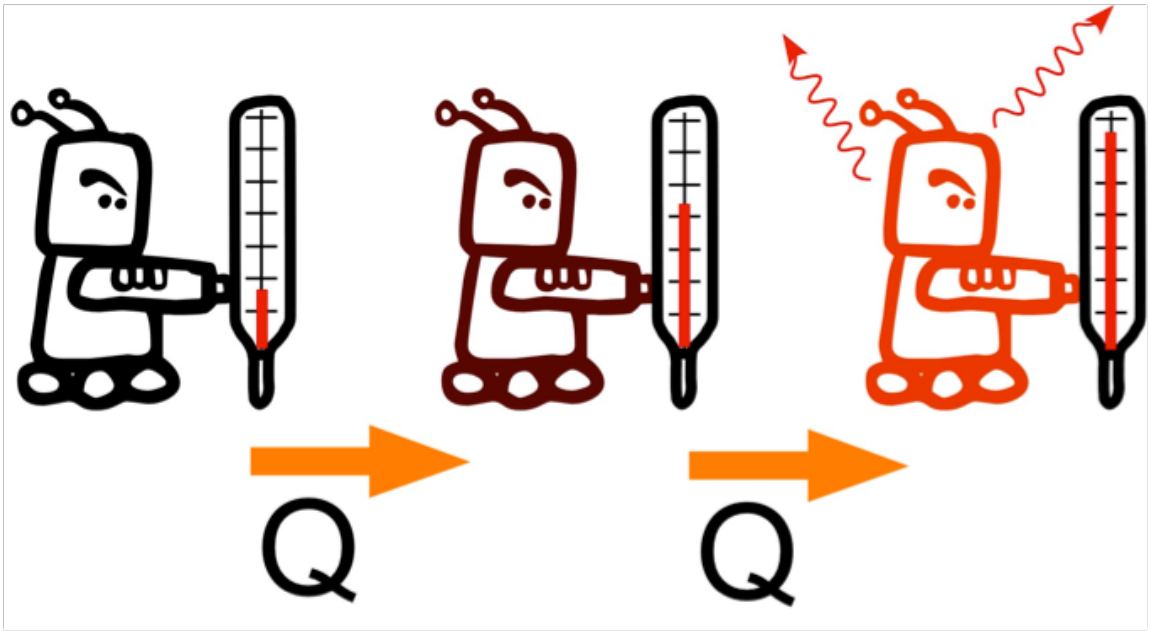

Unit 7.
Thermal Energy

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A TIME for PHYSICS FIRST

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Framing Questions

1. Why do the colorful blobs of "lava" in a lava lamp go up and down?

2. One tea kettle is heated directly over a flame and another is set upon a heavy piece of metal which is directly over a flame. After they begin to whistle you turn off the stoves. Which of the following do you think will happen? Explain.

   A. The kettle heated directly over the flame continues to whistle but the kettle resting on metal stops promptly
   B. The kettle on the metal continues to whistle for some time, but the kettle heated directly stops promptly
   C. Both stop whistling in about the same amount of time

Reason:

3. How does a toaster know when to pop up your pop tarts?

4. If you want to bring a pot filled with cold water to a rapid boil using the least amount of energy, you must (choose your answer and explain your reasoning):

   A. Turn the stove on full force
   B. Put the stove on very low
   C. Put the stove on some medium value
   D. None of the above

Reason:

5. The water is now boiling. To cook the potatoes in that water using the least amount of energy, you should (choose your answer and explain your reasoning):

   A. Keep the stove on full force
   B. Turn the stove down so the water just barely keeps boiling

Reason:

6. The lid of a jar is very tight. Which of the following is more likely to free it? (choose your answer and explain your reasoning):

A. Cooling it
B. Heating it
C. Either
D. Neither

Reason:

7. The weather in New Orleans and along the whole Gulf Coast is hot and humid in the summer-time. In such climates the most comfortable time of the day is (choose your answer and explain your reasoning):

A. Just after sunset when the temperature is dropping slightly
B. Just after sunrise when the temperature is rising
C. At no particular time on the average

Reason:

8. When it is uncomfortably hot, does it help or hinder to wipe the sweat from your brow? Explain your reasoning.

9. If you live in a hot, desert climate, the best color to paint the outside of your house is a (choose your answer and explain your reasoning):

A. Dark color like brown
B. Light color like white
C. The color you paint your house is purely a question of your artistic taste

Reason:

Practice 7.1: Temperature scales

Temperature	In Celsius: (°C)	In Kelvin: (K)	In Fahrenheit: °F)
Melting point of iron	1538	1811	2800
Boiling point of water	100	373	212
Normal (human) body temperature	37.0	310	98.6
Room temperature	20	293	68
Freezing point of water	0	273	32
Boiling point of nitrogen	-196	77	-321
Absolute zero	-273	0	-460

(degrees K is usually written as K not °K)

1. The lowest and highest natural temperatures ever recorded on earth are -127 °F in Antarctica and +136°F in Libya. What are these temperatures in °C?

