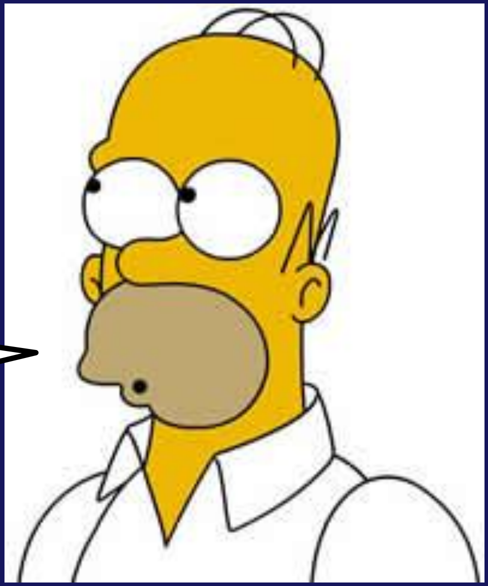
Ready for some more SCIENCE Homer?

**Alright brain,
you don't like me
and I don't like you;
but let's get through this
and I can get back
to killing you
with beer!**



Homer gives his brain a pep talk

Disclaimer: Homer's approach to learning science is not endorsed by Dr H!

REVIEW:
THE TWO LAWS OF THERMODYNAMICS

#1 First Law

(2 simple ways of understanding it)

- Energy can be transformed (changed from one form to another), but the total amount always remains the same. (It is never destroyed)

(same as the "Law of Conservation of Energy")

- HEAT added = increase in THERMAL ENERGY
+ external WORK DONE

p 44

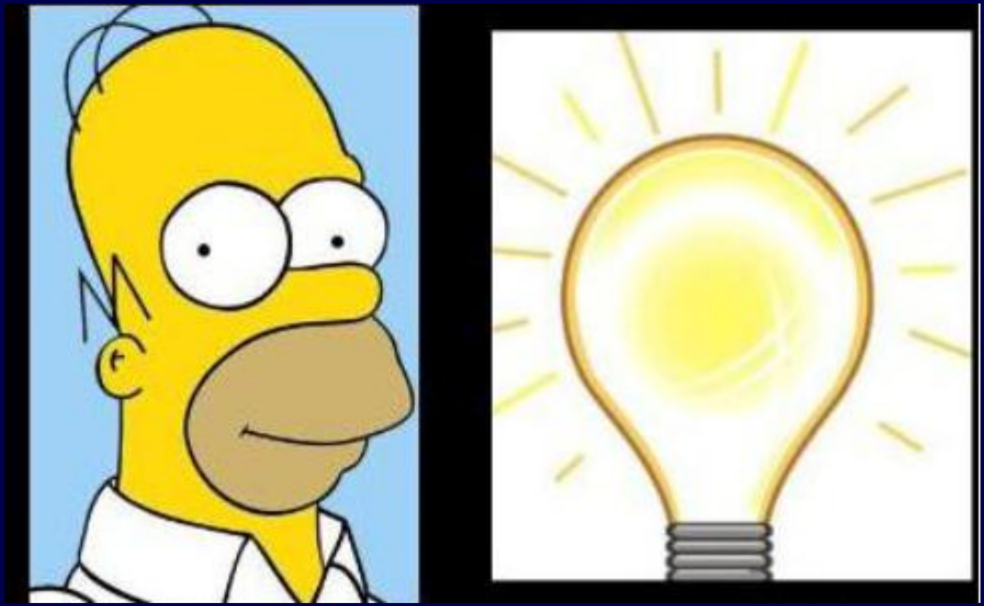
Although energy may not be destroyed, it *can* become **INEFFICIENT**
-- i.e., not easily used or available to do work!

Efficiency = work done / energy used

Review p 24

ENERGY EFFICIENCY & LIGHT BULBS

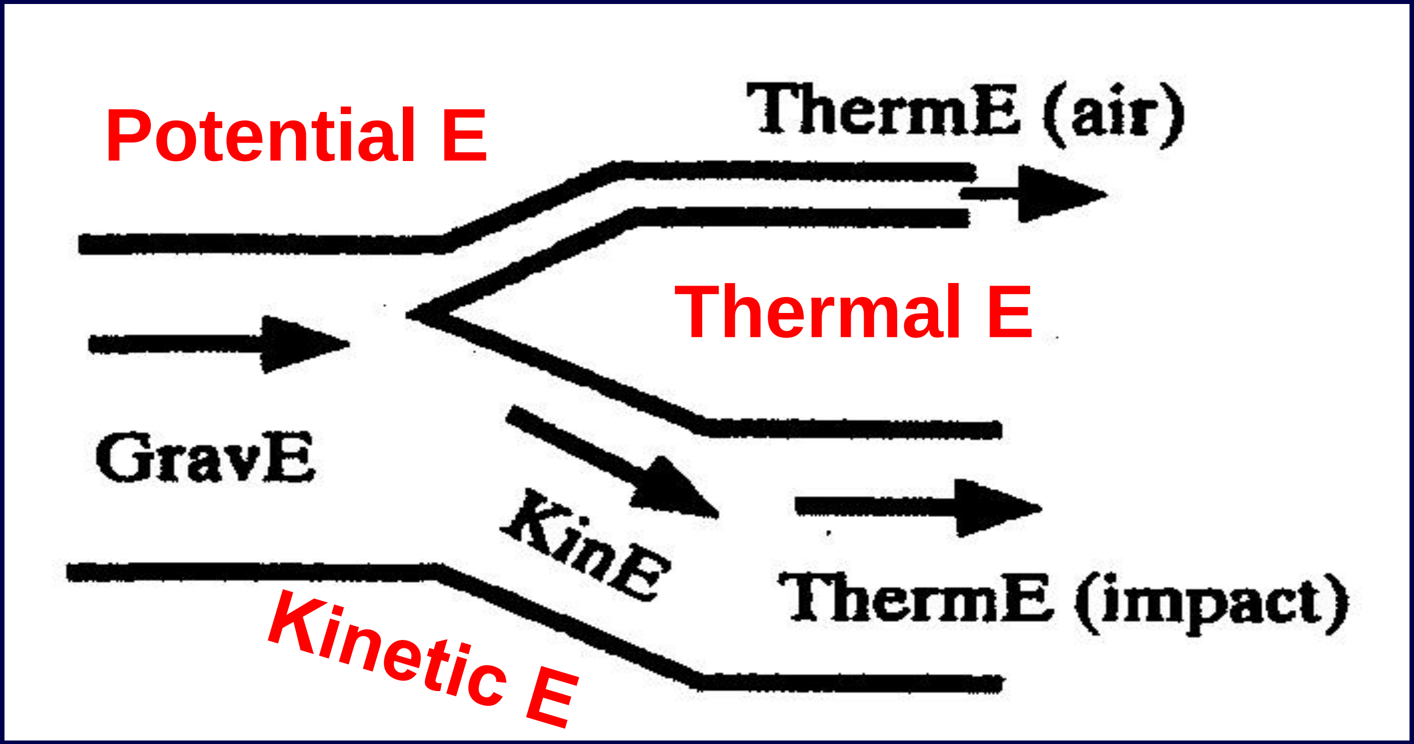
Which type of light bulb should Homer buy???



