Heat and Thermodynamics - Outline

1. Relate temperature to the kinetic energy of atoms and molecules.
2. Describe the changes in the temperatures of two objects reaching thermal equilibrium.
3. Identify the various temperature scales, and convert from Celsius to Kelvin and vice versa.
4. Explain heat as the energy transferred between substances that are at different temperatures.
5. Perform calculations with specific heat capacity to find the change in temperature, mass, or specific heat capacity of a substance.
6. Interpret the various sections of a heating curve.
7. Recognize that a system can absorb or release energy as heat in order for work to be done on or by the system and that work done on or by a system can result in the transfer of energy as heat.
8. Distinguish between isovolumetric, isothermal, and adiabatic thermodynamic processes.
9. Illustrate how the first law of thermodynamics is a statement of energy conservation.
10. Calculate heat, work, and the change in internal energy by applying the first law of thermodynamics.
11. Apply the first law of thermodynamics to describe cyclic processes.
12. Recognize why the second law of thermodynamics requires two bodies at different temperatures for work to be done.
13. Calculate the efficiency of a heat engine.
14. Relate entropy and the disorder of a system to its ability to do work or transfer energy as heat.

Notes

- Temperature and Kinetic Energy

  ✓ Example:

- Internal Energy

  ✓ Example

- Thermal Equilibrium

  ✓ Example:

- <u>Thermal Expansion</u>
  - ✓ Example:
- <u>Temperature Scales</u>
  - ✓ Celsius:
  - ✓ Kelvin:
- <u>Heat and factors that affect it</u>
  - ✓ Change in Temperature
  - ✓ Mass
  - ✓ Material – Specific Heat Capacity
- <u>How Heat is Transferred</u>
  - ✓ Conduction:
  - ✓ Convection:
  - ✓ Radiation:

- <u>Calorimetry</u>

- <u>Latent Heat – Phase Change</u>

  - ✓ <u>Heat of Fusion</u>

  - ✓ <u>Heat of Vaporization</u>

- <u>System and Environment</u>

- <u>Work done on or by a gas</u>
  - ✓ Done on a gas:

  - ✓ Done by a gas:

- <u>First Law of Thermodynamics</u>

- <u>Thermodynamic Processes</u>
  - ✓ Isovolumetric

  - ✓ Isobaric

- ✓ Isothermal

- ✓ Adiabatic

- <u>Cyclic Process</u>

- <u>Second Law of Thermodynamics</u>

  - ✓ Efficiency

  - ✓ Entropy

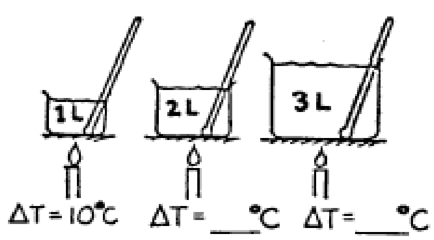
• <u>Sample/Practice Problems</u>

A.

1. Complete the table:

TEMPERATURE OF MELTING ICE	°C	32 °F	K
TEMPERATURE OF BOILING WATER	°C	212 °F	K

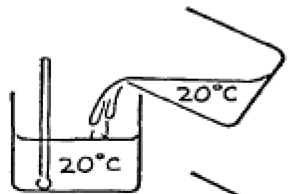
2. Suppose you apply a flame and heat one liter of water, raising its temperature 10°C. If you transfer the same heat energy to two liters, how much will the temperature rise? For three liters? *Record your answers on the blanks in the drawing at the right.*



3. A thermometer is in a container half-filled with 20°C water.

    a. When an equal volume of 20°C water is added, the temperature of the mixture is

        (10°C) (20°C) (40°C)

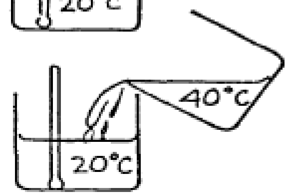


    b. When instead an equal volume of 40°C water is added, the temperature of the mixture will be

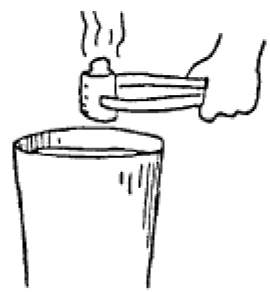
        (20°C) (30°C) (40°C)

    c. When instead a small amount of 40°C water is added, the temperature of the mixture will be

        (20°C) (between 20°C and 30°C) (30°C) (more than 30°C)



4. A red-hot piece of iron is put into a bucket of cool water. *Mark the following statements true (T) or false (F).* (Ignore heat transfer to the bucket.)