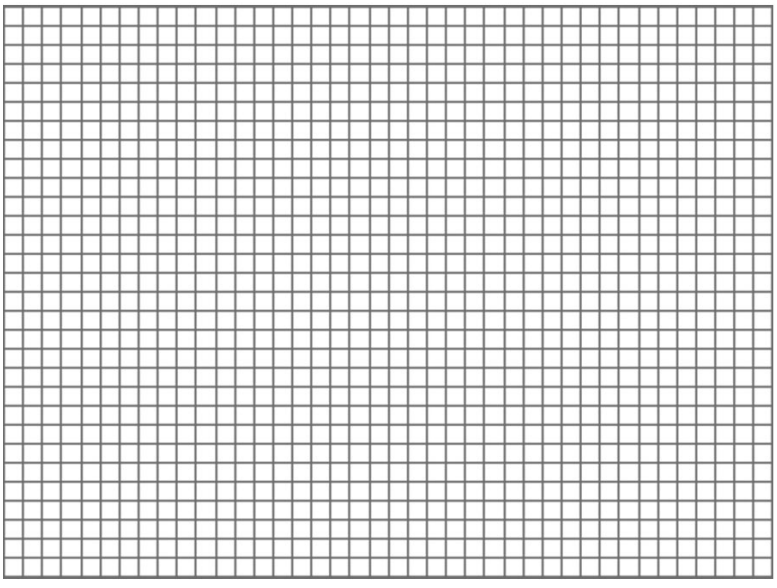
2. At what temperature does the numerical value in °F match the numerical value in °C?

3. A scientist creates a new temperature scale, the "Z scale." He decides to call the boiling point of nitrogen 0°Z and the melting point of iron 1000°Z. Draw a graph so you can convert °C to °Z.

a) What is the boiling point of water on the Z scale?

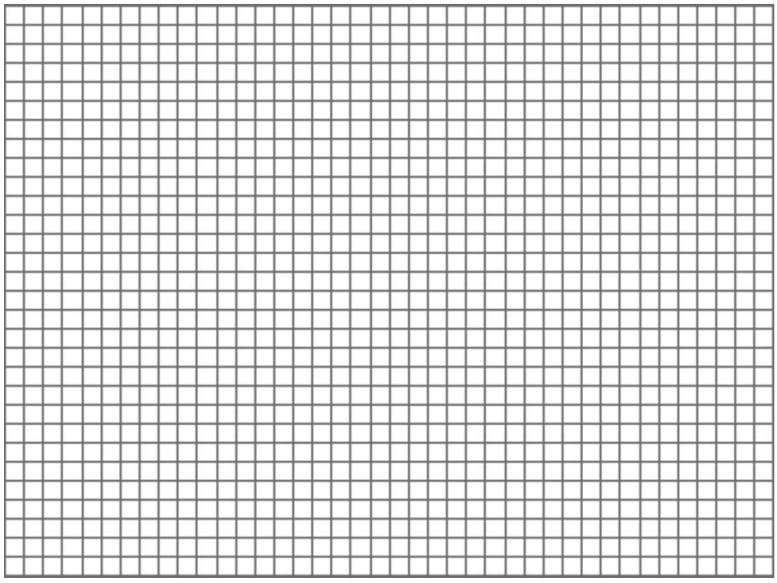
b) Convert 500°Z to the Celsius scale.

Title of graph:



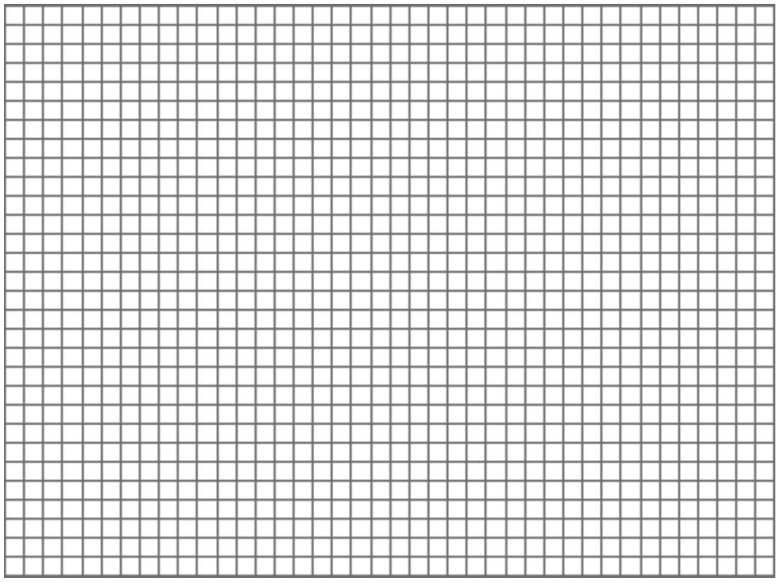
4. Using the data above, draw a graph and obtain a formula to convert between °C and K