Flip to the Class Notes Appendix: p 113

Remember this?
An "Energy Flow Diagram"

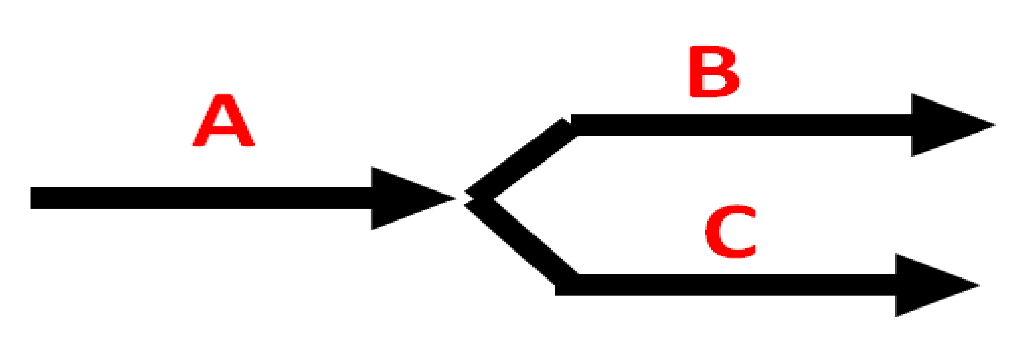
Energy flow for a falling book, with air resistance.



1st Law of Thermodynamics

How would you draw an energy flow diagram for a LIGHT BULB?

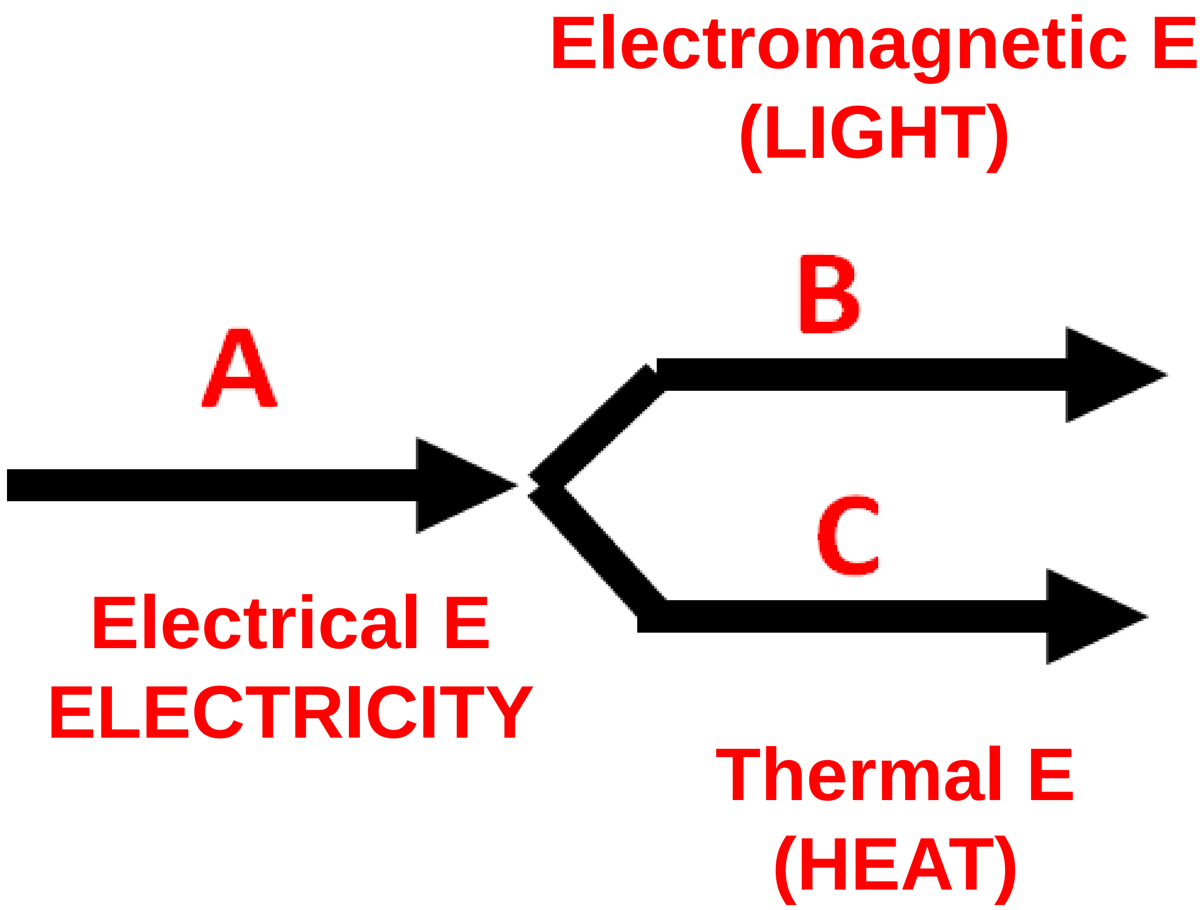
Here is a simple and unlabeled ENERGY FLOW DIAGRAM for a generic LIGHT BULB.



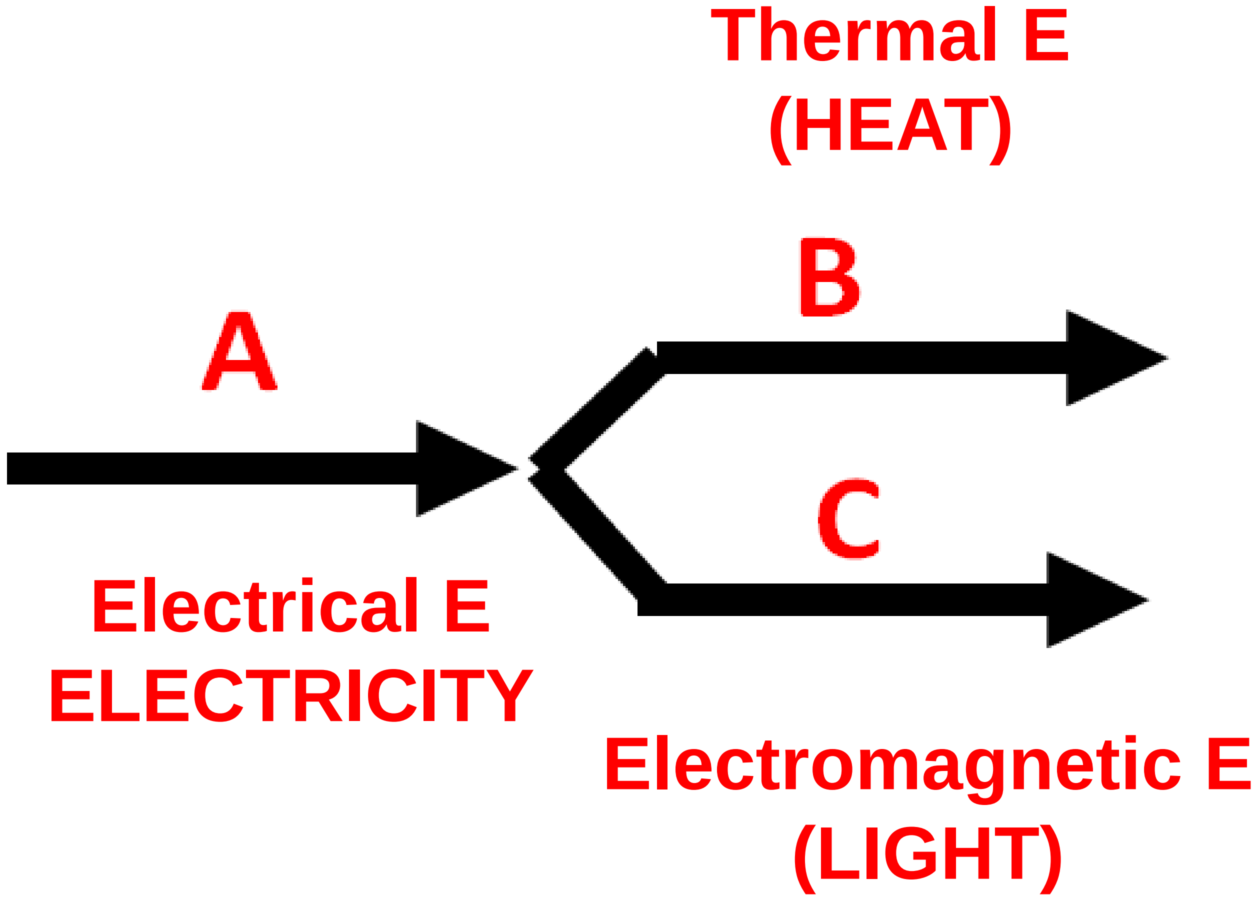
(the width of the arrows has not been adjusted to show the relative amounts of energy in each type of energy flow.)