    a. The decrease in iron temperature equals the increase in the water temperature.__________

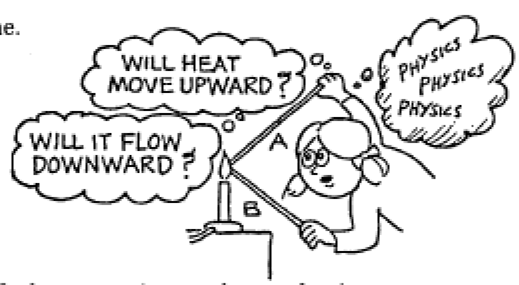
    b. The quantity of heat lost by the iron equals the quantity of heat gained by the water. __________

    c. The iron and water both will reach the same temperature. ________

    d. The final temperature of the iron and water is halfway between the initial temperatures of each. __________

B. Transmission of Heat

1. The tips of both brass rods are held in the gas flame. *Mark the following true (T) or false (F).*



    a. Heat is conducted only along Rod A.______

    b. Heat is conducted only along Rod B.______

    c. Heat is conducted equally along both Rod A and Rod B._________

    d. The idea that "heat rises" applies to heat transfer by *convection*, not by *conduction*.

        ____

2. 

Why does a bird fluff its feathers to keep warm on a cold day?

____

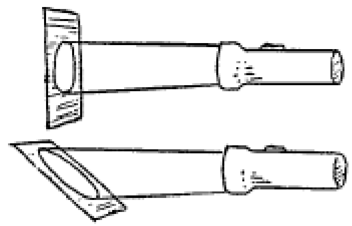
3. Why does a down-filled sleeping bag keep you warm on a cold night? Why is it useless if the down is wet?

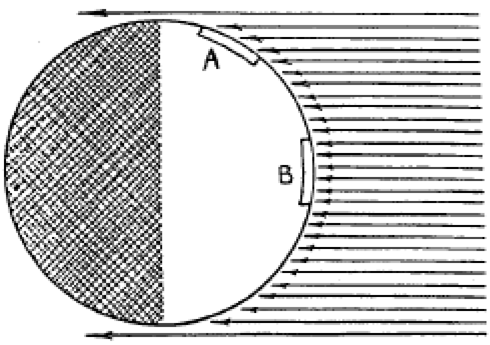
____

4. What does *convection* have to do with the holes in the shade of the desk lamp?

____

5. The warmth of equatorial regions and coldness of polar regions on the earth can be understood by considering light from a flashlight striking a surface. If it strikes perpendicularly, light energy is more concentrated as it covers a smaller area; if it strikes at an angle, the energy spreads over a larger area. So the energy per unit area is less.





The arrows represent rays of light from the distant sun incident upon the earth. Two areas of equal size are shown, Area A near the north pole and Area B near the equator. Count the rays that reach each area, and explain why B is warmer than A.

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C.

1. Calculate the number of joules of heat needed to change the temperature of 500 grams of water by 50 °C.

2. A 0.03 kg piece of iron is heated to 100 °C and then dropped into cool water where the iron's temperature drops to 30 °C. How many joules does it lose to the water? (The specific heat capacity of iron is 448 J/kg °C).

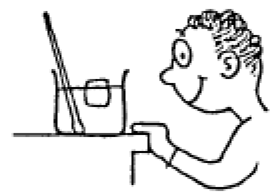
3. What mass of water will give up 1×10^6 joules when its temperature drops from 80 °C to 68 °C.

4. When a 50 gram piece of aluminum at 100 °C is placed in water, it loses 2700 joules of heat while cooling to 40 °C. Calculate the specific heat capacity of the aluminum.

5. What is the specific heat capacity of a 50 gram piece of 100 °C metal that will change 400 grams of 20 °C water to 22 °C?

D.

4. A 50-gram sample of ice at 0°C is placed in a glass beaker that contains 200 g of water at 20°C.

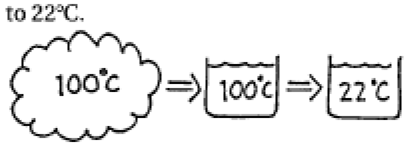


   a. How much heat is needed to melt the ice? ____________

   b. By how much would the temperature of the water change if it gave up this much heat to the ice? ____________

   c. What will be the final temperature of the mixture? (Disregard any heat absorbed by the glass or given off by the surrounding air.) ____________

7. One gram of steam at 100°C condneses, and the water cools to 22°C.



   a. How much heat is released when the steam condenses?____________

   b. How much heat is released when the water cools from 100°C to 22°C?

