HEAT AND LIGHT

INTRODUCTION

The study of energy is abstract and often difficult for first grade students. To help them grasp the concept of energy, access their prior knowledge and provide concrete experiences that allow the students to connect light, heat, and sound to their everyday lives. These actions will help your students develop the foundation needed to differentiate among the types of energy introduced in this module. As students experience increasingly complex interactions of matter and energy, they will begin to understand that many of the changes they observe occur in predictable patterns for each form of energy

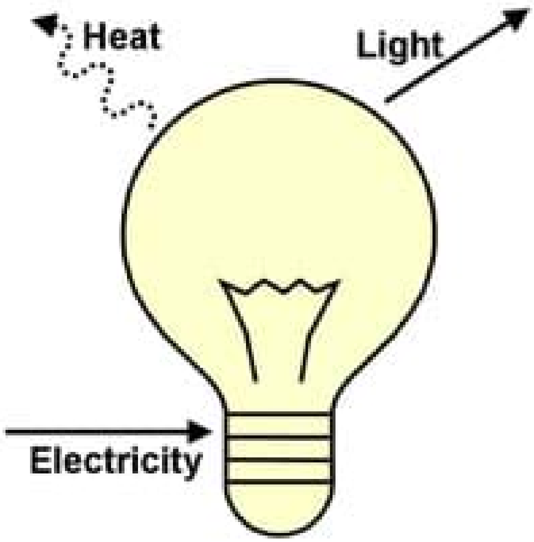
Objectives:

By the end of this lesson, students will be able to:

1. Define and differentiate between heat and light.

2. Apply the concepts of heat and light to solve simple problems.

Lesson 1: Heat and Light



WHAT'S IN

Heat energy is the result of the movement of tiny particles called atoms, molecules or ions in solids, liquids and gases. Heat energy can be transferred from one object to another. The transfer or flow due to the difference in temperature between the two objects is called heat.

For example, an ice cube has heat energy and so does a glass of lemonade. If you put the ice in the lemonade, the lemonade (which is warmer) will transfer some of its heat energy to the ice. In other words, it will heat up the ice. Eventually, the ice will melt and the lemonade and water from the ice will be the same temperature. This is known as reaching a state of thermal equilibrium.

Light energy is a sort of kinetic energy that has the ability to make different types of light visible to human sight. Light is defined as a type of electromagnetic radiation emitted by hot things such as lasers, bulbs, and the sun.

Light contains photons, which are tiny packets of energy. When the atoms of an object are heated, photons are produced, and this is how photons are created. The heat excites the electrons, resulting in more energy. The energy is released in the form of a photon, and more photons are emitted as the substance heats up.

WHAT'S NEW

Heat can be produced by light and light also can be produced by heat. Are they exist at the same time or one is the transform of the other? The answer can be explained with a loop.

If we start with light, the combination of visible light and infrared, it generates thermal radiation which causes an increase in temperature when applied to an object. Thermal radiation, as an electromagnetic wave, has greater energy (heat) with short wavelength. Because of its undulatory property and particle nature, the energy it contains is able to transmit to the object. When the energy of an object is high enough, visible light might be emitted from it. The tungsten filament in light bulbs is a good example. Even if the temperature is not very high, infrared light is constantly emitted when it's above zero degree Kelvin. Therefore, light and heat coexist and they can be transformed from one to another.

Activity 1: Let's Fix This!

Direction. Arrange the following jumbled letters.

1. THEA

2. GHTIL

3. YGNREE

4. METAREPREUT

5. MOTAS

6. ULECOLEMS

7. SNOTHOP

8. NETCIIK ERYGNE

9. TTEMRA

10. YTICITRCLEE

WHAT IS IT

Heat Energy

Heat is the transfer of kinetic energy from one medium or object to another, or from an energy source to a medium or object. Such energy transfer can occur in three ways: radiation, conduction, and convection.

$$q = mc\Delta T$$

The amount of heat gained or lost by a sample (q) can be calculated using the equation $q = mc\Delta T$, where m is the mass of the sample, c is the specific heat, and ΔT is the temperature change.

A good way to remember this formula is **Q = "em cat"**

Basically, this equation is used to determine the amount of heat added to a material to raise the temperature some amount (or the amount lost as the material cools).

This equation only applies to materials that stay in the same state of matter (solid, liquid, or gas) as the temperature changes. **Phase changes** require additional energy considerations.

SAMPLE PROBLEM

Question: A 500 gram cube of lead is heated from 25 °C to 75 °C. How much energy was required to heat the lead? The specific heat of lead is 0.129 J/g°C.

Solution: First, let's the variables we know.

m = 500 grams

c = 0.129 J/g°C

$\Delta T = (T_{final} – T_{initial}) = (75\ °C – 25\ °C) = 50\ °C$

Plug these values into the specific heat equation from above.