Which arrow is which?

Choices: *light* (**electromagnetic energy)**
electricity (**electrical energy**)
heat (**thermal energy**).


Electromagnetic E
(LIGHT)
B
A
C
Electrical E
ELECTRICITY
Thermal E
(HEAT)

Also correct . . . .



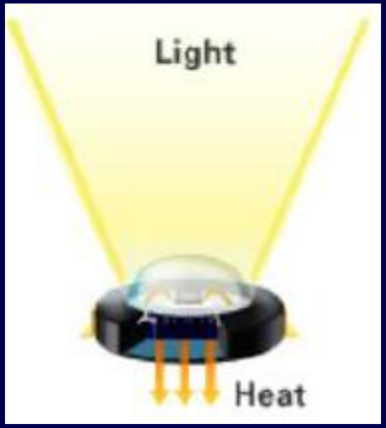
BUT HOW WOULD YOU DRAW THE ARROW WIDTHS??

INCANDESCENT BULBS: electricity passes through a metal filament until it becomes so hot that it glows.

Release 90% of their energy as heat.

COMPACT FLUORESCENT BULBS (**CFL**): electric current is driven through a tube containing gases. Reaction produces ultraviolet light → visible light aided by the fluorescent coating on the inside of the tube.

Release about 80% of energy as heat.



LED bulbs use **LIGHT EMITTING DIODES** to produce light. The movement of electrons through a semiconductor material illuminates the tiny LED light sources.

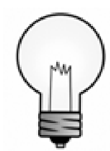
LEDs can approach 80% efficiency

(i.e., 80% of the electrical energy is converted to light energy.)

Draw a **proper ENERGY FLOW DIAGRAM** for each type of light bulb:

Width of the arrows should properly represent (**electrical energy**) converted into *light* (**electromagnetic energy**) and *heat* (**thermal energy**).

THE ARROW WIDTHS WILL BE DIFFERENT FOR EACH TYPE OF LIGHT BULB!

		RANK
	Diagram for CFL bulb:	
	Diagram for CFL bulb:	
	Diagram for LED w/ 80% efficiency:	

Then . . .
based on your Energy Flow Diagrams, RANK the amount of thermal energy being emitted by each bulb type based on the bulb's expected temperature -- from coolest (#1) to hottest (#3)

RANK

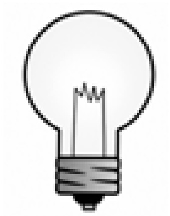


Diagram for CFL bulb:

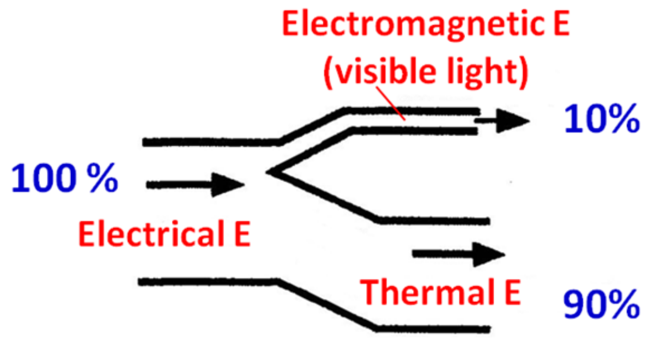


Diagram for CFL bulb:

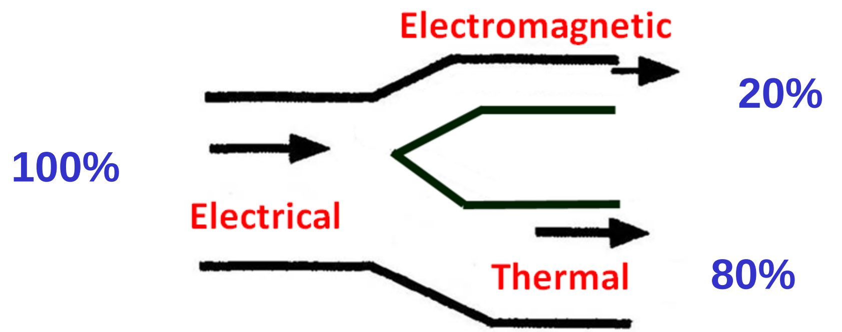
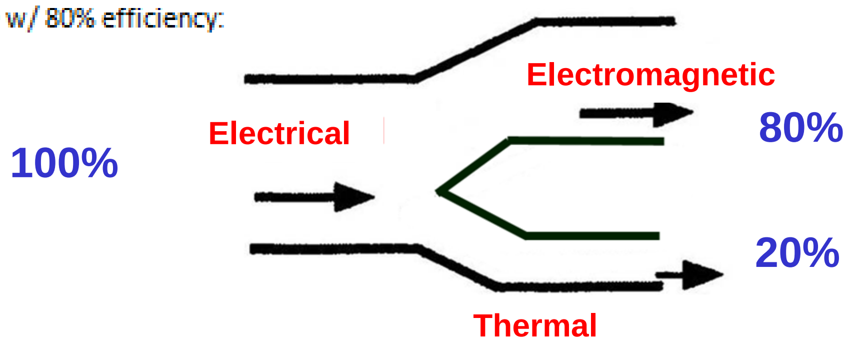


Diagram for LED w/ 80% efficiency:



#2 Second Law

(3 things to remember)

- Thermal energy flows spontaneously ONLY from a higher temperature object to a lower-temperature object (and not the other way).

- Thermal energy input to do the work must also have thermal energy output (exhaust) hence heat engines are never 100% efficient.

- There is an irreversibility about any process that creates thermal energy. Energy disperses or dissipates if it is not hindered from doing so!

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MORE ABOUT THERMAL ENERGY:

First, some more background is needed . . . . .

