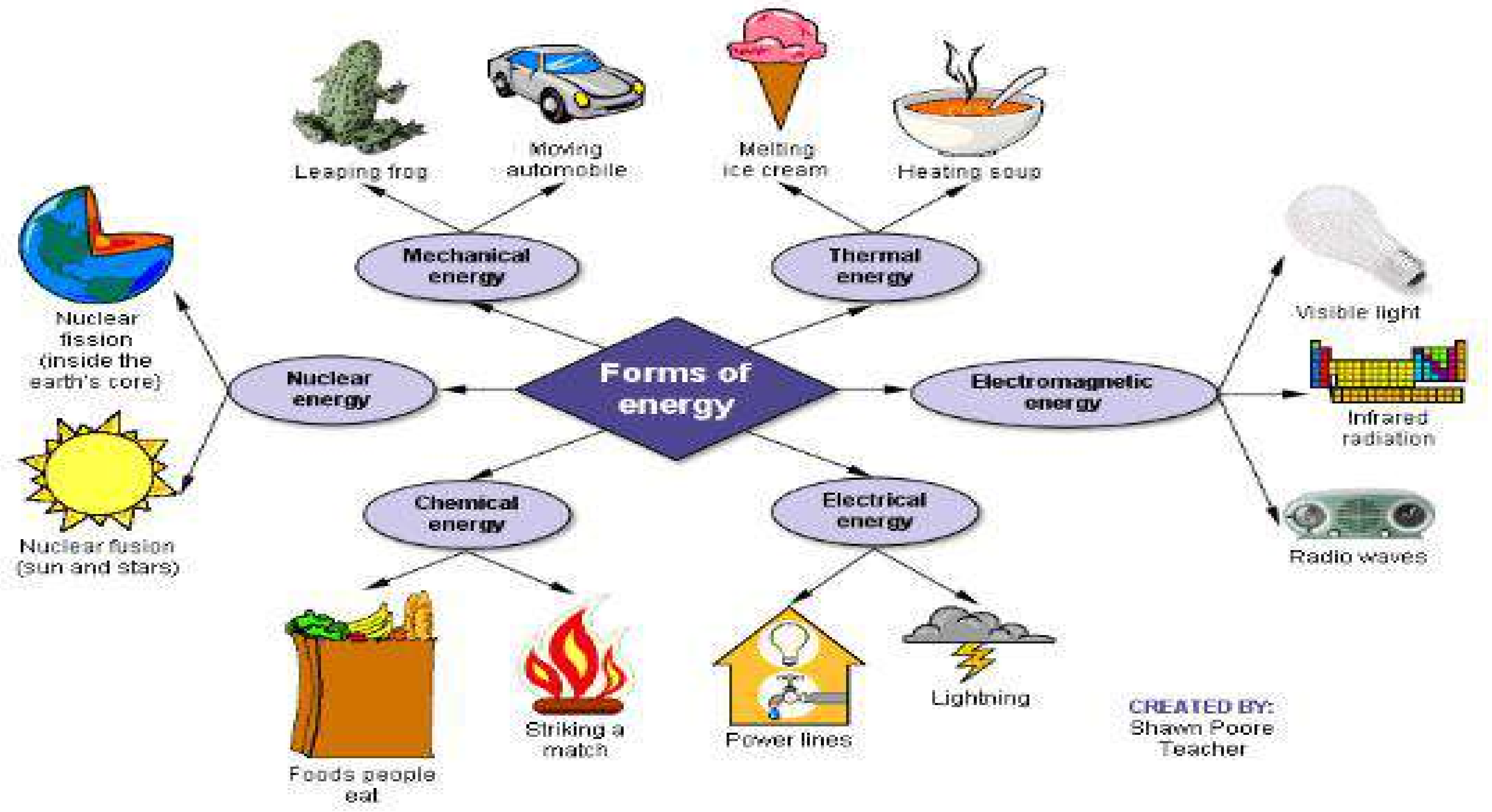
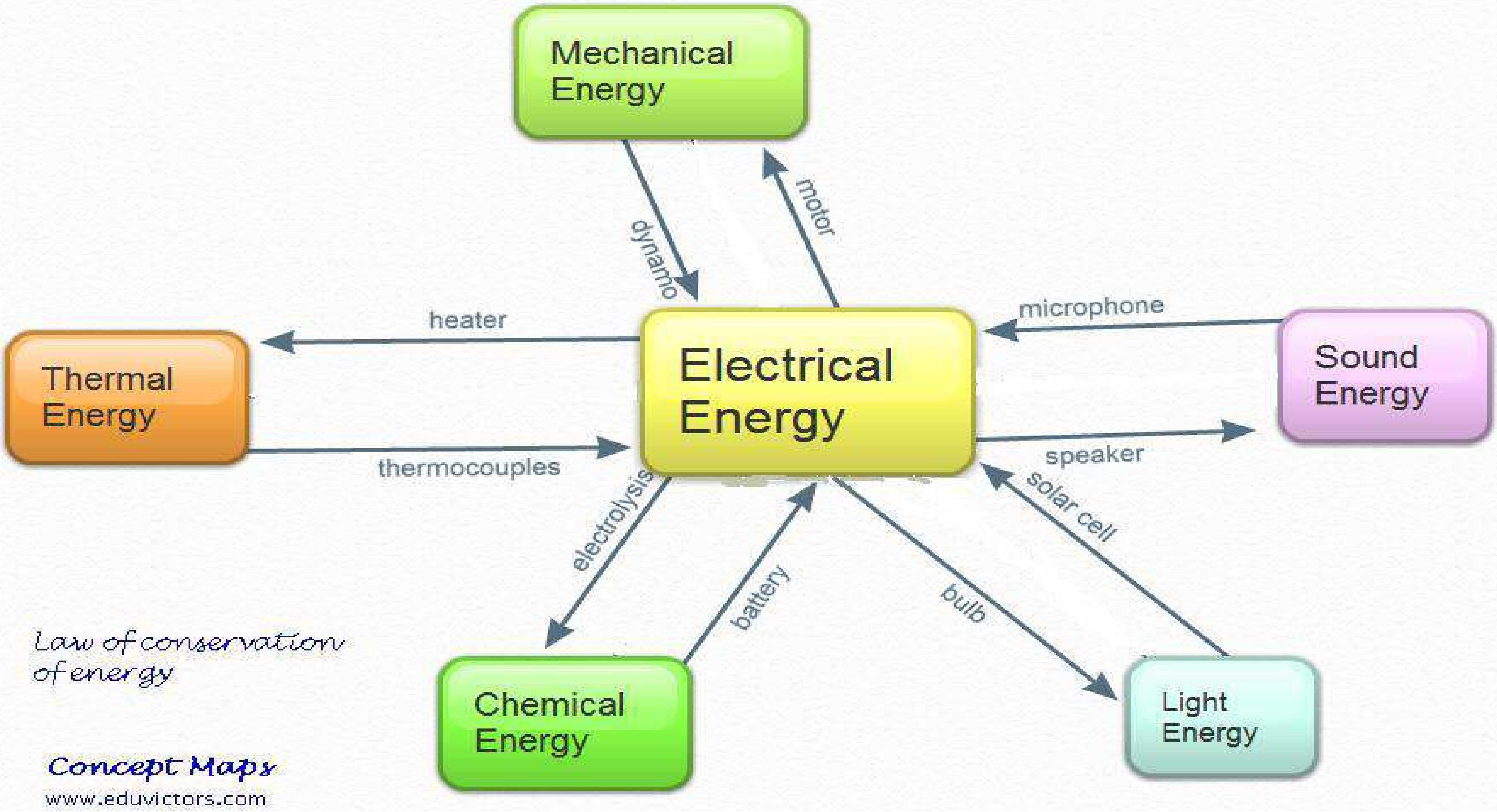
Thermochemistry

