta T$$

28. There are three ways in which heat is transferred between substances.
    A. List each way and provide an example of heat is transferred. (Worth 6 points.)
    B. How are all three ways of heat transfer alike? (Worth 2 points.)
    C. How are all three ways of heat transfer different? (Worth 2 points.)



29. The figure above is a 3-dimensional heat versus distance graph. From this graph, draw circles (about the size of quarters) around the part(s) have the highest temperature and which part(s) have the lowest temperature. Label one circle highest temperature and the other lowest temperature. In addition, draw an arrow showing the direction of the heat flow on the graph. (Worth 5 points.)

30. Imagine that the above figure was the heat signature as 50 kg of water was warmed from 66 degrees Celsius to 84 degrees Celsius. Use the equation below as your starting point, and show all work including units (meaning, show me where you plugged in the values for each variable) (Worth 2 points.)

31. There are three temperature scales that are used by scientists to measure temperature. How are they different from each other? (Worth 3 points.)

Correct Answers for the Multiple Choice Items:

1. D
2. D
3. A
4. C
5. A
6. A
7. A
8. D
9. B
10. C
11. D
12. D
13. B
14. C
15. C
16. A
17. C
18. D
19. B
20. C
21. A
22. B
23. C
24. D
25. D

Correct Answers and Scoring Rubrics for Supply-Response Items:

26. Correct Answer: gas, gas and liquid (turning from gas to a liquid, condensing), liquid

Scoring Rubric:

3 points for an accurate list of all three states of matter the water passes through

2 points for a list of two correct states of matter the water passes through

1 point for a list of one correct state of matter the water passes through

0 points for no answer/no correct answers in the list

27. Correct Answer:

$$Q = (20 \text{ grams})(1.00 \text{ calorie/grams*degrees C})(30 \text{ degrees C} - 55 \text{ degrees C})$$

$$Q = -700 \text{ calories}$$

Scoring Rubric:

2 points for successfully inserting the correct values for each variable and solving for the correct answer

1 point for successfully inserting the correct values for each variable but not solving for the correct answer

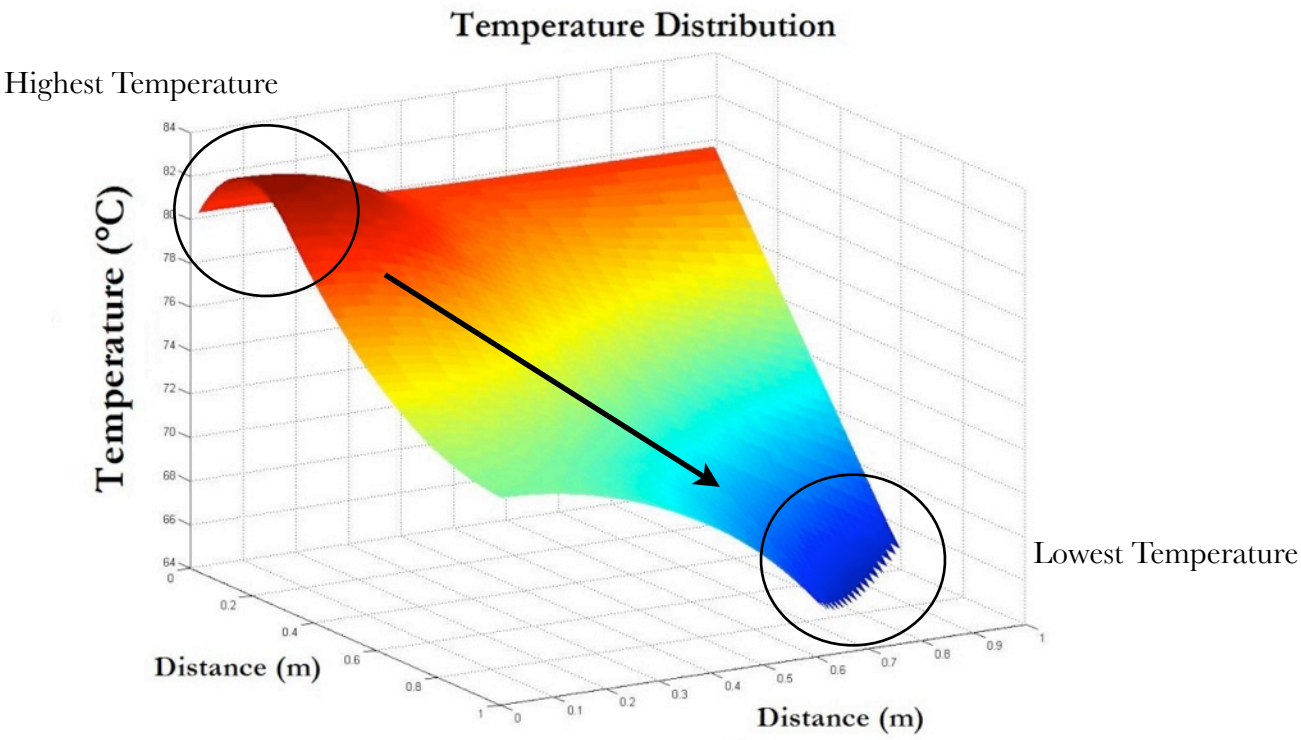
0 points for either not successfully inserting the correct values for each variable and not getting the correct answer or not successfully inserting the correct values for each variable and getting the correct answer

