UNIT LEARNING PACKS

FOCUS IN ACTION

Grade 7 Science in Action

Unit C - Heat and Temperature

EDQUEST
MIDDLE SCHOOL SCIENCE RESOURCES

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‘Focus in Action’ UNIT LEARNING PACKS

These booklets are designed to provide Grade 7 students with all the resources needed to review or reinforce concepts, covered in the Alberta Science Curriculum, and included in the Grade 7 Science Final Exam in June. There are circumstances in which **an entire unit** may be missed and covering the concepts from that unit (for the final exam) can be difficult. This can happen for a number of reasons:

- Students – new to the school – register throughout the year (from other provinces, school jurisdictions or countries)
- Students may be ill or have surgery and often can miss one or more units
- Students have extended holidays throughout the year
- Transfers from another school, who have completed the units in a different order

For additional support, students are directed to the **Edquest Middle School Science Website** or, Scienceman Resource (www.scienceman.com/scienceinaction/pgs/hot_7u3.html)

Unit 3 – Heat and Temperature

- **Section 1 Notes & Quiz**
- **Section 2 Notes & Quiz**
- **Section 3 Notes & Quiz**
- **Section 4 Notes & Quiz**
- **Unit Summary**
- **Review Booklet** (Covered in class, prior to the Final Achievement Exam)
- **Unit Test**
- **Answer Key for Section Quizzes and Unit Test**

Additional support will be provided, in the form of practice Achievement Test Questions, during the course review in June. Multiple Choice Questions and Numerical Response Questions will be reviewed, as these are the types that will make up the Science 7 Final Exam

Handouts and other activities, to reinforce the concepts covered in this Unit, will be made available based on need. If you require further information or resources, email Edquest directly: edquest@gmail.com.

Finding Solutions to Problems, instead of Making Excuses

Student Instructions for use of this Learning Pack

The purpose of this Learning Unit Pack is to provide you with the resources that will help you cover the material from the curriculum that will be tested on the Final Exam in June.
Follow these steps to successfully complete this Unit Learning Pack:

Step 1 – Read the **Topic Notes**

Step 2 – Use a **highlighter** to identify the key words or phrases in the Topic Notes and reread the material again paying close attention to those words that you highlighted. If necessary, modify your highlights to make sure you understand the material in the notes.

Step 3 – Complete the **Topic Quiz**

Step 4 – Correct the Topic Quiz by **checking the answers** in the back of this Learning Pack.

Step 5 – Using your **textbook** and the **completed quiz**, find the page where the question and correct answer can be found and write it next to the question number in your Learning Pack.

Step 6 – **Repeat Steps 1-5** for each of the other Topics in this Unit.

Step 7 – Look over the **Unit Outline** to review the **Key Concepts** once you have completed all of the Topics.

Step 8 – Complete the **Unit Review**, using your **Learning Pack** and **Textbook**.

Step 9 – **Highlight** those sections of the Review that you had difficulty with and review those sections with your teacher prior to taking the Unit Test.

Step 10 – Take the **Unit Test** and correct it using the answer key provided in the back of the Learning Pack.

Step 11 – You should now be ready to answer any questions on the **Final Exam** related to this Unit.

Anything you still do not understand should be discussed with your teacher. Congratulations on your **Independent Study**, and Good Luck on the Final Exam. I hope you have made good use of this resource. Please provide feedback to your teacher, so that this resource can be improved.

Additional support is available in the form of practice Achievement Test Questions. **Multiple Choice Questions** and **Numerical Response Questions** will be made available on request, as these are the types that will make up the **Science 7 Achievement Exam**.

Handouts and other activities, to reinforce the concepts covered in this Unit may be acquired by visiting the Edquest Middle School Science Resource Website

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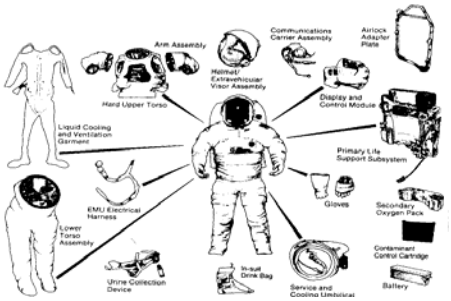
Survival in Space requires technologies that protect astronauts from the extreme thermal energy from the Sun. Their EMU (Extravehicular Mobility Unit) or space suit is such a technology.



Heat energy that we use to supply our basic needs is essential for our survival. An understanding of heat and the technologies that use heat will help us make sure that the energy available to us will sustain our planet now and in the future.

1.0 Human needs have led to technologies for obtaining and controlling heat.

1.1 History of Heat Technologies

Early Theories of Heat

Prior to 1600 - people thought that heat was a combination of fire and air.
1600 – Scientists decided that heat was an invisible fluid called *caloric*, because it seemed to flow from a hot object to a cold one. This was called the Caloric Theory.

Heat Is Energy

After further investigations and observations – Scientists decided that heat was not a substance, but a form of energy, that comes from the movement of tiny particles.

Humans Using Heat

As technology advances, so does our culture. New technologies create more demands for even better technology. The cold climate in Canada creates pressures on science and technology to meet the heating needs of Canadians. By understanding the concept of heat, we will better satisfy our needs to improve our cultural activities by adapting better to the climate.

Heat and Human Needs

The importance of heat in Canada is linked to our basic **needs** of shelter, clothing, food, water, and physical activity. The human range of tolerance for temperature is between 0^{o}C and 45^{o}C. By improving our shelters, clothing and other basic needs, by making advancements in heat technologies, we can increase that range of tolerance to meet our **wants** as well.

Heat-Related Materials and Technologies

Open fires

Pioneer stoves

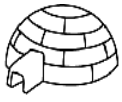
Modern stoves

Wood-burning fireplaces

Sod House Soddies

Solar heating

Igloo



Modern building House

Early Heating Technology Timeline

7000 B.C. – Humans create fire

100 B.C. – Romans develop central heating – heat travels from one source to different areas of a building

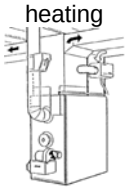
A.D. 1200 – Chimneys first appear in Europe

1300's – Fireplaces with chimneys are built into the walls of buildings

1700's – Cast-iron stoves heat rooms evenly: heat does not escape up the chimney

Late 1700's – Central heating reappears – using coal

1800's – Forced-air heating



1906 – Electric heaters

1.2. Heat Technologies in Everyday Life

In addition to being able to produce heat to meet human needs and wants. It is also important to be able to control that heat. As technologies develop to generate heat, ways to direct and manage that heat have also been created.

Personal and Societal choices

North Americans have a high standard of living, and as a result, take for granted the many tools and technologies that make their living easier, like the microwave oven. This is an example of a want that many people in North America consider to be a need.

Making Sustainable Choices

Both the personal and societal choices we make in using heat energy are important, because they affect our sustainability. We must use our heat energy resources wisely and be careful of the consequences to the environment when we use them. By looking for, and using, a wide variety of heat energy sources and developing technologies that will sustain this energy, we will be making ourselves a better future.

Section 1 – Human Needs for Heat Technologies

1.1 History of Heat Technologies

1. The need to stay warm has always been a part of life for humans. Until about 1600, people thought that heat was a combination of …
   A. Light and air
   B. Fire and air
   C. Light and fire
   D. Color and light

2. In early times, people observed that heat – because it seemed to flow from a hot place to a cold place – must be an invisible fluid that they called …
   A. temperature
   B. energy
   C. thermal
   D. caloric

3. The Franklin stove, invented by Benjamin Franklin, is a heating technology that has a dual purpose. Besides heating a room, it was also used as a
   A. smokehouse
   B. foot warmer
   C. cooking stove
   D. bar-b-cue grill

4. The official unit of heat energy is the …
   A. watt
   B. joule
   C. kilowatt
   D. gigajoule

5. 'Needs' are the basic required conditions for the survival of life. 'Wants' are not vital to survival. Which of the following statements represents a need?
   A. I need that designer jacket, so I can stay warm this winter.
   B. I need a glass of water to quench my thirst.
   C. I need to camp in a trailer, so I don't freeze when I am camping.
   D. I need a clear cover duotang for my science lab notebook.

6. The chimney first appeared in Europe in the …
   A. 1200s
   B. 1400s
   C. 1700s
   D. 1800s

7. The reappearance of central heating occurred in the late 1700s, as coal became the main fuel source. Central heating was originally developed around 100 B.C. by the …
   A. Americans
   B. Canadians
   C. Romans
   D. Greeks

1.2 Heat Technologies in Everyday Life

1. A technology that has replaced boiling water over an open campfire gives us a warning when the water has boiled. This technology is ...
   A. a micro-sensing digital boiler
   B. a solar powered water heater
   C. an electric kettle
   D. a hot water heater

2. This type of Thermal Energy source can be used to cook food, but they are hard to control, dangerous and messy.
   A. open fire
   B. Franklin stove
   C. pioneer stove
   D. modern gas stove

3. Choose the technology that you would need so that you could heat a large room in your house, and maintain a constant comfortable temperature in that room.
   A. a gas furnace
   B. a wood-burning fireplace
   C. an electric fireplace
   D. a digital thermostat

4. Overheating can be a problem for hand-held hair dryers. A device, that is used to shut off the thermal energy when it gets too hot, is needed. This device is ...
   A. automatically controlled
   B. the heating element
   C. the fan
   D. a button on the hair dryer

5. What unit of energy does the heating company use to determine the amount of money they charge to help fuel the heating technology in your house …
   A. kilowatt
   B. gigajoule
   C. watt
   D. joule

2.0 Heat affects matter in different ways

2.1 States of Matter and The Particle Model of Matter

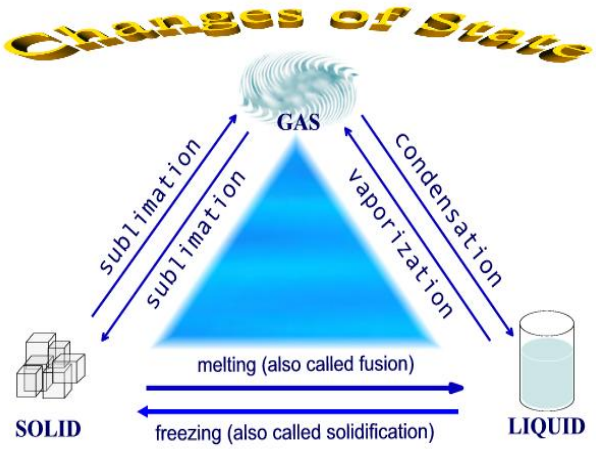
Matter is made up of tiny particles and exists in three states: solid, liquid and gas.
The Particle Model of Matter is a scientific description of the tiny particles that make up all things.
The key elements in this model are:

- **All matter is made of tiny particles too small to be seen**
- **The particles are always moving**
- **The particles have spaces between them**
- **Adding heat to matter makes the particles move faster**

Changes of State: Water

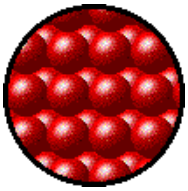
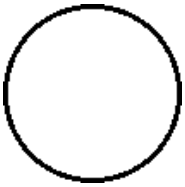
Substances such as water (or wax) can undergo observable changes through all three states of matter - solid liquid and gas.