A. Energy, Heat and Temperature

1. What's the difference?

a. Energy – The ability to do work or supply heat. It uses the units of calorie (cal) or joule (J). Energy is governed by the Law of Conservation of Energy which says that energy is neither created nor destroyed. It is merely converted from one form to another.


Forms of energy
Mechanical energy
Leaping frog
Moving automobile
Thermal energy
Melting ice cream
Heating soup
Nuclear energy
Nuclear fission (inside the earth's core)
Nuclear fusion (sun and stars)
Electromagnetic energy
Visible light
Infrared radiation
Radio waves
Chemical energy
Foods people eat
Striking a match
Electrical energy
Power lines
Lightning
CREATED BY:
Shawn Poore
Teacher


Mechanical Energy
dynamo
motor
Thermal Energy
heater
thermocouples
Electrical Energy
microphone
Sound Energy
speaker
solar cell
electrolysis
battery
bulb
Chemical Energy
Light Energy
Law of conservation of energy
Concept Maps
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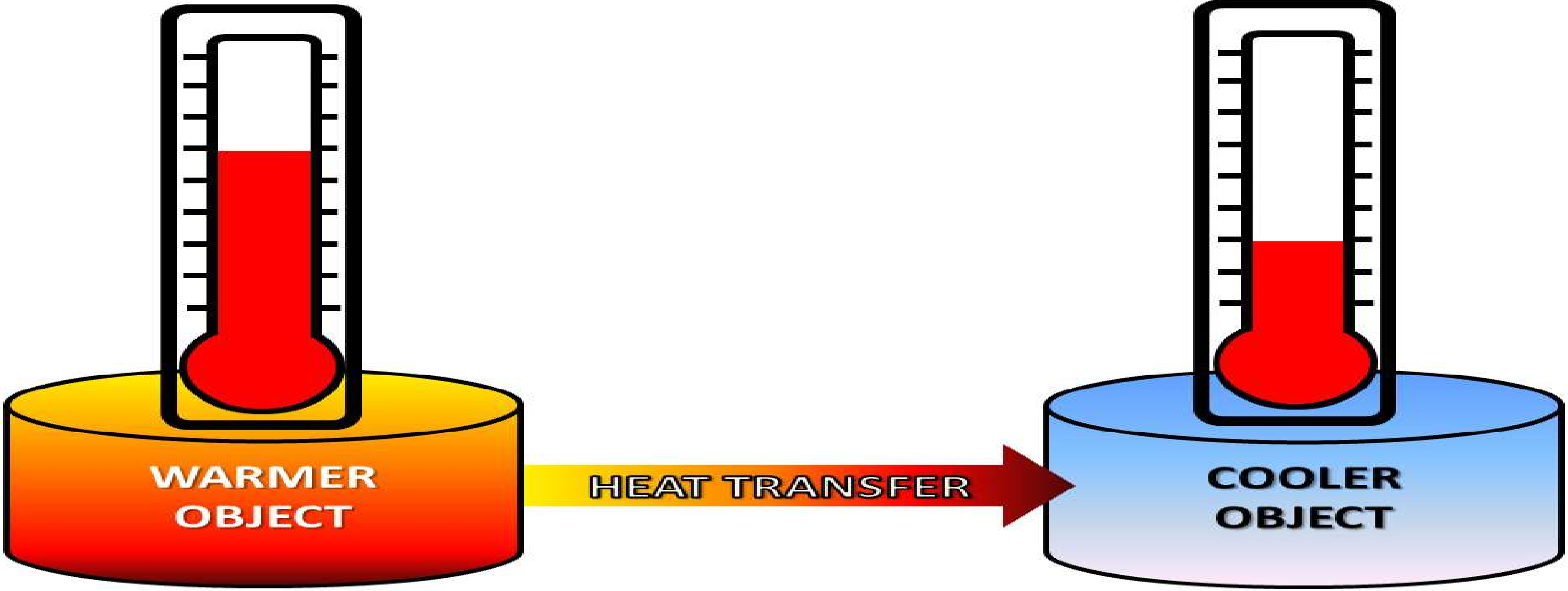


b. Heat (q) is a form of energy that flows from high concentrations to low concentrations. It also uses the units of calorie (cal) or joule (J).

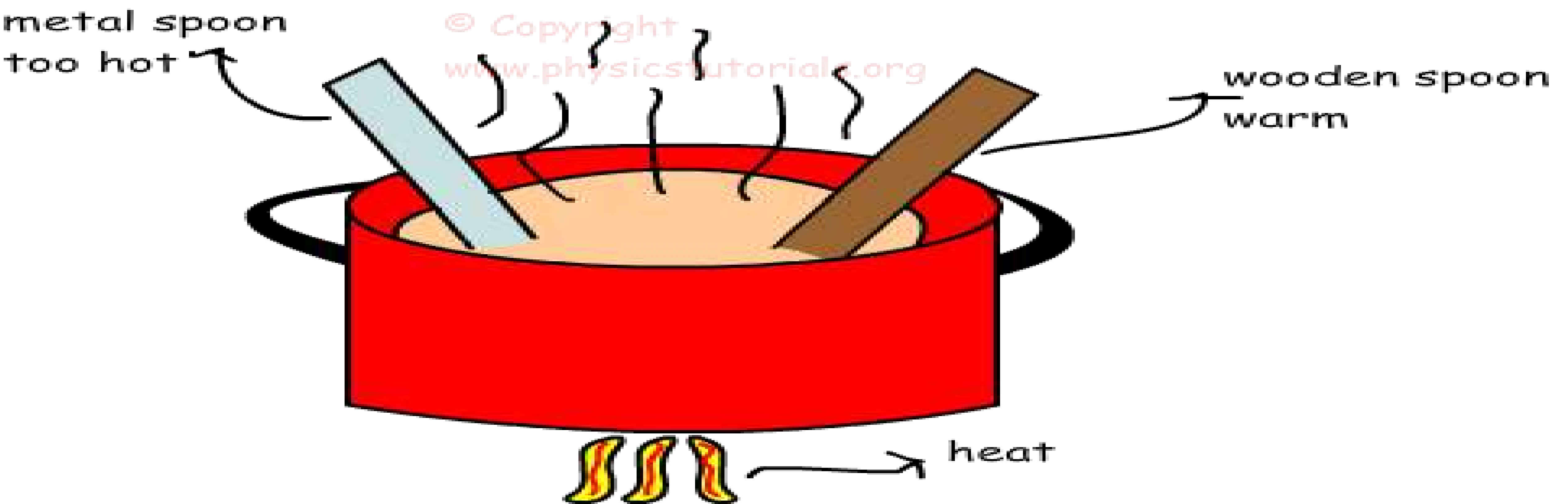
c. Temperature is the measurement of the kinetic energy (KE) inside of matter. It uses the units of °C or K.