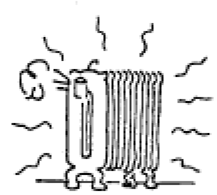
   ____

   c. How much heat is released altogether? ____________

8. In a household radiator 1000 g of steam at 100°C condenses, and the water cools to 90°C.

   a. How much heat is released when the steam condenses?

   ____



   b. How much heat is released when the water cools from 100°C to 90°C?

   ____

   c. How much heat is released altogether?

   ____

1. Calculate the energy in joules needed to melt 200 grams of ice.

2. Calculate the energy absorbed by 200 grams of 100 °C water that is turned in to 100 °C steam.

E.

Internal Combustion Engine

1. What is the general term for the type of engine shown?

2. In general, what does this type of engine do?

3. In the internal combustion engine shown, where does the thermal energy come from?

4. Where in the engine is mechanical energy present?

5. What happens during the intake stroke?

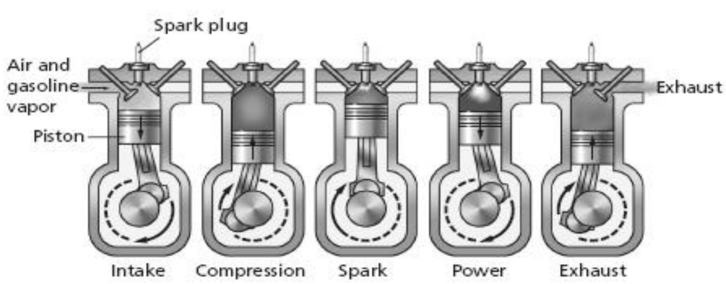
6. What happens during the compression stroke?

7. What happens in the part of the figure labeled spark (Ignition)?

8. What happens during the power stroke?

9. What happens during the exhaust stroke?

10. Is an internal combustion engine 100% efficient? Explain your answer.



F. How Your Refrigerator Works

1. At what point does external energy enter the system?

2. At what location in the refrigerator is the most thermal energy removed?

3. What is the relationship between the evaporation of a liquid inside the circuit and the heat removed from the refrigerator?

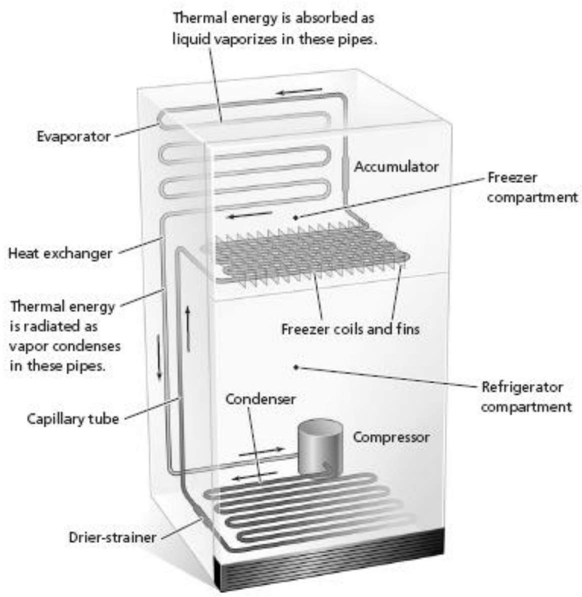
4. Is heat transferred in a refrigerator primarily by conduction, convection or radiation? Explain your answer.

5. What is the purpose of the condenser?

6. If the compressor in a refrigerator requires 300 J of energy to remove 800 J of heat, how much energy is released to the air in the room?

7. What effect would leaving the refrigerator door open on a hot summer day have on the temperature in the room? Explain your answer.

8. Why is it important to keep dust and grease from building up on the condensation coils at the back of a refrigerator?



Homework Problems:

I.

1. Calculate the number of joules given off by 1 kg of water cooling from 50 °C to 20 °C.

2. Suppose the same 0.03 kg piece of iron is dropped into another container of water and gives off 540 joules in cooling. Calculate the iron's temperature change. (The specific heat capacity of iron is 448 J/kg °C).

3. What would be the final temperature if you mixed a liter of 20 °C water with 2 liters of 40 °C water?

4. What is the specific heat capacity of 200 gram piece of 100 °C metal that will change 500 grams of 25 °C water to 28 °C?

II.

1. Calculate the energy in joules needed to melt 200 grams of ice and then heat it to 30°C.
2. Calculate the energy released by 50 grams of 100 °C steam that condenses to 100 °C water and cools down to 0 °C.
3. How many grams of ice is needed to cool 250 grams of tea (water) at 100 °C to 10 °C cold tea with no ice left in the glass.