- Ice is the **solid state** of water at 0°C
- The **melting point** of water is 0°C
- The **boiling point** of water is 100°C
- **Condensation** occurs when water changes from a gas to a liquid



Any pure substance can exist in all three states of matter.

Heat and the Particle Model

Solid	Liquid	Gas
		
Particles are closely packed together	Particles can slip past each other	Particles have lots of space between them

The Effect of Heat on Particles

When heat is added to a substance, the particles move faster. When heat is lost from a substance the particles move slower.

- The motion of the particles increases when the temperature increases.
- The motion of the particles decreases when the temperature decreases.
- Heat energy transfers from high temperature matter to low temperature matter. Heat can affect matter by causing it to change state.

How the Particle Model Explains Changes of State

During a phase change, the average energy of the particles remains the same, but, the particles are rearranging themselves.

Solid	• The particles are tightly packed together. • Solids have a fixed shape.
Heating a Solid	• Particles become less organized as their energy increases, so the substance changes from a solid to a liquid to a gas. • The space between the particles increases, so its volume increases.
Melting a Solid	• Particles move very quickly and attractions between the particles break down, so the solid melts into a liquid state.
Liquid	• In a liquid, the particles are moving very quickly. • The particles have more kinetic energy • Liquids take the shape of their containers
Heating a Liquid	• At the surface, some of the particles are able to escape into the air, while others do not have enough energy to escape and remain in the liquid. • As the liquid expands, its volume increases • As high energy particles escape, the average energy of the remaining particles is less and so the liquid cools. The cool liquid then cools the surface on which it is resting. This is called evaporative cooling. It is common and useful in many situations: Joggers cooling down as their sweaty clothes dry out; Water cools down a roof on hot summer day; A wet cloth is placed on your forehead when you have a fever.
Boiling a Liquid	• The attractions between the particles are very weak • More and more high energy particles escape, and the liquid changes into a gas
Gas	• Particles move very quickly with a lot of kinetic energy • Particles fill up the space of the container they are in. • Large spaces between the particles.
Gas to a Liquid to a Solid	• As the energy of the particles becomes less, the particles rearrange themselves more orderly, so a gas changes to a liquid and then to a solid, when even more energy is lost – the particles are slowing down.

The total energy of the particles changes - by increasing or decreasing, because the particles are not increasing or decreasing their speed, just their arrangement. The average energy doesn't change. The energy change is hidden from a thermometer and is called **'hidden hea**t' or **'latent heat'**.

2.2 Heat and Temperature

Temperature is a measure of how hot or cold matter is. Temperature indicates the average energy (speed) – kinetic energy - of the particles in motion in a substance.
The amount of temperature change, when thermal energy is added to the particles is another property that particles in different materials have. Different materials will increase or decrease their average energy depending on how much thermal energy is provided.

- Heat Capacity is the amount of thermal energy that warms or cools an object by $1^{o}C$ (it depends on the mass and the type of particle the object is made of).
- Specific Heat Capacity is the amount of thermal energy that warms or cools 1 gram, of a specific type of particle, by $1^{o}C$.

Total Kinetic Energy

The thermal energy of a substance is the total kinetic energy of all the particles the substance contains. Energy is the measure of a substance's ability to do work - or cause changes.
There are two important elements that occur:

- **Changes happen when there is a difference of energy (every useful energy system has a high-energy source that powers the changes)**
- **Energy is always transferred in the same direction: from a high-energy source** (hot) to something of lower energy (cold).

Energy Transfers

Heat is the energy that transfers from one substance to another because of the difference in kinetic energy. The average energy of the particles - the **temperature** of the substance - is affected, by increasing or decreasing. The change in temperature depends on the number of particles affected.

The Difference Between Heat and Temperature

Energy is not a substance. It cannot be seen, weighed or take up space. Energy is a condition or quality that a substance has. Energy is a property or quality of an object or substance that gives it the ability to move, do work or cause change.

Understanding The Difference

Thermal Energy is the total kinetic energy of all the particles in a substance
Heat is the energy that transfers from a substance whose particles have a higher kinetic energy to a substance who particles have a lower kinetic energy.
Temperature is a measure of the average kinetic energy of the particles in a substance.

Measuring Temperature With Thermometers

A relative idea about temperature is that it tells you how hot or cold something is. This can be done by using our senses: **Touch** (sensitive nerve endings on your skin can detect changes in temperature); **Sight** (the color of the material giving off heat). Relative ways to determine the temperature are not always reliable or safe. Thermometers are more reliable devices that measure temperature. The Italian scientist Galileo invented the first air thermometer around 1600 and it has, and will continue to be, improved upon.

History Of Thermometers

200 B.C. The first thermometers were called thermoscopes

1590's Several inventors invented a version of the thermoscope at the same time, Italian inventor Santorio Santorio was the first inventor to put a numerical scale on the instrument. Galileo Galilei invented a rudimentary water thermometer in 1593 which, for the first time, allowed temperature variations to be measured.

1630's Early thermometers (like the one Galileo invented) did not have any scale (markings with numbers) to determine precise temperature.

1650's

1701 Ole Romer created one of the first practical thermometers, which used red wine as the temperature indicator. The temperature scale for his thermometer had 0 representing the temperature of a salt and ice mixture (at about 259 K), 7½ representing the freezing point of water (273.15 K), and 60 representing the boiling point of water (373.15 K).
Daniel Gabriel Fahrenheit (1686-1736) was the German physicist who invented the alcohol thermometer in 1709

1714 In 1714, Fahrenheit invented the first mercury thermometer, the modern thermometer. And in 1724, he introduced the temperature scale that bears his name - Fahrenheit Scale.

1742 The 1st precise scale was developed by Anders Celsius in 1742. He used 'degree' as the unit of temperature. Centigrade means "consisting of, or divided into, 100 degrees". All of his standards for comparison, to make his markings (on his scale), were based on the properties of water.
0^{o} was assigned the temperature at which ice melts at sea level
100^{o} was assigned the temperature at which liquid water boils at sea level
The region between (above and below, as well) these two extremes was separated into 100 equal units (degrees)
The two fixed temperatures that Celsius chose can be used to calibrate a thermometer. The Celsius temperature scale is also referred to as the "centigrade" scale.
The term "Celsius" was adopted in 1948 by an international conference on weights and measures

1852 Lord Kelvin invented the Kelvin Scale in 1848. The Kelvin Scale measures the ultimate extremes of hot and cold. Kelvin developed the idea of absolute temperature, what is called the "Second Law of Thermodynamics", and developed the dynamical theory of heat.
Absolute zero is the coldest possible temperature - 273^{o} and is used by scientists. The markings on the scale are not called degrees, but are simply called kelvins.
(0^{o} Celsius is equal to 273.15^{o} Kelvin)

1861 The electrical-resistance-thermometer was invented in Germany. It used an electrical current to measure temperature.
English physician, **Sir Thomas Allbutt** invented the first medical thermometer used for taking the temperature of a person in 1867.

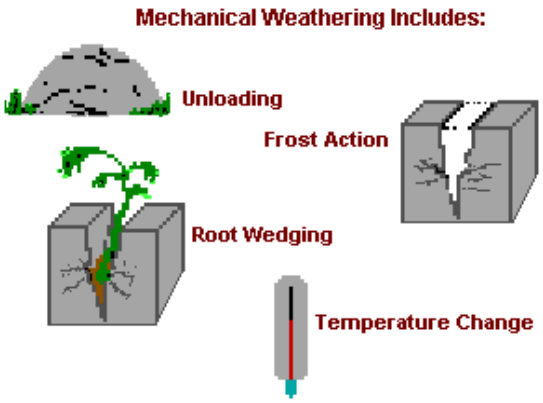
1970's Theodore Hannes Benzinger invented the ear thermometer.
David Phillips invented the infra-red ear thermometer in 1984.

1990's Dr. Jacob Fraden, invented the world's best-selling ear thermometer, the Thermoscan® Human Ear Thermometer.

2.3 Heat Affects the Volume of Solids, Liquids, and Gases

Observing The Effect of Heat

Cracks in rock, due to ice



Fitting a nut to a bolt

Hot water opens a jar lid

Boiling water cracks the cold mug

Thermal expansion is the process of expansion of a substance caused by an increase in thermal energy.

Expansion and Contraction in Solids	Solids can become longer or shorter depending on the temperature (average energy of the particles).
Expansion and Contraction in Liquids	When the particles in a liquid are heated, their average energy increases and they need more room, so they **expand**. When the particles in a liquid are cooled, the volume decreases, or **contracts**, because the particles need less room. This is demonstrated by the liquid used in a thermometer. As the liquid expands and contracts, it moves up and down the inside tubing (the *bore*) of the thermometer.
Expansion and Contraction in Gases	When the particles in a gas are heated, their average energy increases and they need more room, so they **expand**. When the particles in a gas are cooled, the volume decreases, or **contracts**, because the particles need less room. Under extremely high temperature conditions (like the temperatures inside the Sun, particles can be split into what makes them up (electrons and ions). This creates a fourth state of matter called **plasma**.

Heat Affects the Volume of Solids, Liquids and Gases

As the average energy of particles increases, the space between the particles increases. They expand (increase their volume) as the temperature increases. As the average energy of particles decreases, the space between the particles decreases. They contract (decrease their volume) as the temperature decreases.