- Unit of Measure of Thermal Energy
  (i.e., the joule or calorie)
- Specific Heat
- Heat Capacity
- Change of Phase
  (i.e., Latent Energy LE & Sensible Heat (H)
- Heat Transfer

p 45

Quick Review: Thermal Energy Units

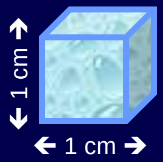
Unit for Thermal Energy
= the *joule* or *calorie*.

"Low Joule Cola"

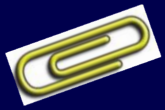
Label from a soda bottle purchased in Europe

A CALORIE is the amount of thermal energy required to change the temperature of 1 gram of water by 1°C (specifically from 14.5°C to 15.5°C)   1 calorie = 4.186 joules

(one gram of water is roughly equivalent to the weight of one cubic centimeter of water



. . . or about the mass of 1 small paper clip!)



review

REMINDER: 1 calorie is NOT the same as our everyday language use of the term "calorie" in "nutrition" discussions:

"nutrition calorie" = kilocalorie!

"Munch"

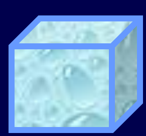
1 "calorie" in nutrition context =
1000 calories
or a kilocalorie (Kcal)

review

Key Term:

Specific Heat = the amount of thermal energy (in calories) required to raise the temperature of 1 gram of ***any substance*** by 1°C.

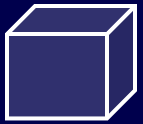
Specific heat =
1.00 calorie



1 g
of water

vs.

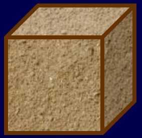
Specific heat =
0.24 calorie



1 g
of air

vs.

Specific heat =
0.20 calorie



1 g
of sand

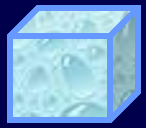
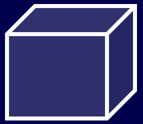
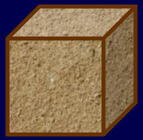
p 45

One Other Key Term:

Heat Capacity = **specific heat x mass (density)**
of a substance for a given <u>VOLUME</u>.

(Density is measured in grams per cubic centimeter.)

Heat capacity represents the capacity of a substance to absorb heat in relation to its ***<u>volume</u>*** and ***<u>density</u>***.

Heat capacity = 1.00 calorie / cubic cm		Heat capacity = 0.00024 – .00034 calorie / cubic cm		Heat capacity = 0.1 – 0.6 *higher if wet* calorie / cubic cm
	vs.		vs.	
1 cubic cm of water		1 cubic cm of air		1 cubic cm of sand

p 45

Specific Heat & Heat Capacity for Different Substances

Substance	Specific Heat		Heat Capacity
	cal	*joules*	
water	1.00	4.186	1.00
air	0.24	1.005	0.00024 - 0.00034
concrete	0.21	.879	0.50
sand	0.20	.837	0.10 - 0.60 (higher if wet)
iron	0.105	.440	0.82
silver	0.056	.234	0.59

Note the HEAT CAPACITY differences between higher density substances (like water, iron) vs. the low density substance of AIR.

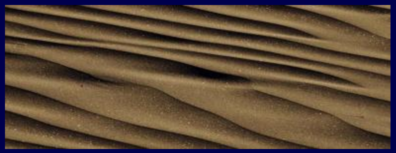
CLICKER SELF-TEST TIME!!! . . . . ➔

Channel 32

Q1 - Assume you have an equal volume of WATER, AIR & SAND.

Which will HEAT UP THE FASTEST if the same amount of thermal energy is transferred into the substance?

1. AIR
2. WATER
3. SAND

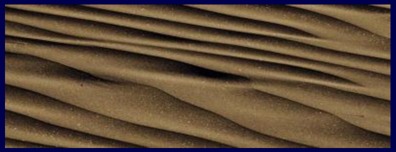


HINT: the greater the heat capacity, the LONGER it will take to heat up the substance.

Q1 - Assume you have an equal volume of WATER, AIR & SAND.

Which will HEAT UP THE FASTEST if the same amount of thermal energy is transferred into the substance?

1. AIR
2. WATER
3. SAND



Explanation:

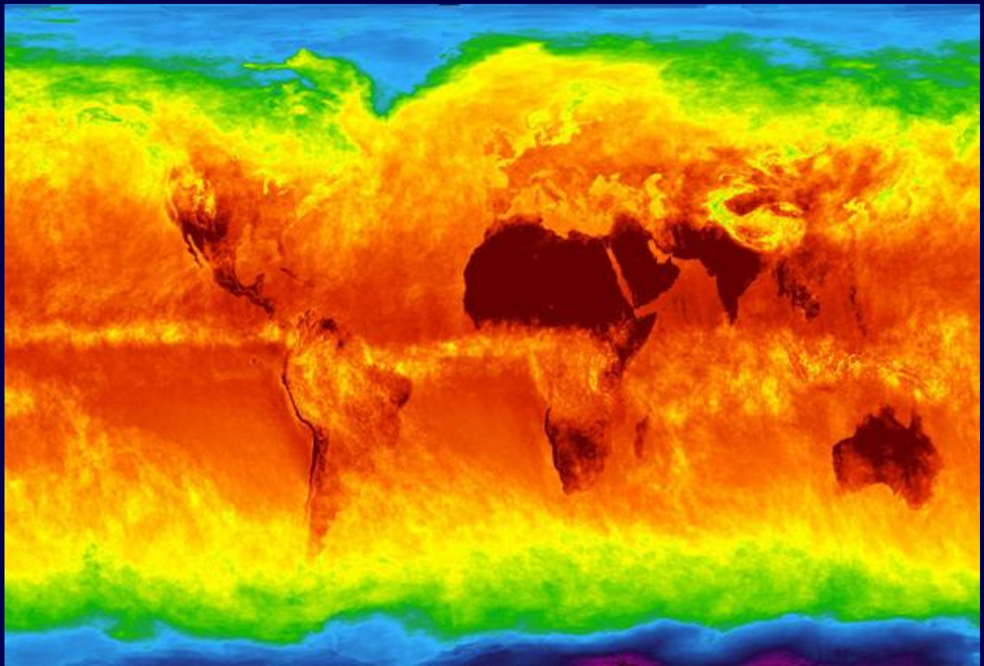
The lower the heat capacity, the quicker the response to a transfer of heat into the substance!

Q2 – As global warming is occurring we will be able to detect it FIRST where?