$Q = mc\Delta T$

$Q = (500 \text{ grams})\cdot(0.129 \text{ J/g°C})\cdot(50 \text{ °C})$

$Q = 3225 \text{ J}$

Answer: It took 3225 Joules of energy to heat the lead cube from 25 °C to 75 °C.

WHAT'S MORE

Activity 2: Heat Energy

Direction. Solve the following problems. Show your solutions.

1. A 25-gram metal ball is heated 200 °C with 2330 Joules of energy. What is the specific heat of the metal?

2. A hot 1 kg chunk of copper is allowed to cool to 100°C. If the copper gave off 231 kJ of energy, what was the initial temperature of the copper? The specific heat of copper is 0.385 J/g°C.

3. How much heat is released when 30 g of water at 96°C cools to 25°C? The specific heat of water is 1 cal/g°C.

4. If a 3.1g ring is heated using 10.0 calories, its temperature rises 17.9°C. Calculate the specific heat capacity of the ring.

5. The temperature of a sample of water increases from 20°C to 46.6°C as it absorbs 5650 calories of heat. What is the mass of the sample? (Specific heat of water is 1.0 cal/g °C).

What is It

ASSESSMENT

Direction. Choose the letter of the best answer.

1. Which of the following is optically denser?

a. Air

b. Water

2. The splitting of white light into its constituent colours is known as ________

a. Reflection

b. Refraction

c. Dispersion

d. Interference

3. Humans are able to see ________

a. X-rays

b. Visible light

c. Ultraviolet rays

4. When a ray of light travels from water to air, it bends _______

a. Towards the normal

b. Away from the normal

5. List five uses of light.

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6. The angle between the normal and refracted ray is known as ________

a. Angle of incidence

b. Angle of deviation

c. Angle of emergence

d. Angle of refraction

7. What is the wavelength of visible light?

8. When white light passes through a prism it _______

a. Converges

b. Diverges

c. Disperses

d. Neither converges or diverges

9. Name three natural sources of light.

10. Lowest frequency of an electromagnetic spectrum is occupied by ______.

a. X-rays

b. Ultraviolet rays

c. Radio waves

d. Gamma rays

WHAT'S NEW

Light Energy

Light energy is a form of electromagnetic radiation that can be seen by the human eye. But there are also many commercial and scientific uses of light energy, some of which are listed below.

Food

Light is the only source of food generation for all living organisms. Every organism is dependent on light for its energy and food except a few chemotrophic organisms such as bacteria.

Vision

Any organism can view the objects around them due to the presence of eyes. But these might be useless without light. The eyes receive the image when light falls on them, and the information is sent to the brain. Hence, light lets us see objects around us.

Colours

The whole world is beautiful due to colours, and all these colours are possible due to light. The light consists of many spectra; every spectrum has an individual colour, broadly specified as VIBGYOR.

Light Properties - shows the relationship between the speed of light, its wavelength and its frequency. A fairly simple, but important relationship.

Formula: $c = f \lambda$ where:

- c = the speed of light = 300,000 km/s or 3.0 x 108 m/s
- λ = the wavelength of light, usually measured in meters or Ångströms (1 Å = 10-10 m)
- f = the frequency at which light waves pass by, measured in units of per seconds (1/s).

This is a very important relationship since it tells you several things - first of all, the speed of light is constant - it never changes (as far as we're concerned in this class). So the left side of the formula always has the same value. That means if you change something on the right side (either the wavelength or the frequency) then the other thing has to also change, but in the opposite sense. So if the wavelength goes down the frequency goes up, and vice versa.

Typical Problems:

1. If a light's wavelength is increased by a factor of 10, how does its frequency change?

2. If a particular type of light has a wavelength of 6430 Å, what is its frequency?

3. If a particular type of light has a frequency of 1 million /second, what is its wavelength?

Energy of a photon - There are two versions of this formula, one using the frequency, the other using the wavelength. The basic upshot is that as frequency goes up, so does energy, however wavelength goes down. So as wavelength goes up frequency and energy go down. This formula is for the energy of an individual photon. In general, only relational values will be needed (no exact values calculated).

Formula: $E = h f$ where:

- E = Energy of the photon (in Joules)
- h = Constant, actually known as Planck's constant, a really ugly number
- f = frequency of the light in units of per seconds (1/seconds)

The second version of the formula is found by using the light properties formula ($c = \lambda f$) and substituting that in for the above relation. The result is how the energy depends upon the wavelength of light.

Formula: $E = hc/\lambda$ where:

- E = Energy of the photon (in Joules)
- h = same constant as before, still ugly
- c = speed of light, another constant
- λ = wavelength of the light, usually in units of meters

Typical Problems:

1. If you increase the frequency of a light source by a factor of 30, how much does the energy of the photons change?

2. If a light source's wavelength is 25 times smaller than before how does that change the energy of the photons?