	Solids	Liquids	Gases
Shape and Size	**Keep their shape and size**	**Take the shape of the container**	**No definite shape or size**
Compressibility (volume)	**Cannot be compressed (fixed volume)**	**Almost incompressible (fixed volume)**	**Can be compressed (volume changes)**

2.4 Heat Transfers by Conduction

Conduction
In solids, where the particles are closely packed together, thermal energy can be transferred from one particle to another very easily. Thermal conduction is the process of transferring thermal energy by the direct collisions of the particles. The space between the particles, in different solids, determines how quickly these collisions can take place. Good conducting materials are those materials where there is little space between the particles - like most metals. Poor conductors, like glass and wood are called heat insulators. These insulators when wrapped around an object slow down the rate of thermal conduction.

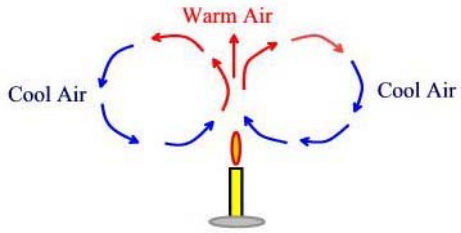
Conductors
Metals are good conductors of heat, so they are used extensively in cooking, because they transfer heat efficiently from the stove top or oven to the food. Hot and cold packs are used to treat muscle injuries. The Radiator of a car transfers heat away from the engine, so that the gasoline being used will not ignite. (Antifreeze is used to achieve this).
Applications

Insulators
Insulators are materials that do not easily allow heat transfer

2.5 Heat Transfers by Convection and Radiation

Understanding Convection

Thermal energy can be transferred in fluids, by the circular motion of the particles, called convection.



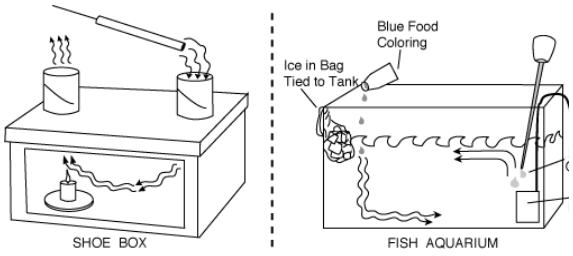
In convection, the warmer particles transfer their energy to the cooler particles as they move in a circular pattern, called, a 'convection current'. A simple experiment

The **convection oven** is one of the many practical applications of convection.
The heat inside the oven helps to provide uniform beating as the convection current transfers the heat evenly inside.


Lava lamps are good examples to convection currents in action.

Convection Currents in Air
Birds and para-gliders make use of '**thermals**' to help them soar and glide - helping them to conserve energy when they migrate.
Heating occurs through convection currents in a fluid, such as radiator water heating - flowing from the basement to heat a radiator on a floor above.

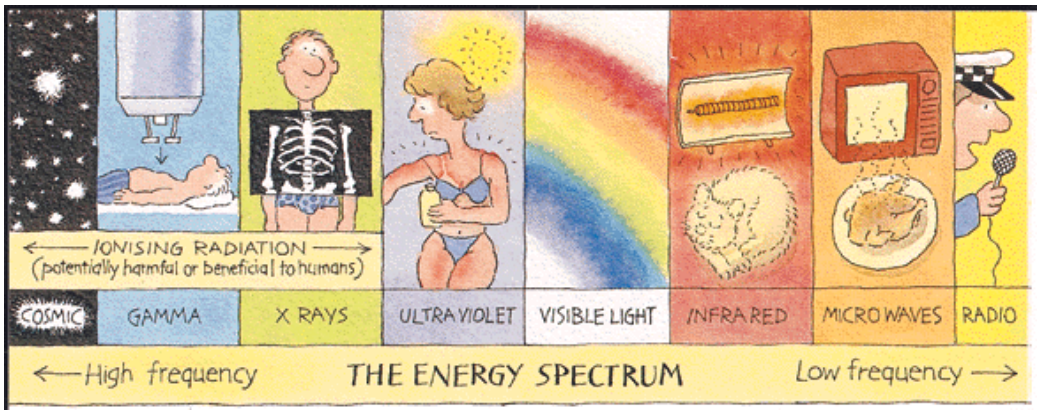
Convection currents are also involved in creating the force of magnetism that surrounds the earth.



As are the **convection box** and aquarium

Heat Transfers By Radiation

Energy can be transferred even though there are no particles to transfer the energy. This type of energy transfer is called **radiation**. Radiation is the transfer of energy without any movement of matter. Energy that is transferred in this way is called radiant energy or **electromagnetic radiation** (**EMR** for short). Radiant energy travels in waves. These waves can travel through space, air, glass and many other materials. There are different forms of EMR, including radio waves, microwaves, visible light and X-rays.



If the energy source is a warm object, like the sun, some of the thermal energy is transferred as a type of EMR called **infrared radiation** (IR) or '**heat radiation**'.

Waves of radiant energy can travel in a vacuum. All waves travel, across empty space, at an extremely high speed (300 Million m/s). Radiant energy travels in a straight line.
All kinds of radiant energy interact with matter:

Radiant Energy waves can be absorbed and reflected by objects.

- Absorption occurs if the energy penetrates part way into the object. Dull dark objects absorb radiant energy when they are cool, and emit radiant energy when they are hot. (eg. asphalt sidewalk)

- Reflection occurs if the energy cannot penetrate the surface of the material it comes into contact with. Light, shiny objects or surfaces do not absorb radiant energy readily and do not emit radiant energy readily. (eq. ice surface)

- Transmission occurs if the energy penetrates completely, passing through the object with no absorption of energy.

Radiation is a natural part of our environment and it can be detected, measured and controlled. The measurement of radiation is by the amount of radioactivity present, or the amount of radiant energy given off. Natural radiation reaches earth from outer space and continuously radiates from the rocks, soil, and water on the earth. Background radiation is that which is naturally and inevitably present in our environment. Levels of this can vary greatly.

Section 2 – Heat affects Matter in different ways

2.1 States of Matter and The Particle Model

1. Water has a distinct characteristic that sets it apart from other liquids on Earth. Water expands when it freezes. This means that solid ice is …
   A. More dense than liquid water
   B. Less dense than liquid water
   C. Thicker than liquid water
   D. Thinner than liquid water

2. The Particle Model of Matter helps to explain ideas about Thermal Energy. This model includes each of the following points EXCEPT ...
   A. all substances are made up of tiny particles that are too small to see
   B. the particles are always in motion
   C. the particles increase their energy output when they collide
   D. the particles have spaces between them

3. Another important idea about temperature and the particle theory is that the motion of particles increases when the temperature increases. Which statement below is correct?
   A. as the motion of particles decreases the temperature remains the same
   B. as the temperature decreases the motion of the particles also increases
   C. as the motion of the particles decreases the temperature decreases
   D. as the temperature increases the motion of the particles decreases

4. The energy of movement is the kind of energy the particles of matter have. This energy is called …
   A. potential energy
   B. kinesthetic energy
   C. phase energy
   D. kinetic energy

5. Transferring heat energy from water in a gas state causes it to change into a liquid. This cooling process is called ...
   A. fusion
   B. condensation
   C. precipitation
   D. evaporation

6. As more heat is transferred to a solid, the particles vibrate and some of the particles in the solid break loose. The solid begins to change state. This is an example of …
   A. heating a solid
   B. heating a liquid
   C. melting a solid
   D. freezing a liquid

7. Which change of state involves a release of energy?
   A. melting
   B. sublimation
   C. evaporation
   D. fusion

8. Which of the following statements about energy is a correct scientific description of what energy is?
   A. energy is a substance that can be transferred
   B. the mass of energy can be measured using a precision instrument
   C. energy fills the space with highly charged tiny particles
   D. energy is a description of a quality or a condition

9. Certain materials are found naturally in the environment. Chlorine is found most often in the gas state. To change it to a liquid, this would have to be done ...
   A. add heat
   B. remove heat
   C. increase its temperature
   D. maintain its temperature

10. During a change of state, the temperature remains the same, so the particles have ...
   A. less average energy
   B. more average energy
   C. the same average energy
   D. a faster speed

11. When heat is added to or removed from moving particles it changes their …
   A. physical characteristics
   B. speed
   C. ability to change state
   D. size

2.2 Heat and Temperature

1. Absolute zero is a temperature on the Kelvin scale. Although no one has ever been able to cool anything down to absolute zero, scientist know that it is ...
   A. - 137.15 K
   B. - 237.15 K
   C. - 173.15 K
   D. - 273.15 K

2. A device, used to show the expansion of air when there was an increase in temperature, was used as early as 200 B.C. This device is now generally known as a …
   A. thermometer
   B. thermograph
   C. thermoscope
   D. thermopile

3. The thermal energy of a substance is the …
   A. total kinetic energy of all the particles
   B. average kinetic energy of the particles
   C. kinetic energy of each particle separately
   D. measure of how hot or cold the substance is

4. The temperature of a substance is the …
   A. total kinetic energy of all the particles
   B. average kinetic energy of the particles
   C. kinetic energy of each particle separately
   D. measure of how hot or cold the substance is

5. Which of the following energy transfers would be correct?
   A. thermal energy in a hot drink is transferred to cold hands
   B. thermal energy is transferred from a room to a heater, so it can be heated
   C. an ice cube loses thermal energy when it melts in hot lemonade
   D. thermal energy is lost when a snowball melts

6. Galileo Galilei, an Italian scientist, invented the first device for measuring temperature in the 1590s. But it wasn't until the 1700s that an accurate way to measure temperature was developed by a German physicist. The scale that he created on his thermometer is still used in many countries, including the United States. It is called the ...
   A. Celcius scale
   B. Absolute zero scale
   C. Fahrenheit scale
   D. Locke scale

7. One of the most sensitive substances to heat was used in early thermometers, until it was found that it was highly toxic. This substance is ...
   A. mercury
   B. alcohol
   C. air
   D. water

8. A material, affected by changes in some feature of the environment, such as temperature, is called a ...
   A. circuit
   B. sensor
   C. signal
   D. responder

9. Because your senses can easily be fooled, thermometers were developed, because they are more reliable. The earliest thermometers contained a glass bottle with a long glass tube for the liquid to rise and fall. An important part was missing though. It was the ...
   A. type of liquid that senses temperature change
   B. type of glass that doesn't expand
   C. the calibrated scale of relative temperatures
   D. the protective stoppers to prevent the liquid from escaping

10. Estimating temperature, without using a thermal sensing device, is something that we do automatically. Touching something to see how hot or cold it is represents one technique that we use. Another is to ...
    A. use a thermometer
    B. look at the moving particles
    C. observe the color
    D. use the back of your hand

2.3 Heat Affects Volume – Gasses, Liquids and Solids

1. When air is heated inside a balloon, the air makes the balloon rise. This happens because – compared to the air outside the balloon, the heated air is …
   A. less dense
   B. more dense
   C. warmer
   D. cooler

2. When a substance is heated the particles gain energy and spread out, creating more volume (spaces between the particles). So what about the mass of the substance? What happens to the mass of a substance when it is heated?
   A. mass is lost
   B. mass increases
   C. mass decreases
   D. mass remains the same

3. Solids made of different metals were all heated to 100^{o}C to determine how their volume and length would be affected. Which statement describes the most likely outcome of this experiment?
   A. All the volumes changed the same amount and the lengths remained constant.
   B. All the volumes changed, but each substance was the same length.
   C. Only some of the volumes changed with their length being increased.
   D. All of the volumes changed and so did their lengths.