(1) Higher temperature = more KE. **KE** is atomic motion. More motion = more KE. A higher temperature means that the atoms inside the matter are moving faster than they would be at a cooler temperature.

B. Thermochemistry - The study of the heat changes that occur during chemical reactions and changes of state.

1. Heat capacity versus specific heat capacity

   a. Heat capacity – the amount of heat needed to change the temperature of an object by 1°C. Heat capacity depends of such factors as mass, chemical composition, color …



(1) Which would have a higher heat capacity– 10 grams of water or 100 grams of water?

(2) Which would have a higher heat capacity– an acre of green grass or an acre of black cement?

b. Specific heat capacity (C) – the amount of heat needed to change the temperature of 1.00 grams of an object by 1°C.

(1) Formula

$q = mC\Delta t$

C = specific heat in cal/g°C or J/g°C

q = heat in joules or calories

m = mass in grams

Δt = change in temperature (°C)

Specific Heats of Selected Materials	
Material	**C (J/kg·K)**
Aluminum	897
Concrete	850
Diamond	509
Glass	840
Helium	5193
Water	4181

(1) Which would have a higher specific heat – 10 grams of water or 100 grams of water?

(2) Which would have a higher specific heat – a lawn of green grass or a lawn of black cement?

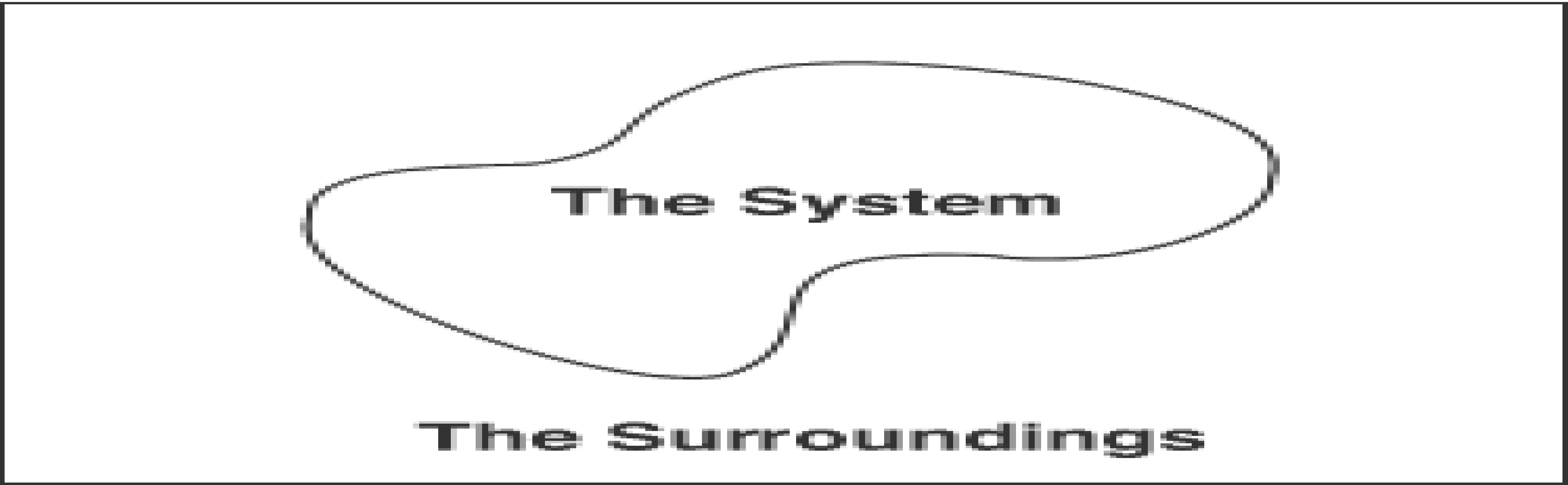
2. Calorimetry – The precise measurement of the heat change from any process.

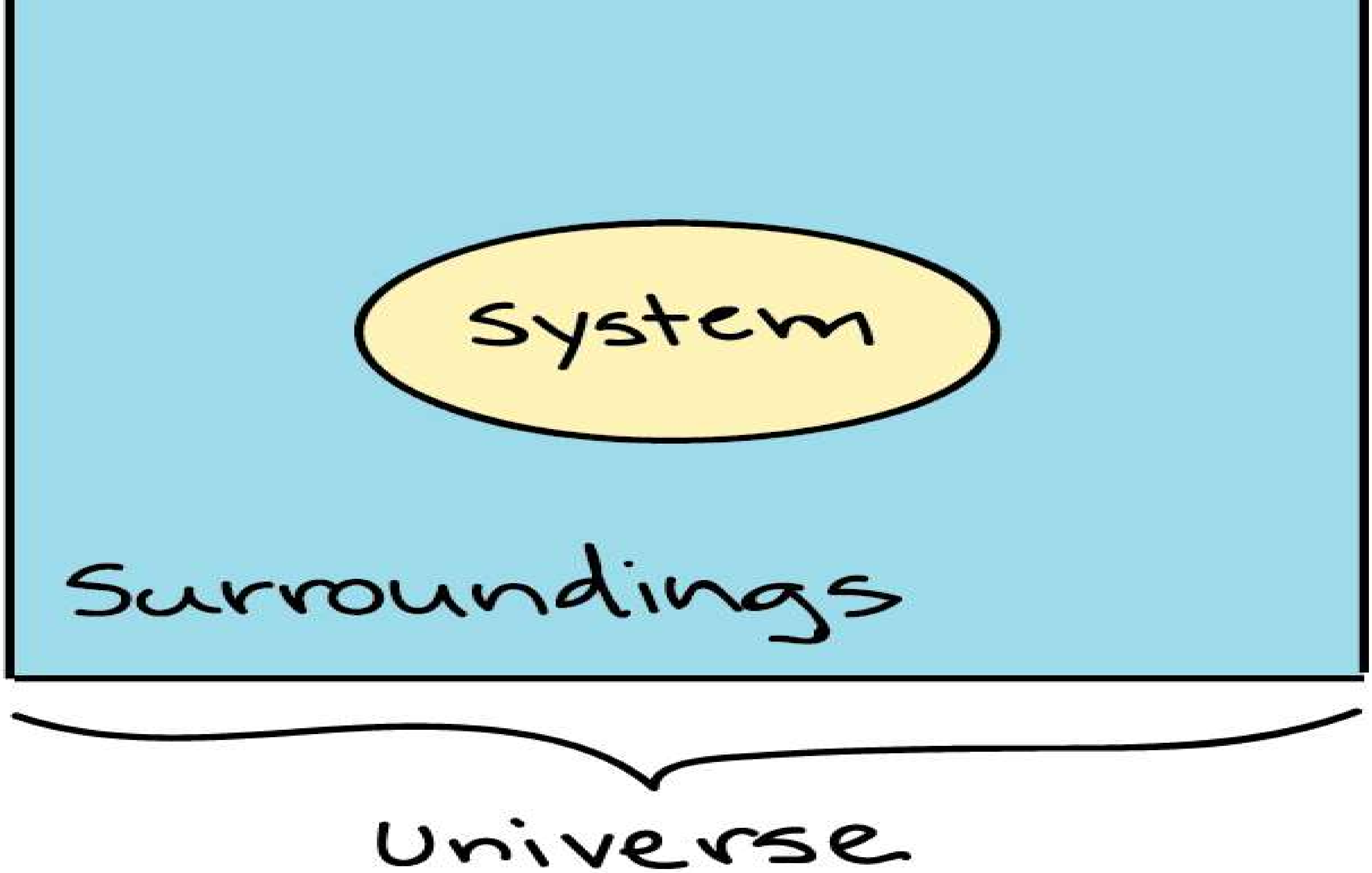
a. To understand calorimetry, you must understand how heat moves.