1 = the ocean temperature

2 = the land surface temperature (i.e., soil)

3 = actually, they will both heat up at the same rate



Map of global surface temperatures

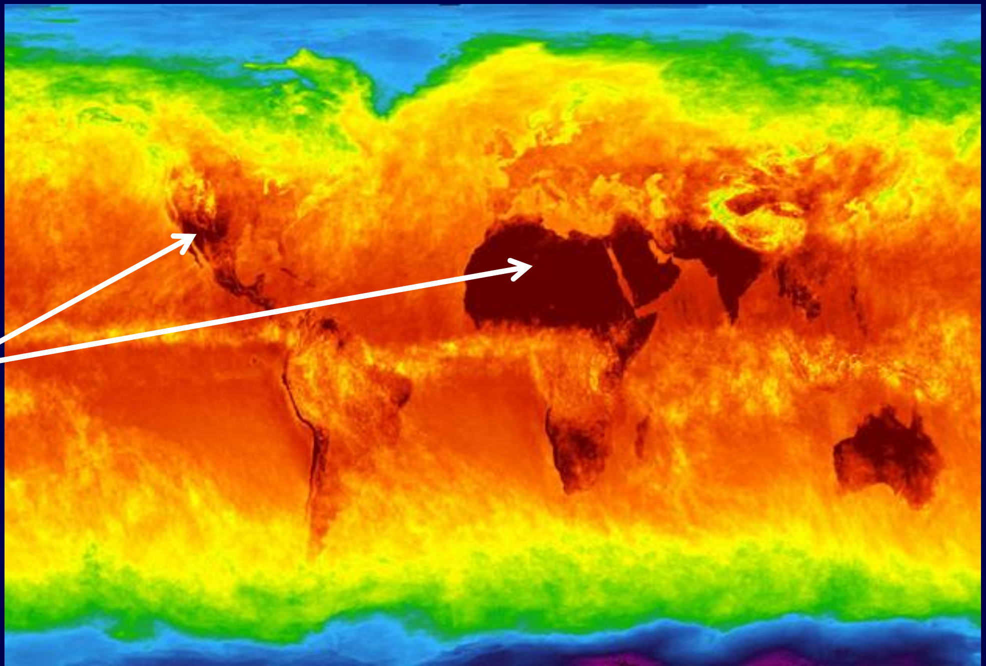
Q2 – As global warming is occurring we will be able to detect it FIRST where?

1 = the ocean temperature

2 = the land surface temperature (i.e., soil)

3 = actually, they will both heat up at the same rate

Note where the hottest temperatures occur



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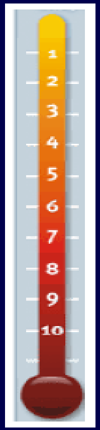
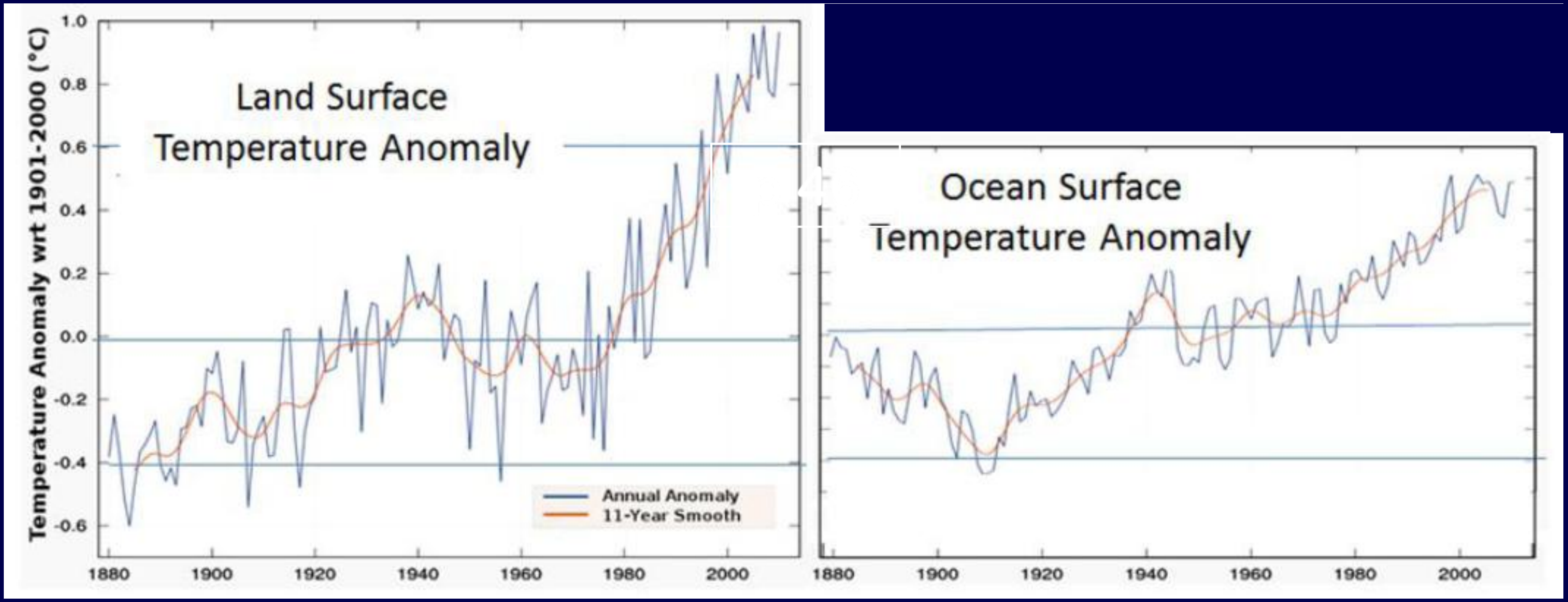


INDICATOR INTERLUDE . . .

Q. Why does the ocean surface warm more slowly than the land surface?



http://www.ncdc.noaa.gov/cmb-faq/anomalies.php

Q3 - Why will he burn his tongue, even if the pie crust is cool enough to hold?

1 - Because due to the high specific heat of the water in the apple pie filling, the filling will heat up faster and to a much higher temperature than the crust can achieve

2 – Because, due to the high specific heat and heat capacity of the water in the apple pie filling, the filling will hold the thermal energy longer than the crust will after the pie is taken out of the oven.

3 - BOTH

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2 – Because, due to the high specific heat and heat capacity of the water in the apple pie filling, the filling will hold the thermal energy longer than the crust will after the pie is taken out of the oven.

3 - BOTH

Q4 - Which component of the EARTH SYSTEM has the ability to store thermal energy the longest -- once it heats up?

1. The ATMOSPHERE
2. The CONTINENTS
3. The OCEAN

Q4 - Which component of the EARTH SYSTEM has the ability to store thermal energy the longest -- once it heats up?

1. The ATMOSPHERE
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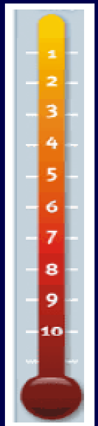


INDICATOR INTERLUDE . . .