4. Some students performed an experiment testing the affect of heat on different solids. Which of the following variables would have been the manipulated variable.
   A. the amount of heat used
   B. the size and color of each solid
   C. the different types of solids
   D. the different length to which the solids expanded

5. When thermal energy is added to a solid the volume of the solid will change. Steel beams bending or even breaking in a bridge, because of an extreme change in temperature are a result of thermal…
   A. conduction
   B. contraction
   C. expansion
   D. design

6. Students set up an experiment to determine if a gas expands when heated. The experiment didn't work because the students were missing an important element to get the results they predicted. Which of the following variables is necessary to perform an experiment such as this?

   A. proper safety equipment
   B. a very large balloon
   C. a heat resistant flask
   D. a heat source

7. A balloon filled with helium was put into a freezer to determine what the effect the lowering of the temperature would have on a gas. The responding variable in this experiment was the ...
   A. amount of gas in the balloon before and after
   B. the volume of the balloon before and after
   C. the temperature variation of the freezer
   D. the amount of time needed to change the balloon

2.4 Heat Transfers by Conduction

1. A certain type of thermal energy transfer moves the energy by direct collisions, particle-to-particle. This type of thermal energy transfer is called ...
   A. concurrent
   B. conduction
   C. conduit
   D. convective

2. Special thermal protection tiles cover the underside of the space shuttles. As the shuttles reenter the Earth's atmosphere these tiles can withstand 1400^{o}C of heat caused by friction in the atmosphere. The material that these tiles are made of is …
   A. plastic
   B. fiberglass
   C. ceramic
   D. thermofilm

3. One of the key characteristics of conduction is that heat transfers in only one direction – from areas of …
   A. greater kinetic energy to areas of less kinetic energy
   B. less kinetic energy to areas of greater kinetic energy
   C. greater potential energy to areas of less potential energy
   D. less potential energy to areas of greater potential energy

4. Students did an experiment with four pieces of metal with a slab of butter placed on the end of each. They placed them in a beaker of hot water and timed how long it took for the butter to melt enough to slide down the metal and enter the water. Each metal showed a different time. The fastest time was recorded on the copper metal. Which of the following variables is the responding variable?
   A. The temperature of the water
   B. The length of the metal
   C. The time it took for the butter to melt
   D. The different types of metal used

5. Materials that allow an easy transfer of heat are called …
   A. conductors
   B. insulators
   C. energizers
   D. thermals

6. Plastic, cork and wood are materials that do not allow an easy transfer of heat. They reduce the amount of heat that can transfer from a hot object to a colder object. They are called …
   A. conductors
   B. insulators
   C. energizers
   D. thermals

2.5 Heat Transfers by Convection and Radiation

1. In a liquid the particles are moving quickly. When heat is added they have more energy, but this energy is transferred from particle to particle in a different way than in a solid. The reason for this is because of the ...
   A. speed of the particles
   B. space between the particles
   C. types of particles
   D. temperature of the particles

2. The transfer of heat energy in a fluid is different than what happens in a solid. The heated particles become less dense and so they rise, with the colder, denser particles rushing in to take their place. This type of thermal energy transfer creates a ...
   A. conduction current
   B. convection current
   C. radiation pathway
   D. concurrent current

3. In a hot tub, your body gains thermal energy from the hot water. This thermal energy is then transferred throughout the inside your body by each of your living cells. It can be dangerous to stay in the tub for a long period of time, because your ...
   A. cells will get so large they will burst, losing all of their nutrients to the water
   B. normal body temperature begins to be transferred to the water
   C. cells will shrink because of osmosis
   D. blood vessels enlarge, blood pressure goes down, and your heart rate increases

4. Storm windows were used in the past to prevent heat from leaving the inside of the house in the winter. They weren't very efficient, because the space between the two panes of glass allowed convection current to take heat out even more. The new energy efficient windows prevent this from happening by preventing convection from happening. Krypton gas fills the space between the panes of glass because it is a …
   A. better conductor than air
   B. better insulator than air
   C. poor insulator
   D. noble gas

5. Energy systems have five things in common - input energy, energy transfer, output energy, waste energy and ...
   A. collisions between particles
   B. energy source
   C. energy equilibrium
   D. concentrated flow

6. Radiation is the transfer of energy without any movement of matter. This type of energy transfer is called ...
   A. radiative transduction
   B. radioactive transfer
   C. electrospectrum radiation
   D. electromagnetic radiation

3.0 Human Needs have led to technologies for obtaining and controlling heat

3.1 Natural Sources of Thermal Energy

Biological Energy

Living organisms burn food (chemical energy) in their bodies to generate body heat (thermal energy). A composter is another source of thermal energy. Decomposers break down food and as these chemical changes occur, thermal energy is produced, which in turn helps speed up the process of decomposition.
(*Environmental Impacts:* waste management)

Chemical Energy

Chemical Energy can be transformed into Thermal Energy when wood, or coal is burned.
(*Environmental Impacts:* pollution caused by the burning of these fossil fuels)

Geothermal Energy

Volcanoes, hot springs and geysers are sources of geothermal energy - energy from the interior of the earth. The thermal energy from these events can produce hot water or steam, which can be then piped to a power plant at the surface. This can be used to run turbines which produce electrical energy. HRD (hot, dry rock) can be used as another technique to generate thermal energy. (Water is pumped into cracks in the earth's crust. It returns to the surface as steam, which can be used to generate electricity.
(*Environmental Impacts:* more extensive use of this *clean and environmentally friendly technique*, could reduce the threat of oil spills, the pollution caused by burning fossil fuels and the wastes from mining fossil fuels.)

Wind Energy

Wind energy is the energy of moving air, and is a result of solar energy and convection. As the sun heats up the air, the warm air rises and cools off. The cooler air falls, creating the convection currents called thermals. These convection currents, on a global basis, form the Earth's wind systems. The windmill is a turbine (a wheel with fan blades), which is connected to a generator. When the windmill spins the generator produces electricity.
(*Environmental Impacts:* aesthetics)

Mechanical Forces

Mechanical forces that push or pull objects often release thermal energy, as do Frictional forces.
(*Environmental Impacts:*

Electrical Energy

Electricity is produced in many ways. Hydro-electric dams use the force of gravity which pulls the water over the dam to turn turbines, which are attached to generators, which produce the electrical energy from the mechanical energy of the generators. Electricity can also be produced at thermo-electric (fuel-burning) generating stations that burn fossil fuels.
(*Environmental Impacts:* wildlife in the area of the dam lose valuable habitat, plants may perish when the river which was blocked overflows its banks to create the reservoir for the dam, commercial enterprises may be adversely affected, pollution by the burning of fossil fuels, heated waste water can affect organisms in lakes where this waste water is dumped.)

Solar Energy (A Solar Energy Information Resource)
Solar energy is clean and is guaranteed not to run out. It is not available all the time (nighttime, less in winter/ than in summer).

There are two techniques that can help to overcome these issues. (See Figure 3.32, page 243)

- **Passive solar heating** - uses the materials in the structure to absorb, store and release the solar energy.

Passive Solar Heating

Passive solar heating means that the system simply lets the radiant energy from the sun to come into the home and prevents heat from escaping. These principles are also used for solar greenhouses. The best spot for a greenhouse is on the south or southeast side of the house, in a sunny or partially shaded area. A southern exposure maximizes sunlight to the greenhouse during the winter when it is needed the most, and the home shelters it from the northern arctic blasts. A lean-to greenhouse model gets attached to the house, and may have a doorway from the greenhouse into the house and/or to the outside. A freestanding greenhouse model, which affords more growing room, may be attached to the house at one end, or situated entirely away from the house. Components to consider:

- Style of building
- window size
- orientation to the sun
- landscaping
- building materials

You will want your home to be energy efficient.
Solar Cooker Links (Simple Design)

- **Active solar heating** - uses mechanical devices to collect and distribute the thermal energy.

Active Solar Heating
Heating buildings directly using solar heating devices, so that as much solar energy as possible is absorbed by the material (usually a "liquid'), which then distributes It throughout the home environment. How it works**.**

Solar collectors can be:
flat ... collecting the solar energy by using a liquid -usually water mixed with antifreeze (Because water is cheap and readily available and has a high specific heat capacity. However, it freezes when the temperature drops below 0, so antifreeze is added to overcome this shortfall)
and then recirculating it throughout the house (by convection - with the help of pumps - and by radiation)
curved ... collecting the solar energy by reflecting it to a central point: Both are very expensive.