b. When considering heat, there exists a system and the surroundings.

(1) The system is a specific part of the universe like a cup, a room or a beaker.

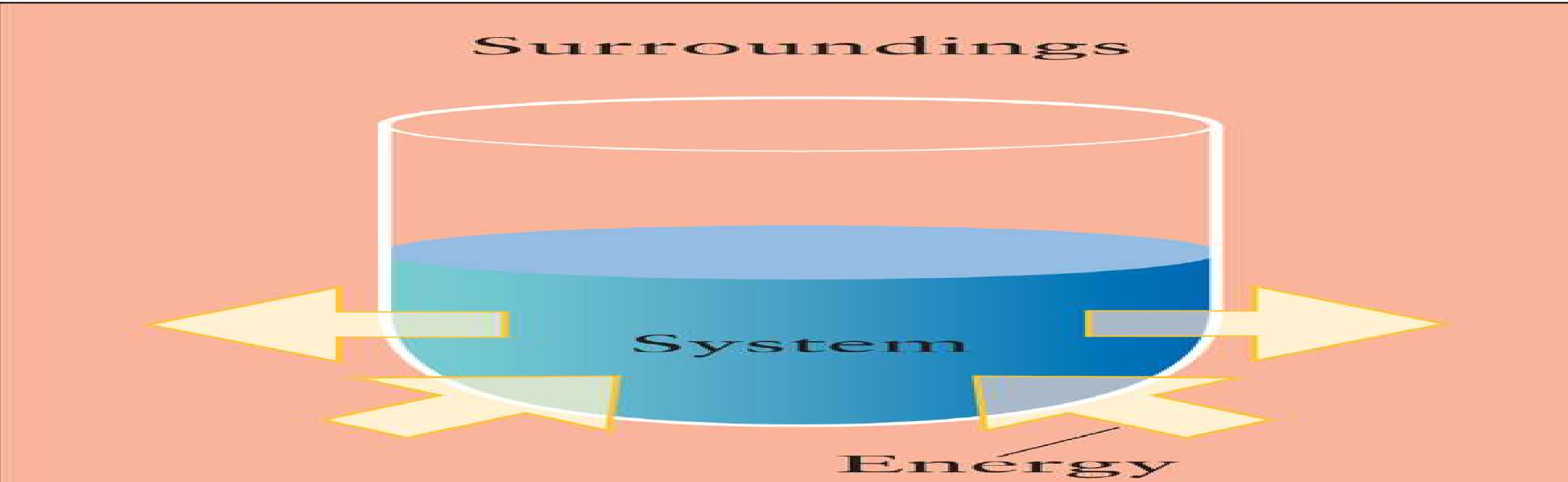
(2) The surroundings are *everything* outside the system, touching the system.