Q. Why is the heat CONTENT of the ocean so much greater than the land?

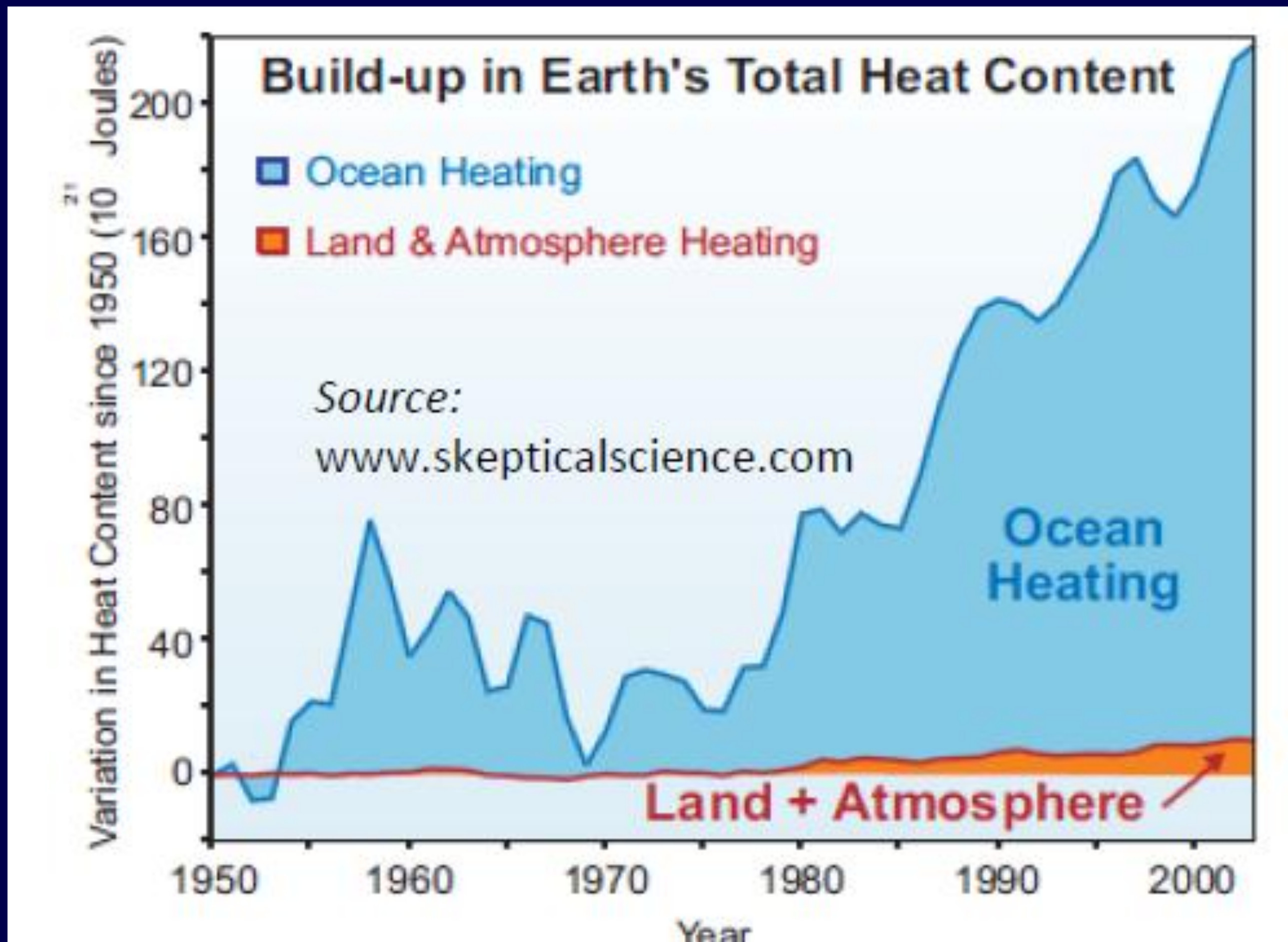


Figure: Total Earth Heat Content from 1950 (Murphy 2009). Ocean data from Domingues et al 2008.
http://www.skepticalscience.com/How-do-we-know-global-warming-is-still-happening.html

One last quick review point . . . .

Heat generally causes *EXPANSION* of a substance.

WHY?

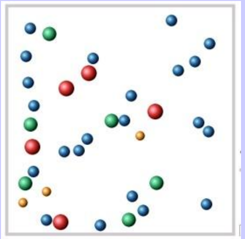
When the temperature of the substance increases:

-- the molecules jiggle faster
-- more energetic collisions occur between the molecules
-- molecules are forced to move farther apart
-- thereby expanding the substance and making it LESS DENSE.

Top of p 46

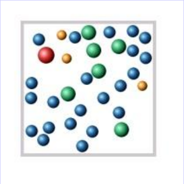
As air heats up, it expands, hence hot air is less dense than cold air & tends to RISE.

HOT



Likewise, cold air is more dense than hot air & tends to SINK

COLD



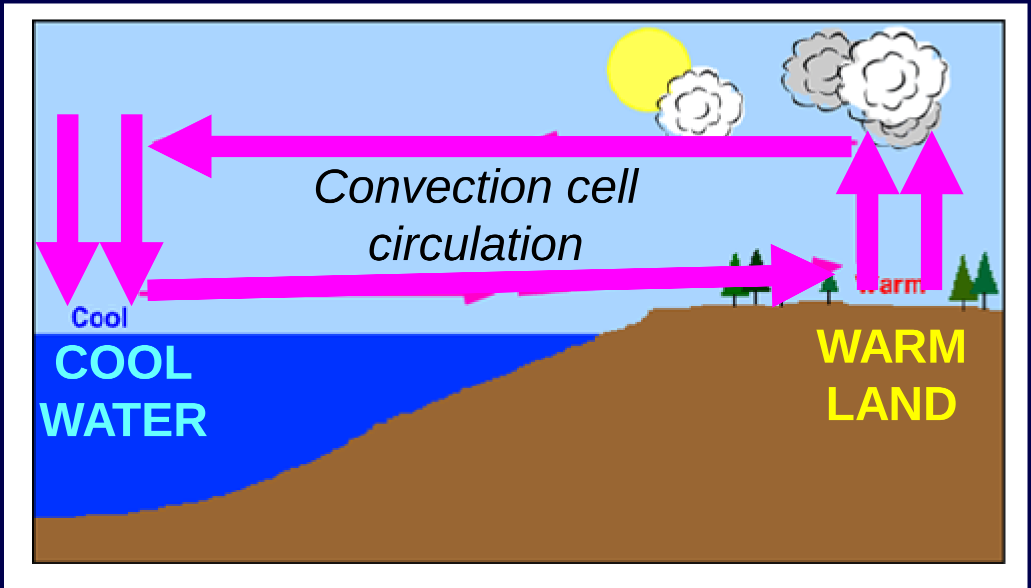
We call this process **CONVECTION** & it is a form of HEAT TRANSFER

These thermal differences play an important role in driving ATMOSPHERIC CIRCULATION, WEATHER & GLOBAL CLIMATE PATTERNS . . . . .

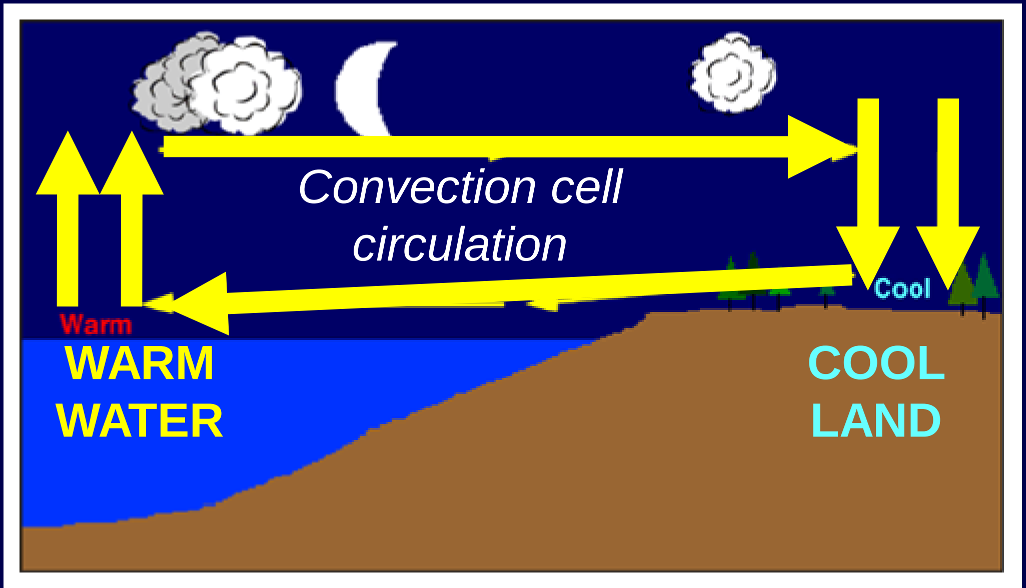
p 46 + 47

Example:

Sea Breezes & Land Breezes are driven by <u>CONVECTION</u>



(this will be connected to global climate patterns later this semester)



"Convection" is a form of . . . . .