Solar technology involves all of the principles you have studied thus far - conduction, convection, radiation and heat capacity. There are many myths and Unknown facts about Solar Energy Possibilities. Several kinds very practical solar energy systems are in use today. The two most common are **passive solar heated homes** (or small buildings), and small stand-alone **photovoltaic** (solar electric) systems. These two applications of solar energy have proven themselves popular over a decade of use. They also illustrate the two basic methods of harnessing solar energy: solar thermal systems, and solar electric systems. The solar thermal systems convert the radiant energy of the sun into heat, and then use that heat energy as desired. The solar electric systems convert the radiant energy of the sun directly into electrical energy, which can then be used as most electrical energy is used today.
(*Environmental Impacts:* none)

3.2 Heating Systems Technologies

Technologies, like micro-sensors, have advanced the use of thermal energy in heating and cooking. The ones used for this purpose have:

- A **sensor** - a material which is affected by changes in some feature of the environment, such as temperature
- A **signal** - provides information about the temperature, such as an electric current
- A **responder** - which indicates the data with a pointer, light or other mechanism using the signal

Thermostats

Heating systems are controlled by thermostats. Thermostats are used to control the air temperature in indoor environments. They also are used to regulate temperatures in electrical devices, such as ovens or air conditioners. The switch in a thermostat is a **bimetallic strip**, made of two different metals joined (fused) together, often formed into a coil. When heat is applied to the end, one of the metals will expand faster than the other and the coil can operate a switch or valve just as the thermocouple does.

Thermocouple

Two wires of different metals are twisted together. When heat is applied to one end an electric current is produced. (the amount of current depends on the temperature and the type of wires) This current can turn on and off a switch or valve.

The Recording Thermometer

When a bimetallic coil strip is attached to a long arm lever, with a marker at the end and a drum that has graph paper, a recording thermometer can be made. This instrument works much the same as a seismograph.

The Infrared Thermogram

If an object is warmer than absolute zero it gives off infrared radiation (IR). The infrared radiation can be photographed with special films or detected by special sensors that display colored images. The brightness or color of the image indicates the temperature of the object.

Heating Systems

There are two types of heating systems:

- **Local heating systems** provide heat for only one room or a small portion of a building. Fireplaces, wood-burning stoves and space heaters are examples.
- **Central heating systems** provide heat from a single, central source, such as a furnace. Heat transfers throughout the building through pipes, ducts, vents and openings in different places. Two types of central-heating systems are **forced-air heating** and **hot-water heating**

Convection At Work

In each of the two systems described, convection is working to transfer the heat evenly throughout the building.

Keeping Cool

Thermal energy is needed to run refrigerators, freezers and air conditioners. The basic parts of a cooling system are: a storage tank, a compressor, a freezer unit, condenser coils, and a refrigerant. The refrigerant (liquid) in the cooling system evaporates at a very low temperature, which creates freezing temperatures inside the unit. A diagram of the unit is on p. 232.

3.3 Heat Loss and Insulation

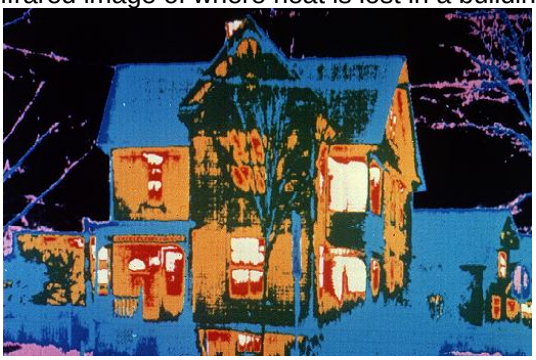
One of the challenges for Albertans is to keep the temperature of their building comfortable. In winter this means keeping the cold air out and hold in as much of the warm air as possible. In summer the opposite is true.

Insulation

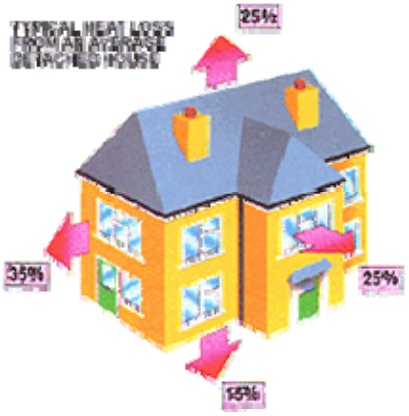
Insulation is used to reduce heat loss and limit cold air from entering buildings. The building materials determine how effectively this is done. The thermal conductivity of a material reflects its ability to transfer heat by conduction. Materials with low thermal conductivity are useful – such as brick or stone. These are not always the most economical, so Styrofoam and fiberglass insulation is used in most buildings. Doors and windows are also very important when determining what materials will work most effectively.

Heat Loss

Infrared image of where heat is lost in a building



Typical Heat Loss In A House



Heat in a typical home is lost from the roof, doors, walls and the windows. This means that additional heat will be needed to replace the heat lost.

Research into improving the materials to prevent heat loss is ongoing. New windows, doors, siding, weather stripping, and insulation that are more efficient at reducing heat loss are constantly being developed. A system of rating these insulators has been developed to inform consumers how effective the material is. Every insulator is given an R-value. The higher the R-value, the most effective it is as an insulator. Different areas of the home have different recommended R-values, depending on how what materials are used and how much space is available for insulation.

The recommended **R-values** for homes:

- Attic = R-38 to R-44
- Sidewalls = R-11 to R-18
- Basement = R-10 to R-19
- Crawlspace = R-19

Section 3 – Understanding Heat and Temperature

3.1 Natural Sources of Thermal Energy

1. Much of the energy used in Alberta is found in the vast resources of fossil fuels. This type of energy source is useful and is stored until we need it. Fossil fuels are considered to be sources of ...
   A. chemical energy
   B. industrial energy
   C. biological energy
   D. geothermal energy

2. Solar energy is an excellent natural thermal energy source. This type of energy is produced inside of the Sun by ...
   A. biological processes
   B. nuclear reactions
   C. magnetic waves
   D. electric storms

3. There are two types of solar energy heating systems. The system using direct Sun rays is called …
   A. active
   B. activating
   C. positive
   D. passive

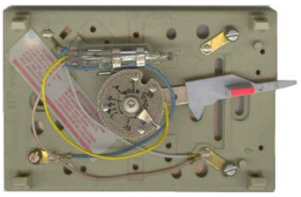
4. Thermal energy from inside the Earth's crust can be harnessed as a useful thermal energy source. Volcanoes, hot springs and geysers are example of this type of thermal energy source. This type of thermal energy is ...
   A. an environmental pollutant
   B. a clean alternative to using fossil fuels
   C. called geovolcanic energy
   D. used to generate fossil fuel resources

5. The thermal efficiency of a building's design can be measured by how well it prevents …
   A. heat gain
   B. heat loss
   C. direct sunlight
   D. convection currents

6. Solar collectors are used to capture the Sun's energy. These collectors are filled with ...
   A. coal
   B. water
   C. air
   D. glass

7. Solar cells are arranged in panels, which are connected in a series, and then placed to capture and store the Sun's energy in low voltage batteries. The panels are connected in a series to form what is called a solar ...
   A. system
   B. field
   C. array
   D. site

3.2 Heating Systems Technologies

1. 

This illustration shows the inside workings of a thermostat.

The bimetallic strip, made of two different metals that expand and contract at different rates, enables the coil to act as a …

A. element
B. switch
C. conductor
D. insulator

2. Relative temperature for a comfortable room is maintained by using a thermostat, that is connected to a central heating system. The relative temperature of a comfortable room is …

A. 18°C
B. 20°C
C. 37°C
D. 100°C

3. Two types of heating systems in a house help to maintain heat flow where it is needed. The type of heating system that provides heat from a single, central source such as a furnace is called …

A. local heating
B. central heating
C. boundary heating
D. thermal heat control

4. Air that is heated by burning fuel in a furnace and then sent throughout the house through ducts to a register in every room is an example of this type of heating system …

A. forced-air
B. hot-water
C. convection
D. conventional

5. When a fireplace becomes too hot, this device - a moveable plate, that controls the flow of air to the fire - can be adjusted …

A. cooler
B. deflector
C. airfoil
D. damper

6. Thermal energy is needed to create the cold temperatures we need in technologies such as refrigerators, air-conditioners and freezers. Electricity or natural gas can provide the fuel that runs this device that the heart of these cooling technologies …

A. fan
B. motor
C. compressor
D. refrigerant

7. Basic parts of a cooling system are: a storage tank, a compressor, a freezer unit, condenser coils, and a …

A. fan
B. cooler
C. evaporator
D. refrigerant

3.3 Heat Loss and Insulation

1. A natural insulator helps to keep animals, such as polar bears and seals, warm in frigid water. This natural insulator forms a protective layer to help keep heat from leaving the body. This natural insulator is …
   A. skin
   B. fat
   C. hair
   D. fur

2. A material's ability to transfer heat by conduction is reflected by its thermal …
   A. capacity
   B. rating
   C. conductivity
   D. energy

3. Stone and brick are excellent insulators, but are not widely used because they are too expensive. The most common type of insulation that provides a layer of paneling between the outer walls and the siding is …
   A. plaster
   B. gyprock
   C. styrofoam
   D. fiberglass

4. In an average house heat is lost (transferred to the outside) in five major places. The least amount of heat is lost through the …
   A. walls
   B. windows
   C. through the floor
   D. gaps and poorly sealed areas

5. In an average house heat is lost (transferred to the outside) in five major places. The most amount of heat is lost through the …
   A. walls
   B. windows
   C. roof
   D. floors

6. To determine where heat is lost in a building, contractors can ask a photographer to take this type of photo of the house.
   A. A thermogram
   B. A radiogram
   C. A thermal negative
   D. An infogram

7. Insulators are rated by their insulating ability. R-value is given to each material that is used in the construction of a building. The best insulating product would have a …
   A. low R-value
   B. high R-value
   C. fractional R-value
   D. restricted R-value

4.0 Human Needs have led to technologies for obtaining and controlling heat

4.1 Looking At Different Sources of Heat

There are two types of natural resources in the environment: **renewab**le and **non-renewable**. Renewable energy sources are those that can be replaced, while non-renewable energy sources are those that cannot be replaced – once they are used up, they are gone.

Focus On Fossil Fuels

An energy resource is anything that can provide energy in a useful form. Most energy supplies come from fossil fuels (in Alberta and throughout the world). Fossil Fuels are chemicals from plants and other organisms that died and decomposed millions of years ago and have been preserved underground. The widespread use of fossil fuels has created many problems. More than 60% of the world's energy needs were met by burning oil and natural gas, while another 30% was provided by coal. Despite the many disadvantages of using fossil fuels, we continue to use them. Coal is burned to generate electricity. Oil and natural gas are abundant in Alberta and we use it, maybe more than we should. Alternatives to using these non-renewable resources need to be utilized, so that future generations of Albertans can continue to thrive in our beautiful province.