28. Correct Answers:

A. Conduction: stovetop burners, blowtorch, anything with contact to a flame/heat source; Convection: upwelling in the oceans, roasting a marshmallow over a fire, etc.; Radiation: anything dealing with a light source
B. All three ways are alike because they all transfer energy in the form of heat from one object to another. The amount of heat may also be large or small, and all three may vary the time energy is transferred.
C. All three are different because of the various ways in which they transfer energy. Conduction involves touching, convection involves movement of warmer particles upward and cooler particles downward, and radiation involves light energy. Each type of transfer is unique, and therefore different.

Scoring Rubric:

A. 6 points for all three correct ways and a correct example for all three ways
5 points for all three correct ways and two correct examples
4 points for all three correct ways and one correct example; two correct ways and two correct examples
3 points for two correct ways and one correct example
2 points for one correct way and one correct example
1 point for one correct way and a no correct examples
0 points for no correct ways or examples
B. 2 points for two correct similarities
1 point for one correct similarity
0 points for no correct similarities
C. 2 points for two correct differences
1 point for one correct difference
0 point for no correct differences



29. Correct Answer: see above for both parts

Scoring Rubric:

5 points for both circles correctly drawn and labeled and arrow showing the correct direction of heat flow

4 points for both circles correctly drawn and labeled and no arrow or incorrect arrow

3 points for both circles correctly drawn but no labels and arrow showing correct direction of heat flow

2 points for both circles correctly drawn and no arrow; both circles correctly drawn but not labeled and arrow showing the correct direction of heat flow

1 point for both circles correctly drawn but not labeled and arrow showing the incorrect direction of heat flow; no circles but arrow showing the correct direction of heat flow

0 points for no circles and arrow; incorrect circles or heat flow

30. Correct Answer:

Q = (50,000 grams)(1.00 calorie/grams*degrees C)(84 degrees C - 66 degrees C)

Q = 900 kilocalories

Scoring Rubric:

2 points for successfully inserting the correct values for each variable and solving for the correct answer

1 point for successfully inserting the correct values for each variable but not solving for the correct answer

0 points for either not successfully inserting the correct values for each variable and not getting the correct answer or not successfully inserting the correct values for each variable and getting the correct answer

31. Correct Answer: The three temperature scale are different in their measure of absolute zero. For the Kelvin scale, absolute zero is 0 Kelvins, for the Fahrenheit scale it is -460 degrees, and for the Celsius scale it is -273 degrees. The Fahrenheit scale is also different from the Kelvin and Celsius scales because it has 180 ticks between the melting and boiling points of water, whereas the other two have 100 ticks between the points. Finally, the three scales have different measures for the melting and boiling points of water.

    Scoring Rubric:
    3 points for three correct differences
    2 points for two correct differences
    1 point for one correct difference
    0 point for no correct differences

References:

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Gareis, C. R., & Grant, L. W. (2008). *Teacher-made assessments*. Larchmont, NY: Eye on Education.

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