Warm-Up | Second Law of Thermodynamics

Lesson Question

How is entropy related to the second law of thermodynamics?

Lesson Goals

Explore the second law of thermodynamics.

Describe how the first and second laws of thermodynamics are related.

Explain why entropy increases over time.

Apply the second law of thermodynamics to describe how heat engines work.

Words to Know

Write the letter of the definition next to the matching word as you work through the lesson. You may use the glossary to help you.

C entropy

A second law of thermodynamics

D efficiency

B spontaneous

A. the law that states when substances of differing temperatures are in contact, thermal energy flows from the higher temperature substance to the lower temperature substance and that this flow of thermal energy can be used to do work

B. naturally occurring

C. a measure of the disorder of a system

D. the ratio of output work to input work expressed as a percentage

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First Law of Thermodynamics

- The first law of thermodynamics states that energy can be transformed and transferred but not [created] or destroyed.
  - [Thermal] energy can increase a system's internal energy and/or do [work].

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The Second Law of Thermodynamics

- The **second law of thermodynamics** describes the direction of the flow of thermal energy in [spontaneous] processes.
    - When two substances of differing temperatures are in contact, thermal energy flows from the higher temperature substance to the [lower] temperature substance.

Thermal Energy Flow

- The natural tendency of systems is to [evenly] distribute energy.

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The Relationship between the First and Second Laws of Thermodynamics

- The first law of thermodynamics describes how energy can be transformed and transferred but not created or destroyed.
    - Some energy is lost to the [surroundings] and some is used to do work.
- The second law of thermodynamics describes how [thermal] energy flows.
- Energy flows from an object with the higher [temperature] to an object with lower temperature.

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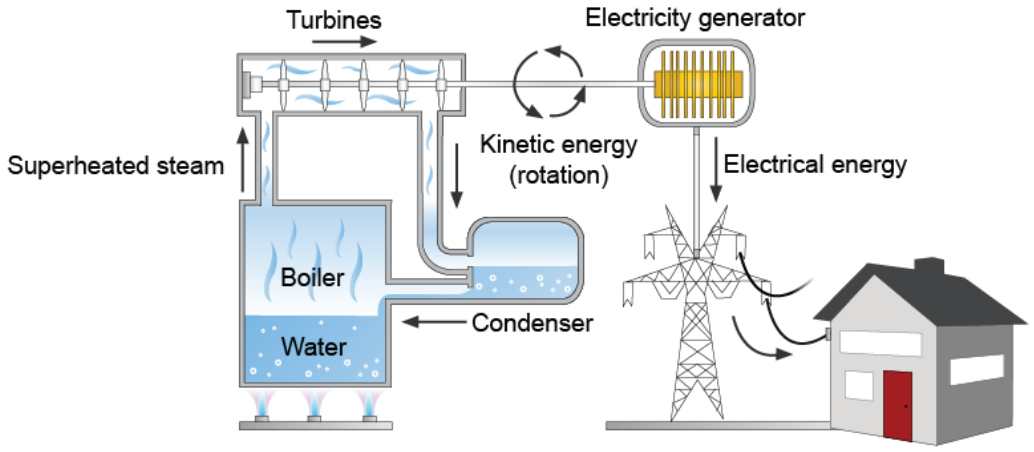

When the water in this tank here is warmed, steam with high thermal energy is produced. And this thermal energy moves to areas of lower thermal energy. As dictated by the [second] law of thermodynamics, some of this energy is used to do [work] to spin the turbines, but some of this is lost to the surroundings. All of the energy is conserved, as stated by the [first] law of thermodynamics.

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Entropy

- [Heat] flows from hotter objects to cooler objects.
- The natural tendency of systems is to [break] down, from order to disorder.
- **Entropy** is a measure of the [disorder] of a system.

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Entropy in Nature

- Increasing entropy can be seen in nature.
  - Cars left alone will naturally rust.
  - Lawns left alone will grow tall grass and weeds.
  - A bedroom, if not cleaned, will become messy.

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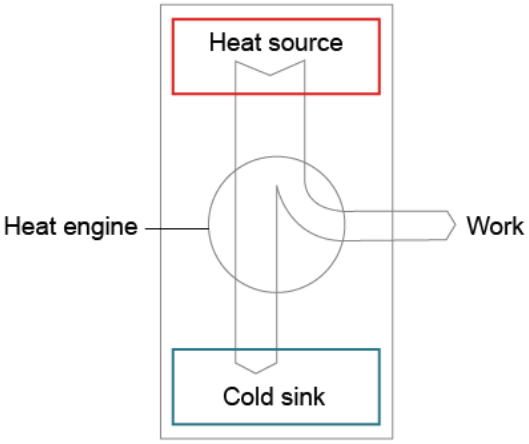
Heat Engines and the Second Law of Thermodynamics

- Thermal energy flows from a heat source to a cold sink.
  - Some of the thermal energy is used to do work.
  - Some of the thermal energy is released to a cold sink, which is unavailable to do useful work.



Efficiency

- An engine or a machine cannot be 100 percent efficient.
  - **Efficiency** is the ratio of output work to input work expressed as a percentage.

$$\text{Efficiency} = \frac{\text{Output energy}}{\text{Input energy}} \times 100$$

$$\text{Efficiency} = \frac{T_h - T_c}{T_h} \times 100$$

Efficiency Calculation

EXAMPLE

Suppose a heat engine's temperature is 625 K. Some of the heat generated by the engine flows to the surroundings and is equal to 297 K. What is the efficiency of the heat engine?

- Given:
  - $T_h = 625\ \text{K}$
  - $T_c = 297\ \text{K}$
- Unknown:
  - Efficiency
- Formula:
  - $\frac{T_h - T_c}{T_h} \times 100$

Solution:

$$\frac{T_h - T_c}{T_h} \times 100$$

$$\frac{625\,\text{K} - 297\,\text{K}}{625\,\text{K}} \times 100 = \boxed{52\%}$$

Summary | Second Law of Thermodynamics

Lesson Question

How is entropy related to the second law of thermodynamics?

Answer

(Sample answer) As thermal energy flows from warmer substances to cooler substances, some thermal energy is used to do work and the rest is released as energy that is unavailable for useful work. The release of this energy unavailable for useful work increases the entropy in the universe.

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Review: Key Concepts

- The second law of thermodynamics states that the flow of thermal energy always flows from a warmer object to a cooler object, and that flow of energy can be used to do work.
- As thermal energy flows from a warmer object to a cooler object, thermal energy is conserved by increasing the [internal] energy of a system and/or by doing work.
- Entropy is a measure of the [disorder] of a system and increases over time.
- Heat engines demonstrate the second law of thermodynamics.
  - Thermal energy flows from the heat source to the cold sink.
  - Some of the thermal energy is used to do work and some of it is released to the surroundings as [unusable] energy.

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Use this space to write any questions or thoughts about this lesson.