Economic Impacts	***Environmental Impacts***	***Societal Costs***
price of gasoline, drilling, processing, transporting, exploration, anti-pollution technology,	global warming, changing climate zones around the world, plant growth, depleted water resources thermal pollution	pollution causes health problems, rising health care costs, treating polluted lakes,

Alternatives For Thermal Energy

Wind Energy	Wind energy is the energy of moving air. As the sun heats up the air, the warm air rises and cools off. The cooler air falls, creating the convection currents called **thermals**. These convection currents, on a global basis, form the Earth's wind systems. The windmill is a turbine (a wheel with fan blades), which is connected to a generator. When the windmill spins the generator produces electricity.
Geothermal Energy	Volcanoes, hot springs and geysers are sources of geothermal energy - energy from the interior of the earth. The thermal energy from these events can produce hot water or steam, which can be then piped to a power plant at the surface. This can be used to run turbines which produce electrical energy.
Nuclear Energy	**Nuclear fission** is a process that uses small amounts of radioactive uranium to produce vast amounts of heat. The Canadian developed CANDU reator provides nuclear energy in many parts of Canada and also sells this energy to other countries. A major problem is long-term storage of radioactive wastes.
Hydro-Electric Power	Hydro-electric dams use the force of gravity which directs the water from the **reservoir**, through gates in the dam to turn **turbines**, which are attached to **generators**, which produce the electrical energy from the mechanical energy of the generators. This is very clean, renewable energy.

Comparing The Options

Each energy source has its advantages and disadvantages. When making choices about which type of system to utilize, take into account where, when and how the energy will be used.

4.2 Energy Consumption

Energy Consumption- Reduce Energy Waste

Home Energy efficient products to upgrade energy wasting products. There are many things we can do at home to stop wasting energy. Examples:

- turning off lights before leaving a room
- install low-flow shower heads to conserve water resources
- Recycling is another way to save energy.
- Stop your taps from dripping
- Save water and install more efficient taps and flush systems
- Insulate your roof and retrofit window to be double glazed
- Don't open doors and windows to cool down a room. Turn down your heat instead.
- Did you know that by turning down the thermostat by 1^{o}C you can reduce your heating costs by up to 10% and helping the environment at the same time
- Get your heating system serviced regularly.
- Don't forget to turn off your computer and TV properly when not in use.
- Always check that lights and fittings are clean. Dirty lights can reduce lighting output by 20%. By cleaning regularly you can maintain lighting efficiency.
- Replace ordinary light bulbs with energy saving bulbs.
- Reduce, re-use and recycle your waste
- Try to make sure you separate your waste for recycling into: paper, glass, aluminum cans, and food waste for composting.

Transportation Cars and Trucks are big energy wasters and contribute greatly to the problems we have in the environment, including nitrogen oxides which cause breathing problems and contribute to smog. Take action to reduce use of cars – ride a bike, take public transit, use hybrid, or fuel cell vehicles, car pool, reduce speed to conserve on fuel consumption.

Industry Industry is the biggest energy user. Sometime, industry's use of energy can harm the environment, but it is also responsible to find ways to reduce the negative impacts and find better ways to utilize the available energy and find better – more efficient – alternative sources of energy. An **energy audit** is utilized to determine ways to reduce energy usage One of the products (**carbon dioxide**) that is released from the burning of fossil fuels is a greenhouse gas, which traps heat energy in our atmosphere and leads to global warming.
Sulfur-dioxide is released when coal and natural gas are burned. This gas is an irritant to the eyes, nose and throat.
Carbon monoxide is produced when a fire burns without enough oxygen. It is clear, odourless and very lethal. It hinders the brain's reasoning ability and can kill you.

Co-generation This alternative uses some of the two-thirds of the energy released by the burning of fossil fuels as thermal energy, to heat a building, or a fuel, to generate electrical energy.

Being A Responsible Citizen

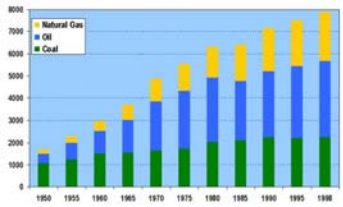
Making responsible decisions means purchasing products and services that will have little negative impact on the environment and will promote a clean environment. Making your voice heard, by supporting government that conducts research into helping environmentally friendly technologies develop and advance our knowledge about energy consumption.
101 Ways To Reduce Your Waste
http://www.wealden.gov.uk/Environment_and_
Class

Section 4 – Technologies that Use Heat – Benefits and Cost to Society and the Environment

4.1 Looking at Alternative Sources of Heat

1. Natural sources of energy can be renewable and non-renewable. Non-renewable energy sources cannot be replaced. A non-renewable energy source would be …
   A. coal
   B. wind
   C. solar
   D. geysers

2. The use of fossil fuels around the world is steadily increasing. The fuel that has increased the most since 1950 is …
   A. Oil
   B. Coal
   C. Crude
   D. Natural gas



3. The costs in dollars of using fossil fuels are what are considered to be …
   A. economy use
   B. economic costs
   C. environmental costs
   D. societal costs

4. The environmental costs of air pollution can be reduced by improving …
   A. production
   B. distribution
   C. technology
   D. generation

5. The costs of treating lakes, that have been damaged by acid rain, have to be paid for by every citizen. This makes this type of cost …
   A. personal
   B. economic
   C. environmental
   D. societal

6. An alternative for thermal energy that is inexpensive, practical and renewable, and does not require increased technological advances is wind power. This technology utilizes a windmill to generate electrical power that can then be converted into thermal energy. Unfortunately this alternative is not practical where there is no …
   A. wind
   B. sunshine
   C. shelterbelt
   D. sloping terrain

7. Canadian scientists developed the Canada Deuterium-Uranium reactor to provide nuclear energy in parts of Canada and to sell to other countries. The major problem with this reactor is the …
   A. long time to produce thermal energy
   B. cost and distribution of the power
   C. long term storage of waste materials
   D. safety record it has worldwide

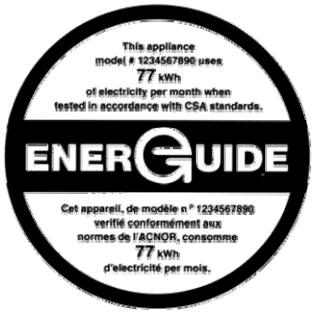
4.2 Energy Consumption

1. The 'hybrid' car was introduced to the general public in 2000. The 'hybrid' vehicle combined two types of systems to power the vehicle. One was gasoline and the other was …
   A. diesel
   B. electric
   C. solar
   D. natural gas

2. The three main energy users are …
   A. home, transportation, industry
   B. recreation, transportation, streetlights
   C. shopping, transportation, industry
   D. home, transportation, recreation

3. An **ENERGUIDE** label is found on most household electrical appliances and tells the consumer how much electricity is ...

   A. needed to run the appliance
   B. used running the appliance
   C. wasted by the appliance
   D. generated while running the appliance



4. Thermal energy has the power to hurt us and destroy our possessions. All of the following practices are dangerous and harmful EXCEPT ...
   A. recycling programs
   B. dumping of toxic chemicals
   C. forest fires
   D. volcanic eruptions

5. A dangerous by-product, from the use of fossil fuels (coal, natural gas and oil) enters the atmosphere when industries burn this fuel. A by-product can react with water in the air to form acid rain. The by-product is ...
   A. carbon dioxide
   B. sulfur dioxide
   C. carbon monoxide
   D. nitrogen monoxide

6. An important tool that companies use to determine where energy is being wasted and ways to fix the problem is an ...
   A. overhaul
   B. economic forecast
   C. energy audit
   D. efficiency rating

7. Co-generation is a process in which two forms of energy are produced at the same time from one energy source. The two forms of energy produced are usually …
   A. heat and light
   B. kinetic and solar
   C. electricity and heat
   D. mechanical and light

REVIEW … Key Concepts

Unit 3 – Heat and Temperature

1.0 Technologies for Obtaining and Controlling Heat

- Heat technologies have evolved over time
- Culture and technology are linked
- Evolution has integrated heat-related materials and technologies
- Choices about the environment involves individuals and society

2.0 Heat Affects Matter

- Transferring heat to and from matter can cause a change in state
- The **Particle Model of Matter** explains changes in state and volume
- **Temperature** is the measure of the average kinetic energy of the particles in a substance
- **Thermal energy** is the total kinetic energy of the particles in a substance – heat is transferred from an area of high kinetic energy to an area of low kinetic energy
- **Conduction** (in contact)**, Convection** (circular motion) **and Radiation** (waves)

3.0 Natural Phenomena and Technology Devices

- Thermal energy is produced by the Sun, decay, fire and geothermal
- **Passive** and **Active** solar heating systems use the sun's energy and are environmentally friendly
- **Thermostats** control temperature in heating systems
- Insulation helps block unwanted heat transfer (heat loss)

4.0 Benefits and Costs of Heat Technologies

- Non-renewable resources have a limited supply
- Fossil fuels are the major sources of heating, but degrade the environment
- Costs of using natural resources: **economic, environmental and societal**
- Energy Alternatives: **solar, wind, geothermal, nuclear and hydro-electric (gravitational)**

1.0 Technologies for Obtaining and Controlling Heat

❖ Heat technologies have evolved over time

Before 1600, people believed heat was a combination of fire and air. They thought it was an invisible fluid. What was the fluid called and explain the 'Theory' it was based on?

_____

_____

_____

_____

Explain the **Particle Theory of Heat**

_____

_____

_____

❖ Culture and technology are linked

How is culture and **heat technology** linked?

_____

_____

_____

Describe the difference between the units associated with heat. **joule, watt, kilowatt, gigajoule**

_____

_____

_____

_____

What is the difference between **'needs '**and **'wants'**?

_____

_____

_____

❖ Evolution has integrated heat-related materials and technologies

What activities are directly related to **heat related technologies**?
(eg. staying comfortable in our homes)

_____

_____

_____

Complete the **Heating Technology Timeline**

7000 **B.C.** _____ 

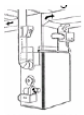
100 **B.C.** _____

A.D. 1200 _____ 

1300**s** _____ 

1700**s** _____ 

late 1700**s** _____

1800**s** _____ 

1906 _____ 

❖ Choices about the environment involves individuals and society

What does it mean when we are asked to make **sustainable** choices?