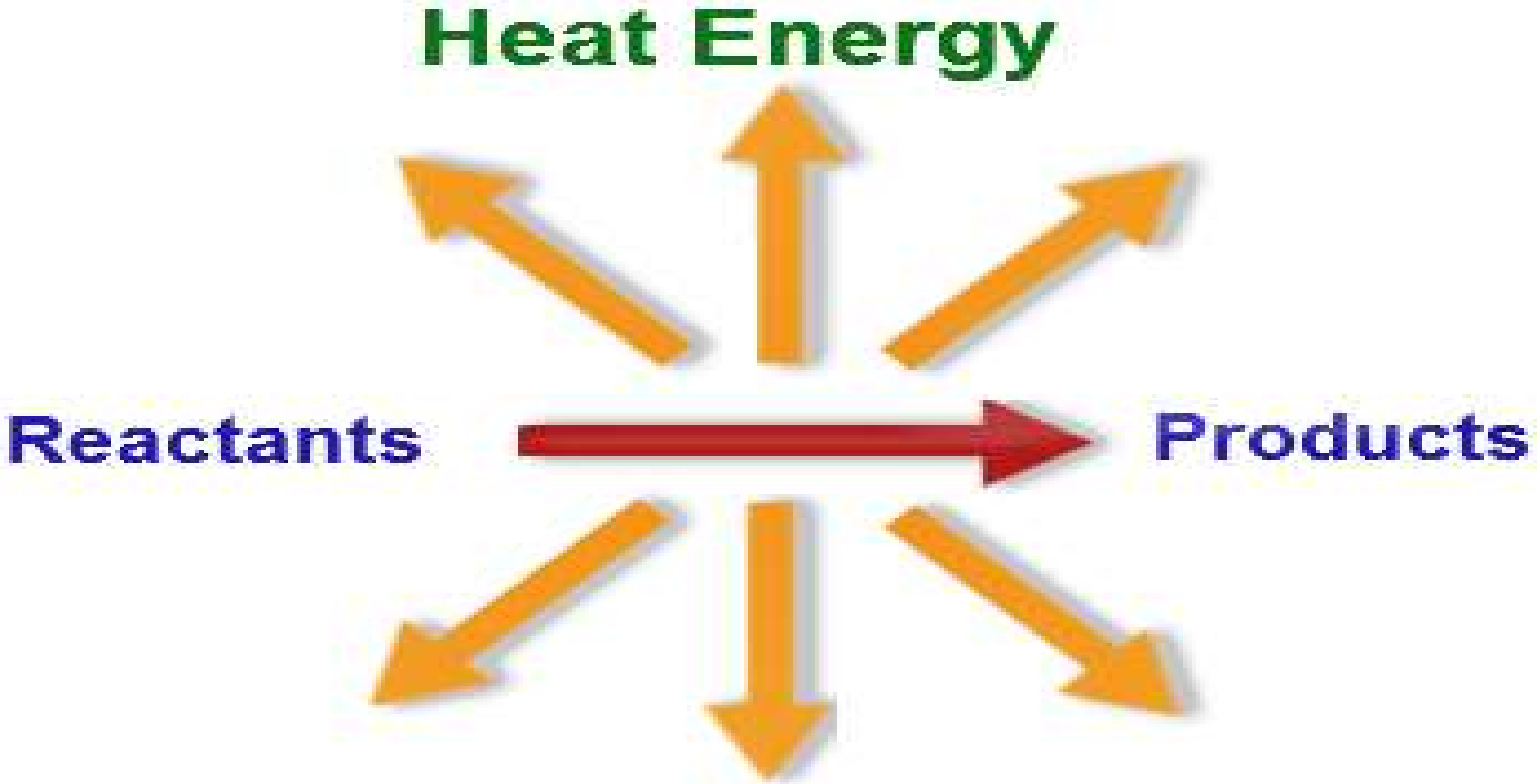


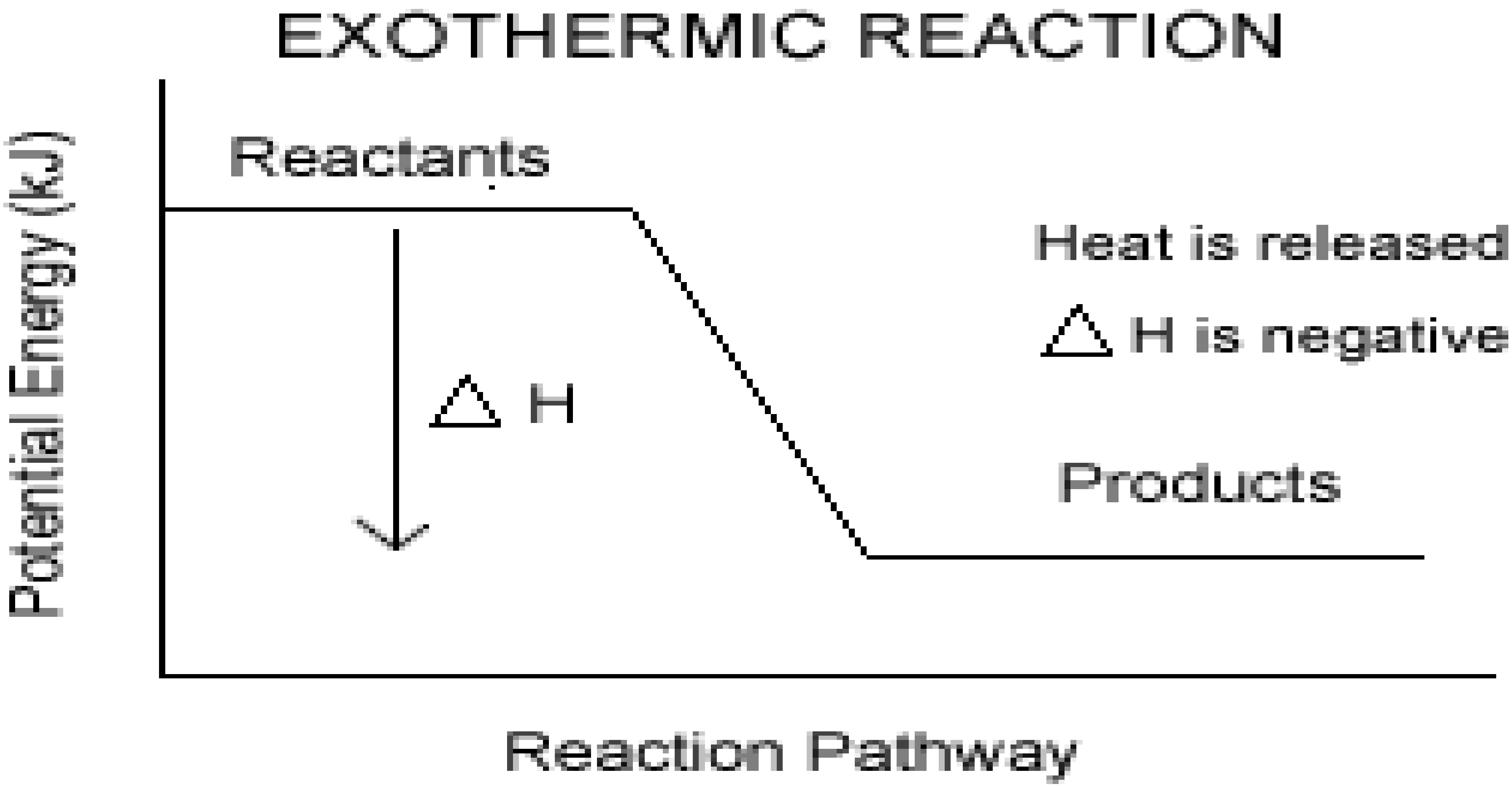

System
Surroundings
Universe

a. When heat moves, it can move from system to surroundings or surroundings to system.