THERMAL ENERGY TRANSFER
(aka "Heat Transfer")

Heat Transfer = the process by which thermal energy moves from one place to another

THERMAL ENERGY TRANSFER

(aka “Heat Transfer”)

There are 3 ways that heat can travel:

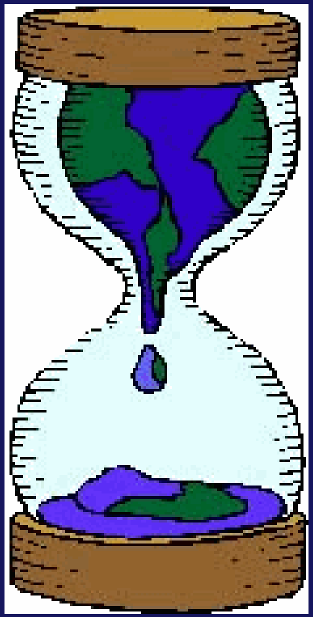
CONDUCTION = passage of thermal energy through a body **without large-scale movement** of matter within the body. Most effective in SOLIDS.

CONVECTION = passage of thermal energy through a fluid (liquid or gas) **by means of large-scale movements** of material within the fluid, as in a convection cell. Most effective in GASES & LIQUIDS.

RADIATION = the transfer of thermal energy by ***electromagnetic radiation*****.** The only one of the three mechanisms of heat transfer that does not require atoms or molecules to facilitate the transfer process, i.e., **does not even need MATTER as a medium to transfer energy!**

Got all that Homer?

A short
“Homer Simpson”
Break!



http://fp.arizona.edu/kkh/nats101gc/Heat-transfer.html

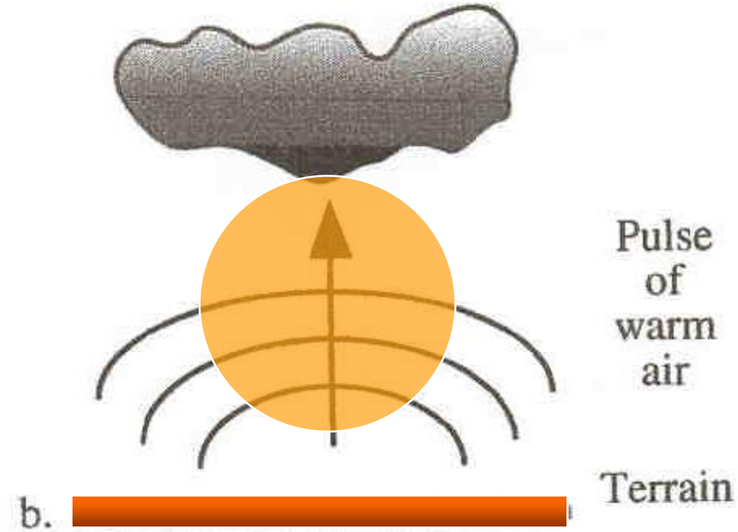
HEAT TRANSFER

CONVECTION

Mass of warm air or liquid heats, expands, rises

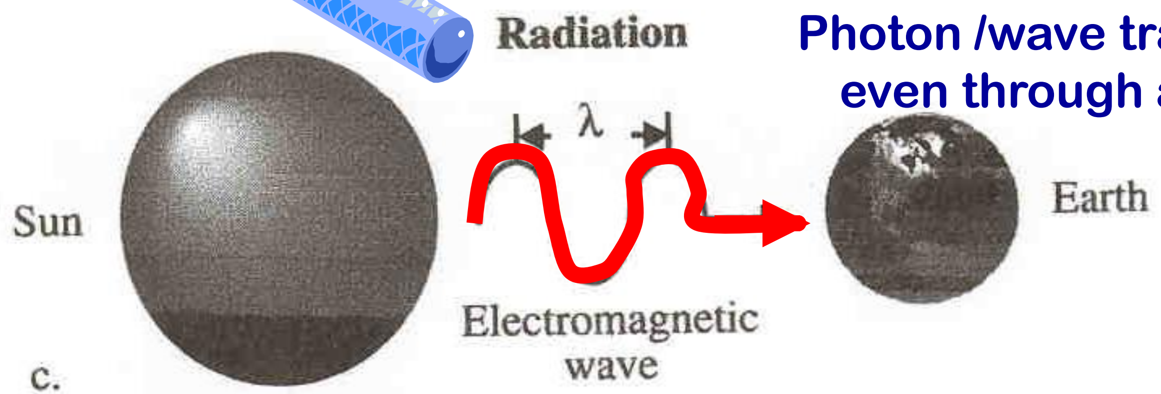
CONDUCTION

Jiggling molecule → jiggling molecule transfer of heat (kinetic energy at molecular scale)



RADIATION

Photon /wave transport: even through a void!



Electromagnetic Radiation
(a KEY POINT about it!)

Electromagnetic energy (radiation) is not heat energy.

It does not become heat (jiggling molecules) until it strikes an object, is absorbed by the object and sets the molecules in the object in motion, thereby heating up the object.

KEY CONCEPT:

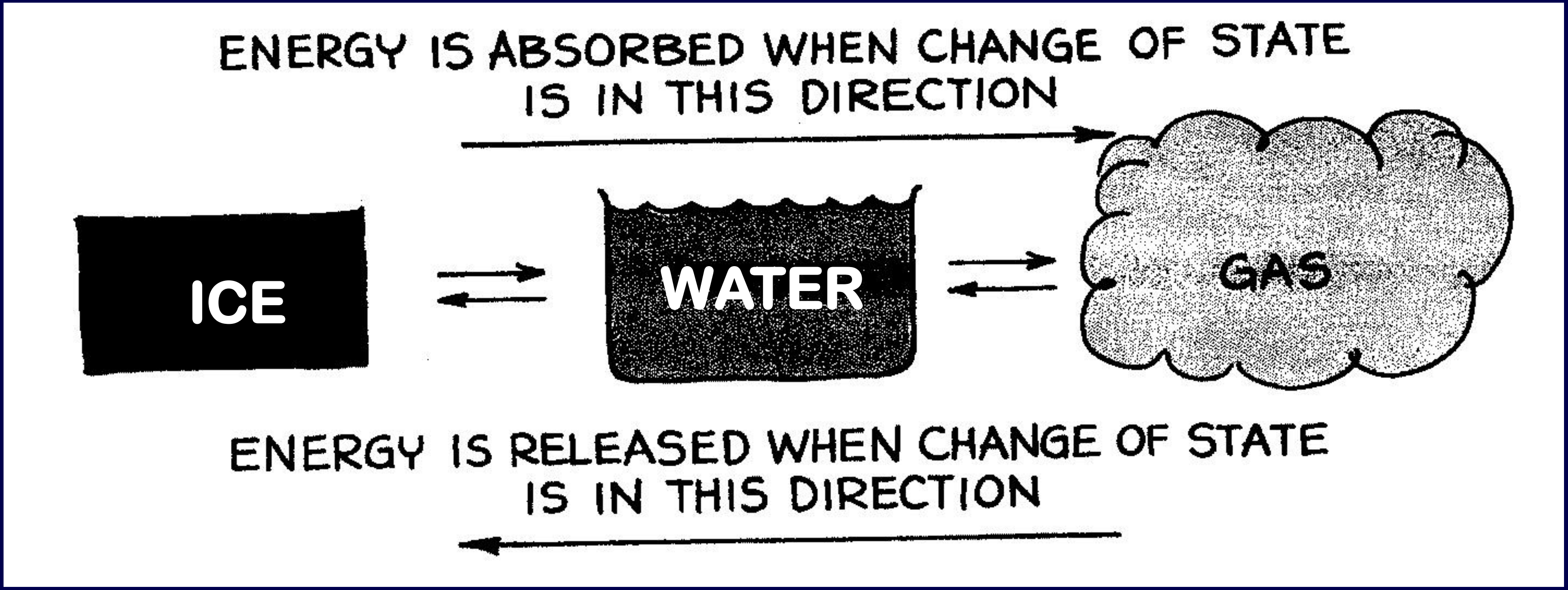
The sun's energy comes in as radiant (electromagnetic) energy, and is converted to measurable heat only after it is absorbed (e.g., by the surface of the earth, a gas in the atmosphere, etc.).