_____

_____

_____

2.0 Heat Affects Matter

❖ Transferring heat to and from matter can cause a change in state

Describe the changes that take place with the transfer of heat to and from water.

_____

_____

_____

_____

❖ The **Particle Model of Matter** explains changes in state and volume

List the four main principles in the **Particle Model of Matter**

_____

_____

_____

_____

Kinetic energy is the energy of movement. Describe the particles in each state of matter.

Solid _____

Liquid _____

Gas _____

Complete the following Chart that helps to show the relationship between **heat, the particle model and changes of state.**

	Solid	Liquid	Gas
Space between particles			
Volume			
Shape			
Adding heat			
Removing heat			

- **Temperature** is the measure of the average kinetic energy of the particles in a substance
- **Thermal energy** is the total kinetic energy of the particles in a substance – heat is transferred from an area of high kinetic energy to an area of low kinetic energy

Explain the difference between **thermal energy**, **heat** and **temperature** in terms of kinetic energy.

_____

_____

_____

_____

How is temperature measured?

_____

_____

Complete the **Timeline**, by adding in the dates that are missing …
History Of Thermometers

Date	**Event**
200 **B.C.** →	The first thermometers were called *thermoscopes*.
_____	*Santorio Santorio* was the first inventor to put a numerical scale on the instrument.
_____	*Galileo Galilei* invented a rudimentary water thermometer, which, for the first time, allowed temperature variations to be measured.
1701 →	*Ole Romer* created one of the first practical thermometers, using red wine as the temperature indicator.
_____	*Daniel Gabriel Fahrenheit* was the German physicist who invented the alcohol thermometer.
_____	*Fahrenhei*t invented the first mercury thermometer.
_____	*Fahrenheit* introduced the temperature scale that bears his name - Fahrenheit Scale.
_____	The 1st precise scale was developed by *Anders Celsius.*
1848 →	*Lord Kelvin* invented the Kelvin Scale.
_____	The *electrical-resistance-thermometer* was invented in Germany.
_____	*Sir Thomas Allbutt* invented the first medical thermometer used for taking the temperature of a person.
_____	*Theodore Hannes Benzinger* invented the ear thermometer.
_____	*David Phillips* invented the infra-red ear thermometer.
1990**s** →	*Dr. Jacob Fraden*, invented, the Thermoscan® Human Ear Thermometer.

❖ **Conduction** (in contact)**, Convection** (circular motion) **and Radiation** (waves)

What happens to the volume of different materials when heat is added? (Give two examples)

_____

_____

_____

_____

_____

_____

Complete the Chart for each type of **Heat Transfer**

	Conduction	Convection	Radiation
States of matter	solid	liquid, gas	
Volume change (heat added)			increases
Volume change (heat removed)	decreases		
Particle motion			waves
Conduction / Insulation		Heat transferred by convection current – needs space	
Reflect			shiny
Absorb	In contact		

3.0 Natural Phenomena and Technology Devices

❖ Thermal energy is produced naturally

Illustrate and describe 4 **natural sources of Thermal Energy** that are available to us.

The Sun

_____

Forest Fires

_____

Geothermal

_____

Decay

_____

❖ **Passive** and **Active** solar heating systems use the sun's energy and are environmentally friendly

Explain the component parts of the different applications of Solar Energy - used for heating and generating electricity.

	Passive	**Active**
Techniques and Technologies	_____ _____ _____	_____ _____ _____
Advantages / Disadvantages **or** **Costs / Benefits**	_____ _____ _____	_____ _____ _____

Describe what a **solar array** is and where it could be used _____

_____

_____

❖ **Thermostats** control temperature in heating systems

Illustrate the component parts of a **thermostat** and explain how it works

_____

_____

Describe how a **bimetallic strip** can be used as a switch.

_____

_____

Describe each of the two types of heating systems**: Local Heating** and **Central heating**

Local Heating System _____

_____

_____

Central Heating System _____

_____

_____

_____

Compare and contrast the differences and similarities between the two types of central heating systems.

Forced-Air	Hot-Water
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

The basic parts of a cooling system are: _____

_____

❖ **Insulation** helps block unwanted heat transfer (heat loss)

The **thermal conductivity** of a material reflects _____

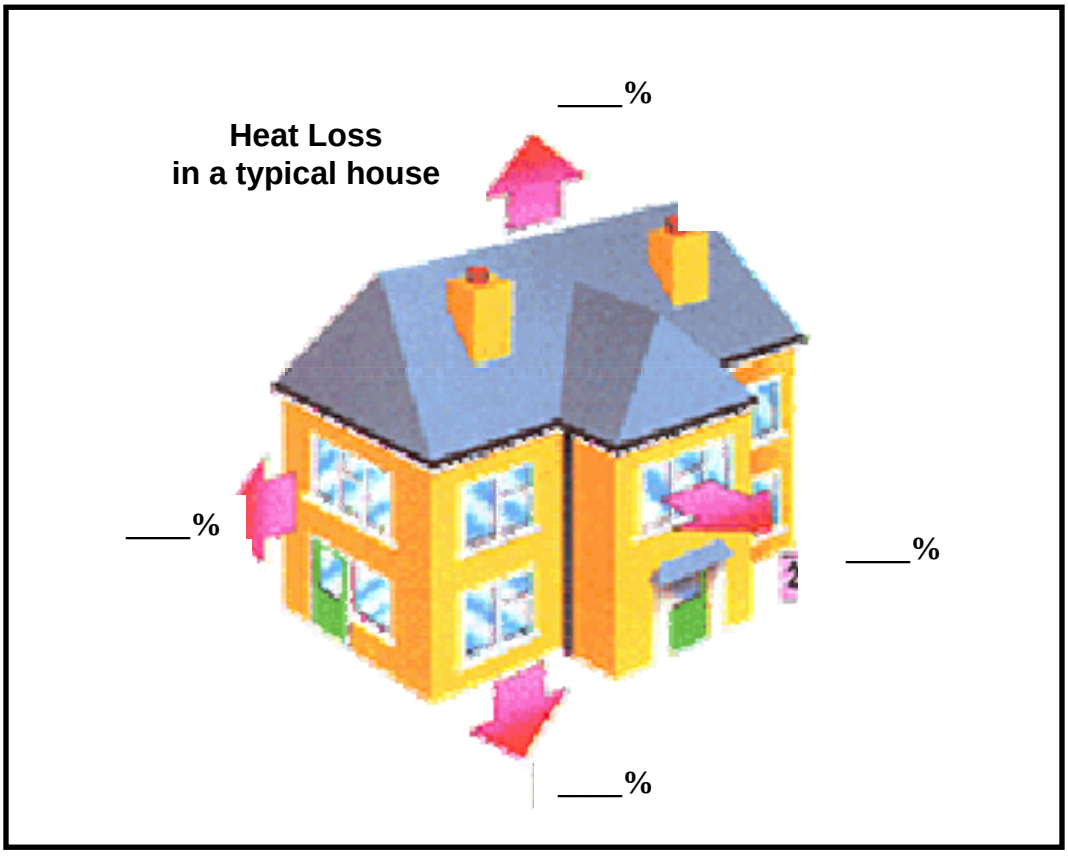
_____

R-Value indicates insulating value of a particular type of material. Explain what it means.

_____

_____

Identify the **% of heat loss** in a typical house.



Describe some types of **insulation material** that are used in Alberta

_____

_____

_____

_____

4.0 Benefits and Costs of Heat Technologies

❖ **Non-renewable resources** have a limited supply

What is the difference between **renewable** and **non-renewable** energy sources?

_____

_____

❖ Fossil fuels are the major sources of heating, but degrade the environment

❖ Costs of using natural resources: **economic, environmental and societal**

Explain the ***'COSTS'*** of using fossil fuels.

Economic Costs _____

_____

_____

Environmental Costs _____

_____

_____

Societal Costs _____

_____

_____

❖ Energy Alternatives:

Describe the ***costs and benefits*** of these **alternative thermal energy technologies.**

Solar _____

_____

_____

Wind _____

_____

_____

Geothermal _____

_____

_____

Nuclear _____

_____

_____

Hydro-electric (gravitational) _____

_____

_____

What does this symbol represent?

_____

_____

Describe ways in which energy can be used wisely in the following places:

Home	Transportation	Industry
_____	_____	_____
_____	_____	_____
_____	_____	_____

Heat and Temperature Unit Test

Section 1 – Human Needs for Heat Technologies

1. In early times, people observed that heat – because it seemed to flow from a hot place to a cold place – must be an invisible fluid that they called …
   A. temperature
   B. energy
   C. thermal
   D. caloric

2. The Franklin stove, invented by Benjamin Franklin, is a heating technology that has a dual purpose. Besides heating a room, it was also used as a
   A. smokehouse
   B. foot warmer
   C. cooking stove
   D. bar-b-cue grill

3. The chimney first appeared in Europe in the …
   A. 1200s
   B. 1400s
   C. 1700s
   D. 1800s

4. The reappearance of central heating occurred in the late 1700s, as coal became the main fuel source. Central heating was originally developed around 100 B.C. by the …
   A. Americans
   B. Canadians
   C. Romans
   D. Greeks

5. This type of Thermal Energy source can be used to cook food, but they are hard to control, dangerous and messy.
   A. open fire
   B. Franklin stove
   C. pioneer stove
   D. modern gas stove

6. Choose the technology that you would need so that you could heat a large room in your house, and maintain a constant comfortable temperature in that room.
   A. a gas furnace
   B. a wood-burning fireplace
   C. an electric fireplace
   D. a digital thermostat

7. What unit of energy does the heating company use to determine the amount of money they charge to help fuel the heating technology in your house …
   A. kilowatt
   B. gigajoule
   C. watt
   D. joule

Section 2 – Heat affects Matter in different ways

8. The Particle Model of Matter helps to explain ideas about Thermal Energy. This model includes each of the following points EXCEPT ...
   A. all substances are made up of tiny particles that are too small to see
   B. the particles are always in motion
   C. the particles increase their energy output when they collide
   D. the particles have spaces between them

9. The energy of movement is the kind of energy the particles of matter have. This energy is called …
   A. potential energy
   B. kinesthetic energy
   C. phase energy
   D. kinetic energy

10. As more heat is transferred to a solid, the particles vibrate and some of the particles in the solid break loose. The solid begins to change state. This is an example of …
    A. heating a solid
    B. heating a liquid
    C. melting a solid
    D. freezing a liquid

11. During a change of state, the temperature remains the same, so the particles have ...
    A. less average energy
    B. more average energy
    C. the same average energy
    D. a faster speed

12. A device, used to show the expansion of air when there was an increase in temperature, was used as early as 200 B.C. This device is now generally known as a …
    A. thermometer
    B. thermograph
    C. thermoscope
    D. thermopile

13. The thermal energy of a substance is the …
    A. total kinetic energy of all the particles
    B. average kinetic energy of the particles
    C. kinetic energy of each particle separately
    D. measure of how hot or cold the substance is

14. Which of the following energy transfers would be correct?
    A. thermal energy in a hot drink is transferred to cold hands
    B. thermal energy is transferred from a room to a heater, so it can be heated
    C. an ice cube loses thermal energy when it melts in hot lemonade
    D. thermal energy is lost snowball when it melts

15. Estimating temperature, without using a thermal sensing device, is something that we do automatically. Touching something to see how hot or cold it is represents one technique that we use. Another is to ...