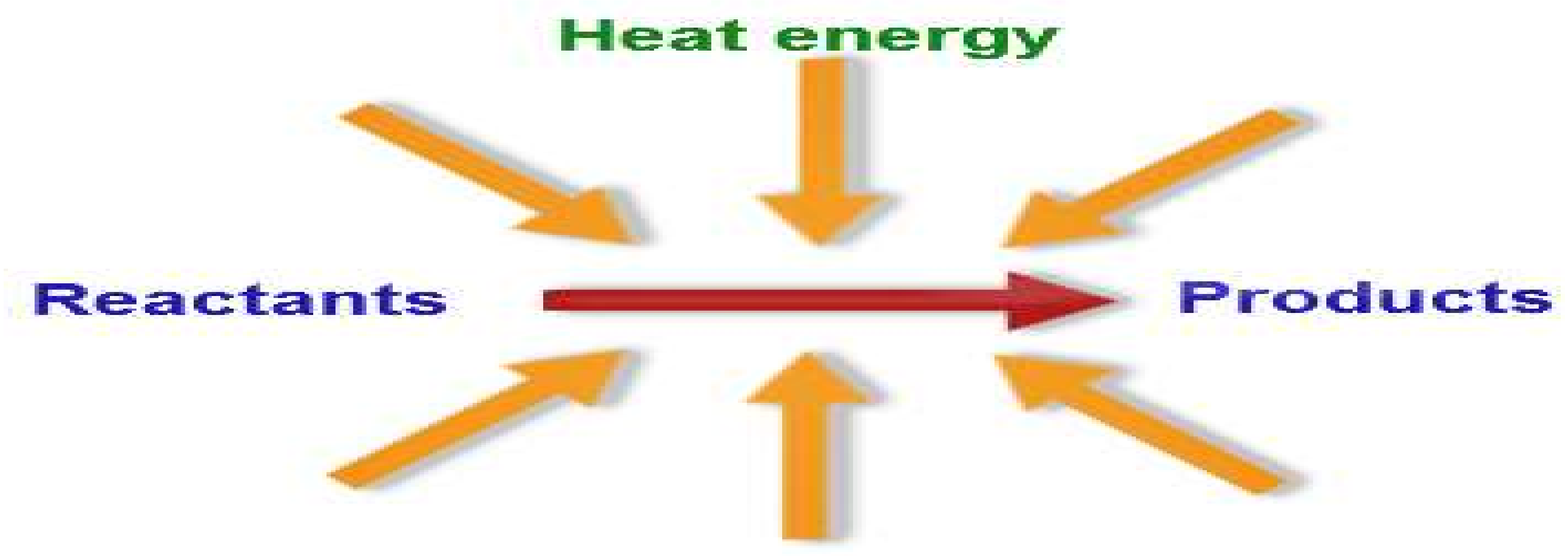
(1) A reaction type in which heat flows out of the system into the surroundings creates a negative heat change for the system (b/c heat flows out) and a positive change for the surroundings (b/c heat flows into). This type of reaction is called exothermic and would feel hot b/c heat is a product. A + B → AB + heat

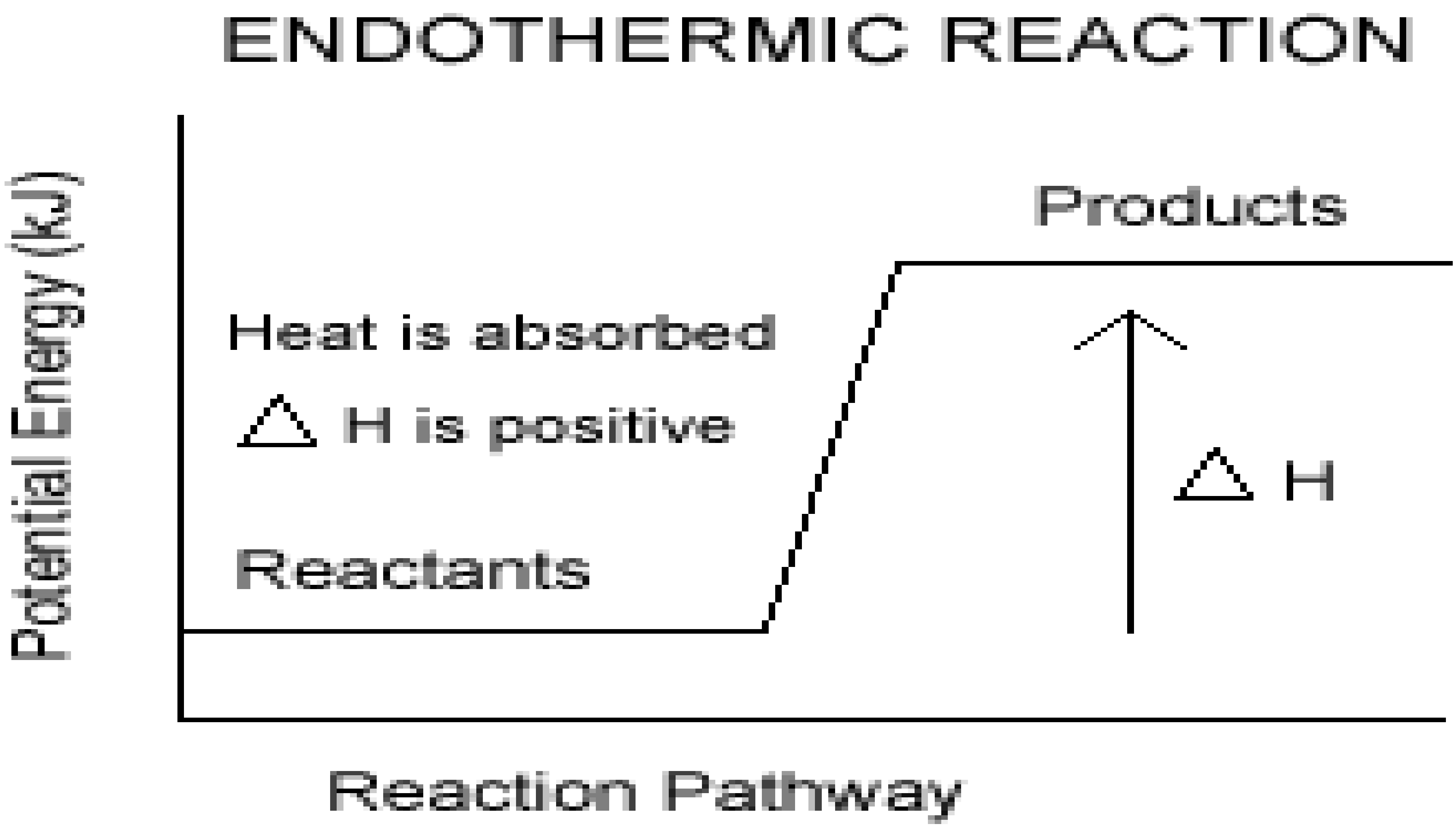



Heat Energy
Reactants
Products


EXOTHERMIC REACTION
Reactants
Heat is released
△ H is negative
△ H
Products
Potential Energy (kJ)
Reaction Pathway

(2) A reaction type in which heat flows into the system from the surroundings creates a negative heat change for the surroundings (b/c heat flows out) and a positive change for the system (b/c heat flows into). This type of reaction is called **endothermic** and would feel cold b/c heat is a reactant. A + B + heat → AB




ENDOTHERMIC REACTION
Potential Energy (kJ)
Products
Heat is absorbed
△ H is positive
△ H
Reactants
Reaction Pathway