Title of graph:



5. Using the data above, draw a graph and obtain a formula to convert between °F and K.

Title of graph:



6. Using the graph or formula obtained in problem 5, calculate

   a) the temperature at which CO_2 solidifies, -40°C in K

   b) the temperature of liquid He, 4.2 K in °F

Practice 7.2: Conduction

The thermal conductivities of a few materials are listed in the Reading Page: Conduction. Look up values for the other materials in a reference book or on the internet.

1. Two long rods, one made of copper and the other made of wood, and the air in the room, are in contact with a pot of hot water. The rods stick out 6 inches above the water. If a person touched the sticking-out end of each rod, and felt the air above the water 5 min after the rods have been inserted, what do you think they might feel for each situation? Explain your reasoning.

2. A skillet is made entirely of stainless steel, including its bottom and its handle. Water is boiled in the skillet, and the water is thrown away. Why is it that touching the handle of the hot skillet will not burn your fingers, but touching the bottom will?

3. On a very cold day, why can you touch the glass of a car's window more comfortably than touching the metal of the car's door?

4. Why do gloves make your hands feel warmer?

4. The two ends of an iron rod are maintained at different temperatures. The amount of energy that flows through the rod by conduction during a given time interval does not depend upon:

A. The length of the iron rod.
B. The mass of the iron rod.
C. The thermal conductivity of iron.
D. The temperature difference between the ends of the rod.

5. The ends of a cylindrical steel rod are maintained at two different temperatures. The rod conducts thermal energy from one end to the other at a rate of 10 J/s. At what rate would a steel rod twice as long conduct thermal energy between the same two temperatures?

A. 5 J/s
B. 20 J/s
C. 80 J/s
D. 10 J/s
E. 40 J/s

6. The ends of a cylindrical steel rod are maintained at two different temperatures. The rod conducts thermal energy from one end to the other at a rate of 10 J/s. At what rate would a steel rod twice the diameter conduct thermal energy between the same two temperatures? (A circular area is calculated as $\pi d^2/4$)

A. 5 J/s
B. 20 J/s
C. 80 J/s
D. 10 J/s
E. 40 J/s

7. The ends of a cylindrical steel rod are maintained at two different temperatures. The rod conducts thermal energy from one end to the other at a rate of 10 J/s. At what rate would a steel rod twice as long and twice the diameter conduct thermal energy between the same two temperatures?

A. 5 J/s
B. 20 J/s
C. 80 J/s
D. 10 J/s
E. 40 J/s

8. Which one of the following materials is the best thermal conductor?

A. diamond
B. brass
C. copper
D. Styrofoam
E. concrete

9. Which of the following materials is the poorest thermal conductor?

A. gold
B. copper
C. air
D. ice
E. wood

Practice 7.3: Convection

1. Complete the following statement: The transfer of thermal energy by convection will occur

   A. only in metals.
   B. with or without the presence of matter.
   C. only in a vacuum.
   D. only in the presence of a liquid or a gas.
   E. only in insulators.

2. Which one of the following statements best explains why convection does not occur in solids?

   A. Molecules in a solid are more closely spaced than in a gas.
   B. The molecules in a solid are not free to move throughout its volume.
   C. Molecules in a solid vibrate at a lower frequency than those of a liquid.
   D. Solids can be compressed more than liquids.
   E. Solids can be compressed less than gases.

3. Which one of the following does not include convection in the process?

   A. Smoke rises above a fire.
   B. Spaghetti gets cooked in boiling water.
   C. An eagle soars on an updraft of wind.
   D. An electric heater warms a room.
   E. A person gets a suntan on a beach.

4. Which one of the following processes does not occur during the heating through convection within a container of air?

   A. The volume of a warmed part of the air is reduced and its density increases.
   B. A continuous flow of warmer and cooler parts of air is established.
   C. The flow of air molecules results in a flow of heat.
   D. The cooler portion of the air surrounding a warmer part exerts a buoyant force on it.
   E. As the warmer part of the air moves, it is replaced by cooler air that is later warmed.

Practice 7.4: Radiation

1. Which one of the following objects, initially all at the same temperature, have a higher rate of energy transfer when they lose heat?