A. use a thermometer
B. look at the moving particles
C. observe the color
D. use the back of your hand

16. When air is heated inside a balloon, the air makes the balloon rise. This happens because – compared to the air outside the balloon, the heated air is …

A. less dense
B. more dense
C. warmer
D. cooler

17. Solids made of different metals were all heated to 100^{o}C to determine how their volume and length would be affected. Which statement describes the most likely outcome of this experiment?

A. All the volumes changed the same amount and the lengths remained constant.
B. All the volumes changed, but each substance was the same length.
C. Only some of the volumes changed with their length being increased.
D. All of the volumes changed and so did their lengths.

18. When thermal energy is added to a solid the volume of the solid will change. Steel beams bending or even breaking in a bridge, because of an extreme change in temperature are a result of thermal…

A. conduction
B. contraction
C. expansion
D. design

19. A balloon filled with helium was put into a freezer to determine what the effect the lowering of the temperature would have on a gas. The responding variable in this experiment was the ...

A. amount of gas in the balloon before and after
B. the volume of the balloon before and after
C. the temperature variation of the freezer
D. the amount of time needed to change the balloon

20. Special thermal protection tiles cover the underside of the space shuttles. As the shuttles reenter the Earth's atmosphere these tiles can withstand 1400^{o}C of heat caused by friction in the atmosphere. The material that these tiles are made of is …

A. plastic
B. fiberglass
C. ceramic
D. thermofilm

21. One of the key characteristics of conduction is that heat transfers in only one direction – from areas of …

A. greater kinetic energy to areas of less kinetic energy
B. less kinetic energy to areas of greater kinetic energy
C. greater potential energy to areas of less potential energy
D. less potential energy to areas of greater potential energy

22. Materials that allow an easy transfer of heat are called …
A. conductors
B. insulators
C. energizers
D. thermals

23. Plastic, cork and wood are materials that do not allow an easy transfer of heat. They reduce the amount of heat that can transfer from a hot object to a colder object. They are called …
A. conductors
B. insulators
C. energizers
D. thermals

24. In a liquid the particles are moving quickly. When heat is added they have more energy, but this energy is transferred from particle to particle in a different way than in a solid. The reason for this is because of the ...
A. speed of the particles
B. space between the particles
C. types of particles
D. temperature of the particles

25. Storm windows were used in the past to prevent heat from leaving the inside of the house in the winter. They weren't very efficient, because the space between the two panes of glass allowed convection current to take heat out even more. The new energy efficient windows prevent this from happening by preventing convection from happening. Krypton gas fills the space between the panes of glass because it is a …
A. better conductor than air
B. better insulator than air
C. poor insulator
D. noble gas

26. Energy systems have five things in common - input energy, energy transfer, output energy, waste energy and ...
A. collisions between particles
B. energy source
C. energy equilibrium
D. concentrated flow

Section 3 – Understanding Heat and Temperature

27. Solar energy is an excellent natural thermal energy source. This type of energy is produced inside of the Sun by ...
A. biological processes
B. nuclear reactions
C. magnetic waves
D. electric storms

28. Thermal energy from inside the Earth's crust can be harnessed as a useful thermal energy source. Volcanoes, hot springs and geysers are example of this type of thermal energy source. This type of thermal energy is ...

A. an environmental pollutant
B. a clean alternative to using fossil fuels
C. called geovolcanic energy
D. used to generate fossil fuel resources

29. The thermal efficiency of a building's design can be measured by how well it prevents …

A. heat gain
B. heat loss
C. direct sunlight
D. convection currents

30. Solar cells are arranged in panels, which are connected in a series, and then placed to capture and store the Sun's energy in low voltage batteries. The panels are connected in a series to form what is called a solar ...

A. system
B. field
C. array
D. site

31. Relative temperature for a comfortable room is maintained by using a thermostat, that is connected to a central heating system. The relative temperature of a comfortable room is …

A. 18^{o}C
B. 20^{o}C
C. 37^{o}C
D. 100^{o}C

32. Air that is heated by burning fuel in a furnace and then sent throughout the house through ducts to a register in every room is an example of this type of heating system …

A. forced-air
B. hot-water
C. convection
D. conventional

33. When a fireplace becomes too hot, this device - a moveable plate, that controls the flow of air to the fire - can be adjusted …

A. cooler
B. deflector
C. airfoil
D. damper

34. Basic parts of a cooling system are: a storage tank, a compressor, a freezer unit, condenser coils, and a …

A. fan
B. cooler
C. evaporator
D. refrigerant

35. A material's ability to transfer heat by conduction is reflected by its thermal …
   A. capacity
   B. rating
   C. conductivity
   D. energy

36. In an average house heat is lost (transferred to the outside) in five major places. The least amount of heat is lost through the …
   A. walls
   B. windows
   C. through the floor
   D. gaps and poorly sealed areas

37. To determine where heat is lost in a building, contractors can ask a photographer to take this type of photo of the house.
   A. A thermogram
   B. A radiogram
   C. A thermal negative
   D. An infogram

38. Insulators are rated by their insulating ability. R-value is given to each material that is used in the construction of a building. The best insulating product would have a …
   A. low R-value
   B. high R-value
   C. fractional R-value
   D. restricted R-value

Section 4 – Technologies that Use Heat – Benefits and Cost to Society and the Environment

39. The costs of treating lakes, that have been damaged by acid rain, have to be paid for by every citizen. This makes this type of cost …
   A. personal
   B. economic
   C. environmental
   D. societal

40. An alternative for thermal energy that is inexpensive, practical and renewable, and does not require increased technological advances is wind power. This technology utilizes a windmill to generate electrical power that can then be converted into thermal energy. Unfortunately this alternative is not practical where there is no …
   A. wind
   B. sunshine
   C. shelterbelt
   D. sloping terrain

41. Canadian scientists developed the Canada Deuterium-Uranium reactor to provide nuclear energy in parts of Canada and to sell to other countries. The major problem with this reactor is the …
   A. long time to produce thermal energy
   B. cost and distribution of the power
   C. long term storage of waste materials
   D. safety record it has worldwide

42. The three main energy users are …
   A. home, transportation, industry
   B. recreation, transportation, streetlights
   C. shopping, transportation, industry
   D. home, transportation, recreation

43. Thermal energy has the power to hurt us and destroy our possessions. All of the following practices are dangerous and harmful EXCEPT ...
   A. recycling programs
   B. dumping of toxic chemicals
   C. forest fires
   D. volcanic eruptions

44. A dangerous by-product, from the use of fossil fuels (coal, natural gas and oil) enters the atmosphere when industries burn this fuel. A by-product can react with water in the air to form acid rain. The by-product is ...
   A. carbon dioxide
   B. sulfur dioxide
   C. carbon monoxide
   D. nitrogen monoxide

NR1 - Match the change in state with the term that is used to describe it.

1 solid to liquid
2 liquid to gas
3 solid to gas
4 liquid to solid

_____ evaporation
_____ fusion
_____ sublimation
_____ solidification

	.	.	
0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

NR2 - There are different sources of **thermal energy**. Match the source with its description.

1 chemical
2 electrical
3 geothermal
4 solar

____ falling water generates energy
____ the sun provides energy
____ heat below the Earth's surface
____ burning of wood and fossil fuels

	.	.	
0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

Heat and Temperature Section Quiz – Answer Keys

Section 1 Quiz

(1.1, 1.2)

	1.1	1.2
1.	B	C
2.	D	A
3.	C	D
4.	B	A
5.	B	B
6.	A	
7.	C	

Section 2 Quiz

(2.1, 2.2, 2.3, 2.4, 2.5)

	2.1	2.2	2.3	2.4	2.5
1.	B	D	A	B	B
2.	C	C	D	C	B
3.	C	A	D	A	B
4.	D	B	C	C	B
5.	B	A	C	A	B
6.	C	C	D	B	D
7.	D	A	B		
8.	D	B			
9.	B	C			
10.	C	C			
11.	B				

Section 3 Quiz

(3.1, 3.2, 3.3)

	3.1	3.2	3.3
1.	A	B	B
2.	B	B	C
3.	D	B	C
4.	B	A	B
5.	B	B	A
6.	B	D	A
7.	C	B	B

Section 4 Quiz

(4.1, 4.2)

	4.1	4.2
1.	A	B
2.	D	A
3.	B	B
4.	C	A
5.	D	B
6.	A	C
7.	C	C

Heat and Temperature Unit Test – Answer Key

1	D	12	C	23	B	34	D
2	C	13	A	24	B	35	C
3	A	14	A	25	B	36	B
4	C	15	C	26	B	37	A
5	A	16	A	27	B	38	B
6	D	17	D	28	B	39	D
7	B	18	C	29	B	40	A
8	C	19	B	30	C	41	C
9	D	20	C	31	B	42	A
10	C	21	A	32	A	43	A
11	C	22	A	33	D	44	B
Numerical Response		NR1	2134	NR2	2431		