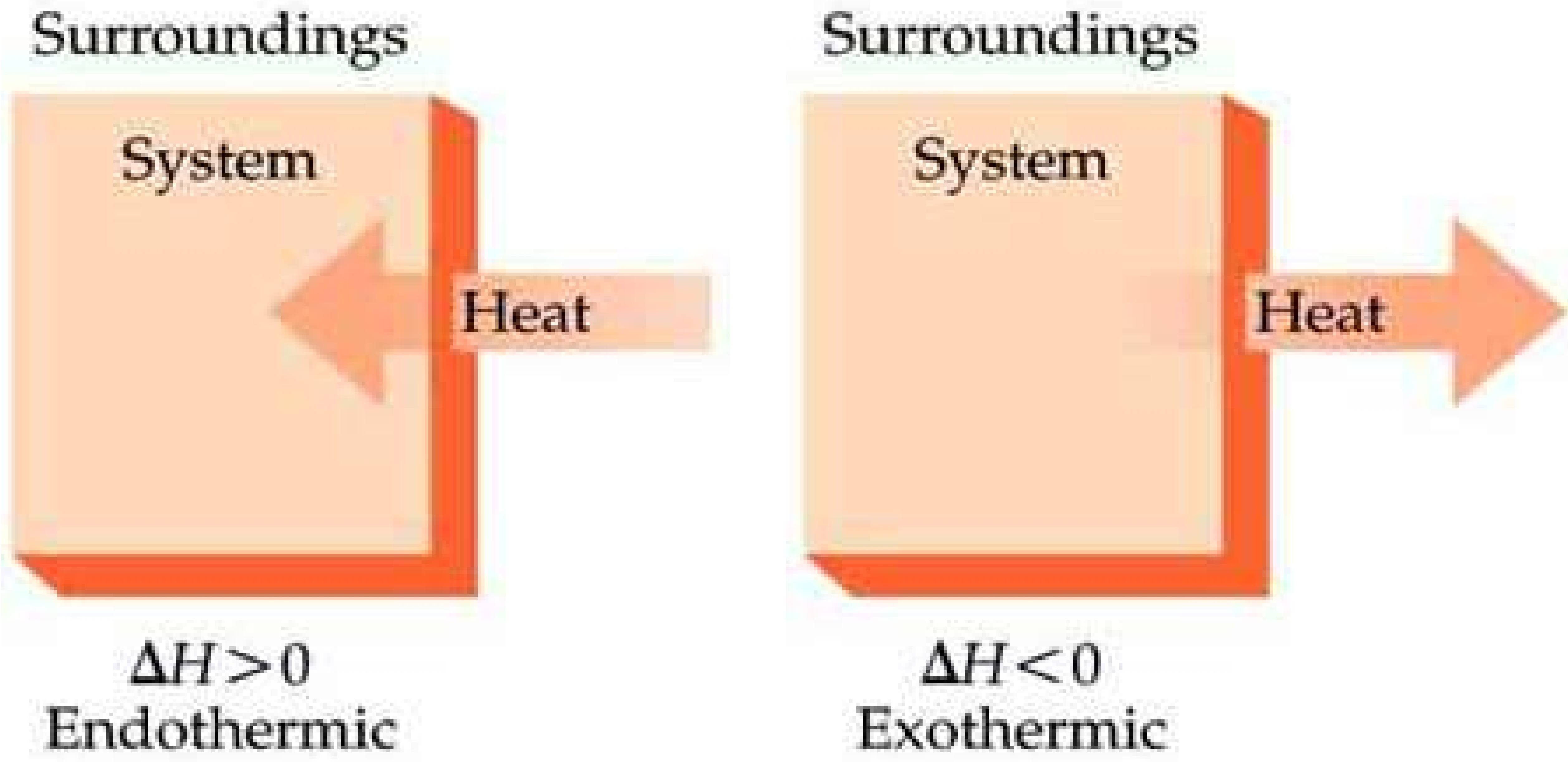
a. Heat can move into/out of the system or surroundings due to chemical reactions.

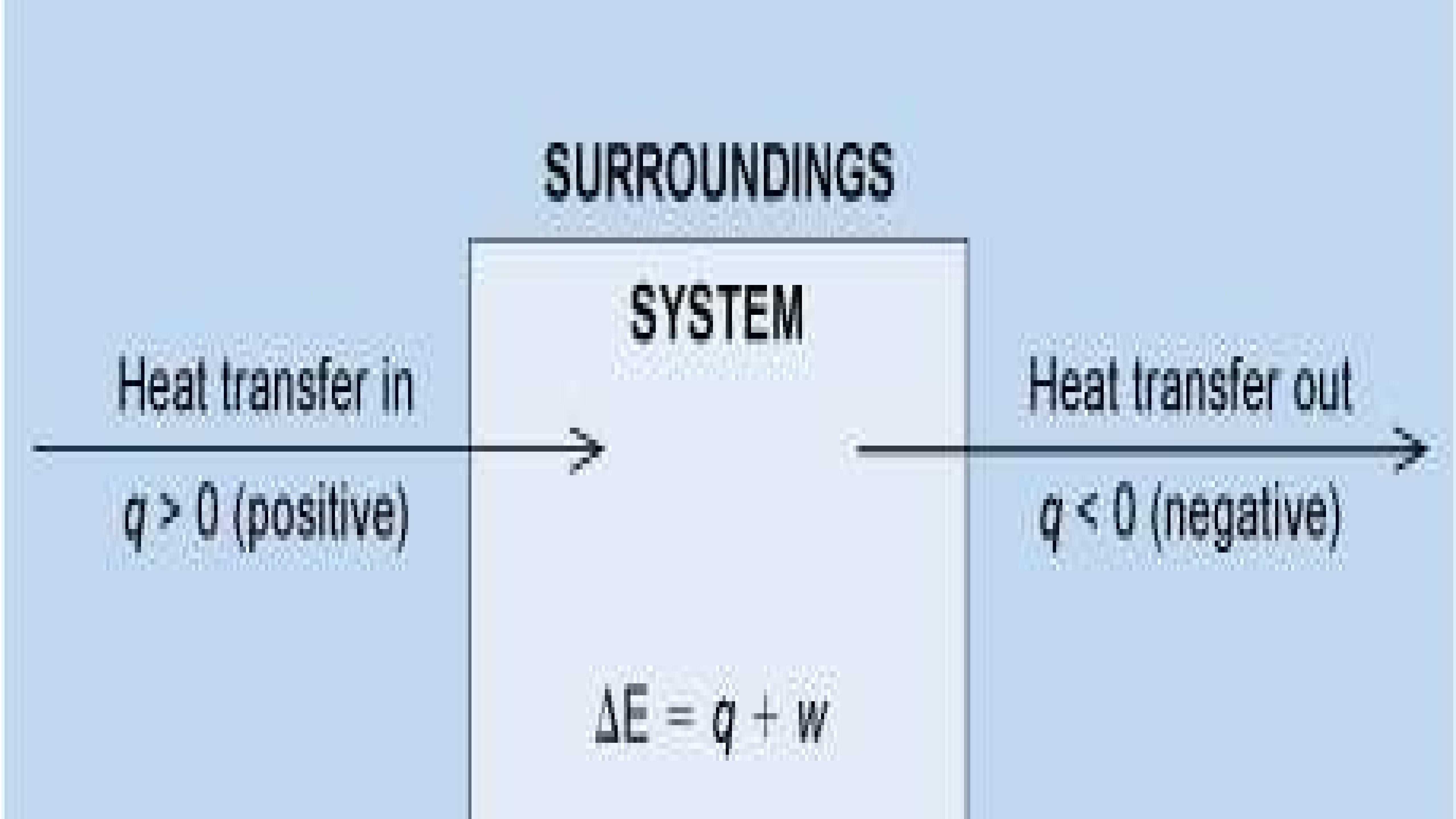
(1) Enthalpy (H) is the heat content of the system which would be the chemical reaction.