   A. A dull black box in vacuum
   B. A dull black box in air
   C. A polished silver box in air
   D. A polished silver box in vacuum

2. Complete the following statement: Most of the thermal energy that is lost to space from the earth (including the atmosphere) occurs by

   A. conduction.
   B. convection.
   C. radiation.
   D. both conduction and radiation.
   E. Both conduction and convection.

3. Which object will emit more electromagnetic radiation than it absorbs from its surroundings?

   A. A 600 °C lead sphere in a 700 °C oven
   B. A girl scout sitting close to a campfire
   C. An ice cube in beaker of water at 50 °C
   D. A 200 °C copper coin in a beaker of water at 98 °C
   E. An ice cube in thermal equilibrium with the interior of a freezer

4. Complete the following statement: The interior of a thermos bottle is silvered to minimize heating through

   A. Radiation.
   B. Conduction.
   C. Conduction and convection.
   D. Conduction and radiation.
   E. Conduction, convection, and radiation.

5. The sun continuously radiates energy into space, some of which is intercepted by the earth. The average temperature of the surface of the earth remains about 27°C. Why doesn't the earth's temperature rise as it intercepts the sun's energy?

   A. The earth reflects the sun's light.
   B. The earth radiates an amount of energy into space equal to the amount it receives.
   C. The energy only raises the temperature of the upper atmosphere and never reaches the surface.
   D. The thermal conductivity of the earth is low.
   E. The thermal energy is carried away from the earth by convection currents.

6. Objects that radiate relatively well,

   A. Absorb radiation relatively well.
   B. Reflect radiation relatively well.
   C. Both of these
   D. Neither of these

7. The same amount of cold water will warm to room temperature faster in a

   A. Silver pot.
   B. Black pot.
   C. Depends more on the size of the pots than their color

8. Wrapping a hot potato in aluminum foil significantly reduces the rate at which it loses energy by

   A. Convection.
   B. Radiation.
   C. Conduction.

9. Which body radiates visible electromagnetic waves?

   A. Both the Sun and the Earth
   B. only the Earth
   C. Only the Sun
   D. neither the Sun or the Earth

10. Black and white road surfaces absorb sunlight. At the end of a sunny day the warmer surface is

   A. The white surface.
   B. The black surface.
   C. There is no difference.

11. Both black and white road surfaces radiate energy. At the end of a cold, starry night the warmer road surface will be

   A. The white surface.
   B. The black surface.
   C. There is no difference.

12. A Thermos bottle has double glass walls with silver coating on the glass surfaces that face one another. The silver coating reduces the energy that is transferred by

   A. Friction.
   B. Conduction.
   C. Convection.
   D. Radiation.
   E. None of these

13. A good absorber of radiation is a

A. Poor emitter of radiation.
B. Good reflector.
C. Good emitter of radiation.
D. None of these

14. A good reflector of radiation is

A. Good absorber of radiation.
B. Poor absorber of radiation.
C. Good emitter of radiation.
D. None of these

15. If you were caught in freezing weather with only a candle for heat, you would be warmer in

A. A car with all the windows down.
B. A wooden house with its door open.
C. An igloo.
D. A tent.

16. Suppose you are served coffee at a restaurant before you are ready to drink it. In order for it to be the hottest when you are ready for it, you should add cream

A. Right away.
B. At any time.
C. When you are ready to drink the coffee.

18. If you run on a hot day on a road that has white markings for traffic, where on the road should you run so that the soles of your shoes do not get very hot or even melt?

Practice 7.5: Thermal Expansion

1. When an iron ring is heated, the hole becomes

   A. Larger.
   B. Smaller.
   C. Neither smaller nor larger.
   D. Either smaller or larger, depending on the ring thickness.

2. As a piece of metal with a hole in it cools, the diameter of the hole

   A. Increases.
   B. Decreases.
   C. Remains the same.

3. When a bimetallic bar made of copper and iron strips is heated, the bar bends so the iron is on the inside of the curve. The reason for this is

   A. Iron gets hotter before copper.
   B. Copper expands more than iron.
   C. Copper gets hotter before iron.
   D. Iron expands more than copper.
   E. None of these

4. If glass expanded more than mercury, then the column of mercury in a mercury thermometer would rise when the temperature

   A. Increases
   B. Decreases
   C. Neither of these

5. During a very cold winter, water pipes sometimes burst. The reason for this is

   A. The ground contracts when colder, pulling pipes apart.
   B. The thawing process releases pressure on the pipes.
   C. Water contracts when freezing.
   D. Water expands when freezing.
   E. None of these

6. A metal ring has a gap cut in it. When the ring is heated, the gap

   A. Becomes wider
   B. Retains its size
   C. Becomes narrower.