p 47

THERMAL ENERGY & PHASE CHANGES IN H_2O

Energy stored as LATENT ENERGY

(energy is "hidden" & not sensed) →



← Energy released as SENSIBLE HEAT

(i.e. the warmth can be "sensed")

Now back to p 46

SNOOZING?

How about some practice questions for TEST #2, Homer?

Q -The “**Goldilocks Problem**” refers to the question: “Why is Venus too hot, Mars too cold, and Earth’s temperature just right!” Your textbook explains that . . .

1. Earth's temperature is "just right" because Earth has a **greenhouse effect** and Venus and Mars do not.

2. Earth's temperature is "just right" due to: (a) **the inverse-square law** (the Earth being just the right distance from the Sun), (b) the **greenhouse effect,** and (c) **the Earth’s reflectivity** – all working together

3. Earth's temperature is "just right" because the Earth radiates like a black body and is just the right distance from the Sun – Mars is too close & Venus too far.

Q -The “**Goldilocks Problem**” refers to the question: “Why is Venus too hot, Mars too cold, and Earth’s temperature just right!” Your textbook explains that . . .

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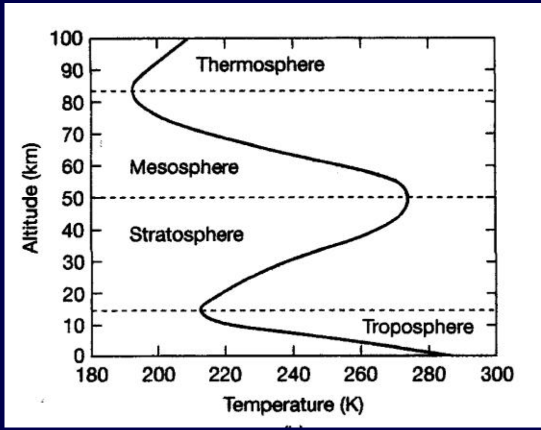
Q The atmospheric layer of **the troposphere** is important to global climate change because:



1. it is the layer that is heated up **primarily** by gases that can absorb high-energy **shortwave radiation** coming in directly from the Sun

2. it is the layer in which **temperature INCREASES with altitude** in the atmosphere

3. it is the layer with a high concentration of **ozone** that absorbs harmful **ultraviolet radiation**.

4. it is the layer in which most of the absorption by **greenhouse gases** occurs in the atmosphere

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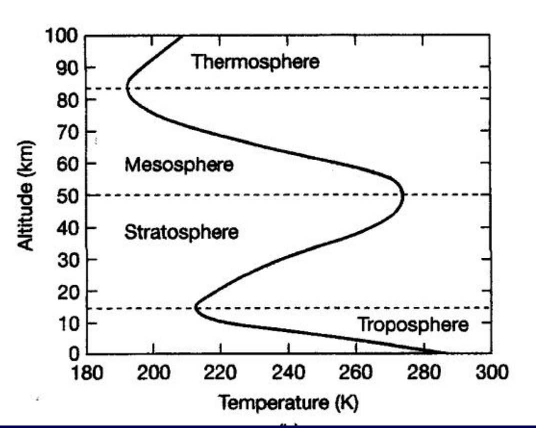

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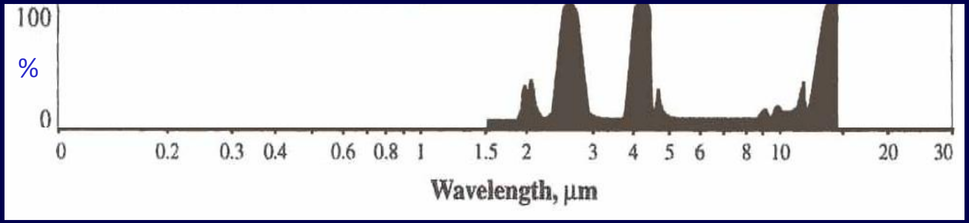
3. it is the layer with a high concentration of **ozone** that absorbs harmful **ultraviolet radiation**.

4. it is the layer in which most of the absorption by **greenhouse gases** occurs in the atmosphere

Q - Which of the following is a correct statement about this absorption curve:



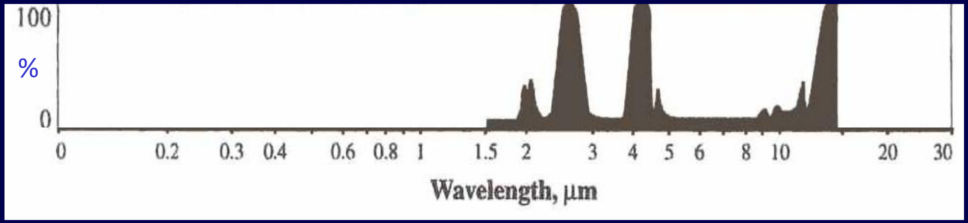
1. the curve represents absorption by a gas that can absorb both **visible light** and **infrared radiation**

2. the curve represent absorption by a gas that is likely to be a **Greenhouse Gas.**

3. the curve represents absorption by a gas that protects the Earth from **ultraviolet (UV) radiation**

4. the curve represents absorption by a gas that can absorb **ultraviolet, infrared,** & **visible** light wavelengths of radiation.

Q - Which of the following is a correct statement about this absorption curve:



1. the curve represents absorption by a gas that can absorb both **visible light** and **infrared radiation**

2. **t**he curve represent absorption by a gas that is likely to be a **Greenhouse Gas.**

3. **t**he curve represents absorption by a gas that protects the Earth from **ultraviolet (UV) radiation**

4. **t**he curve represents absorption by a gas that can absorb **ultraviolet, infrared,** & **visible** light wavelengths of radiation.

Study hard for TEST #2 Homer!