(a) ΔH means change in heat and is calculated using the formula below

$$\Delta H = H_{products} - H_{reactants}$$

(2) Exothermic reactions would have a (–) ΔH, while endothermic reactions would have a (+) ΔH. Why?

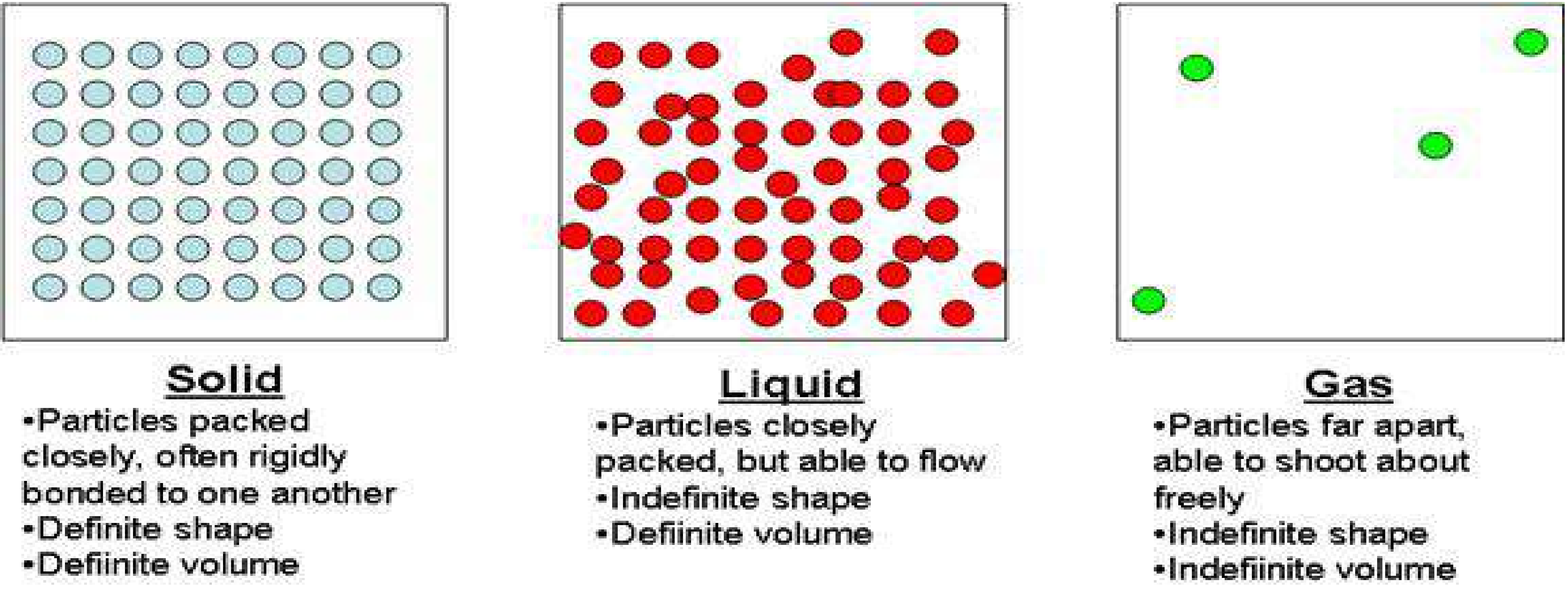

Surroundings
System
Heat
$\Delta H > 0$
Endothermic
Surroundings
System
Heat
$\Delta H < 0$
Exothermic



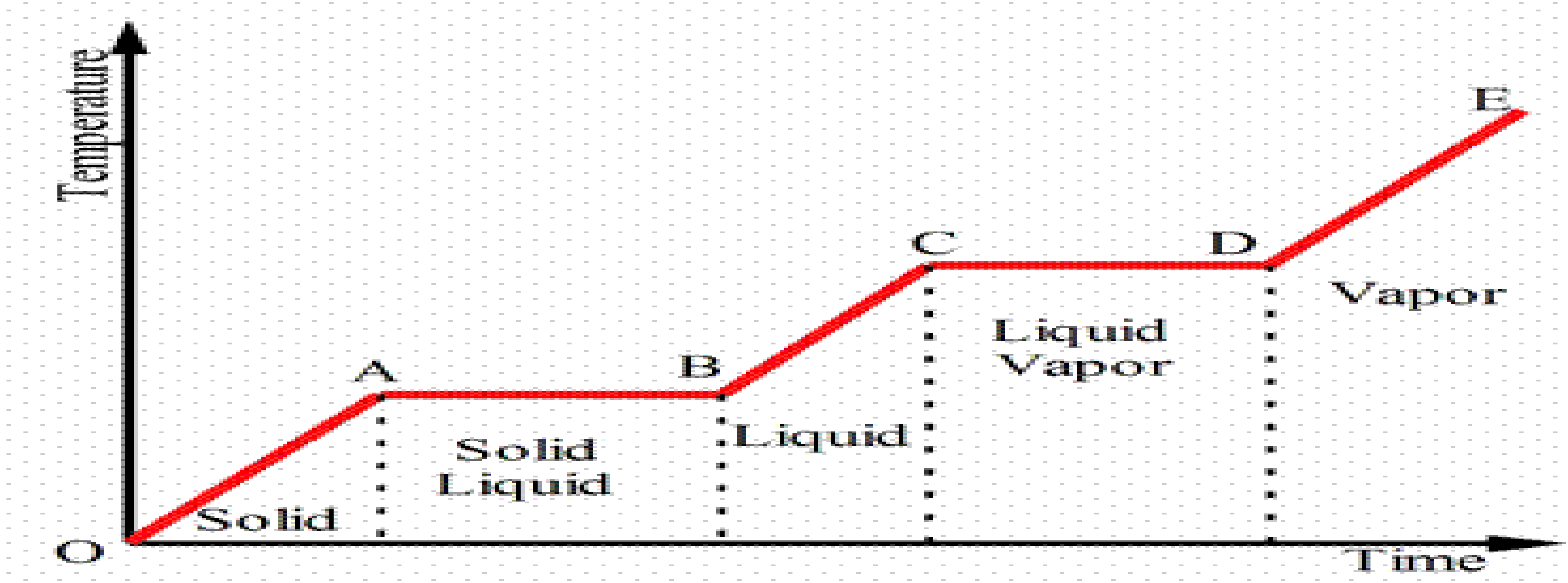
SURROUNDINGS
SYSTEM
Heat transfer in
q > 0 (positive)
Heat transfer out
q < 0 (negative)
ΔE = q + w

3. Phase changes

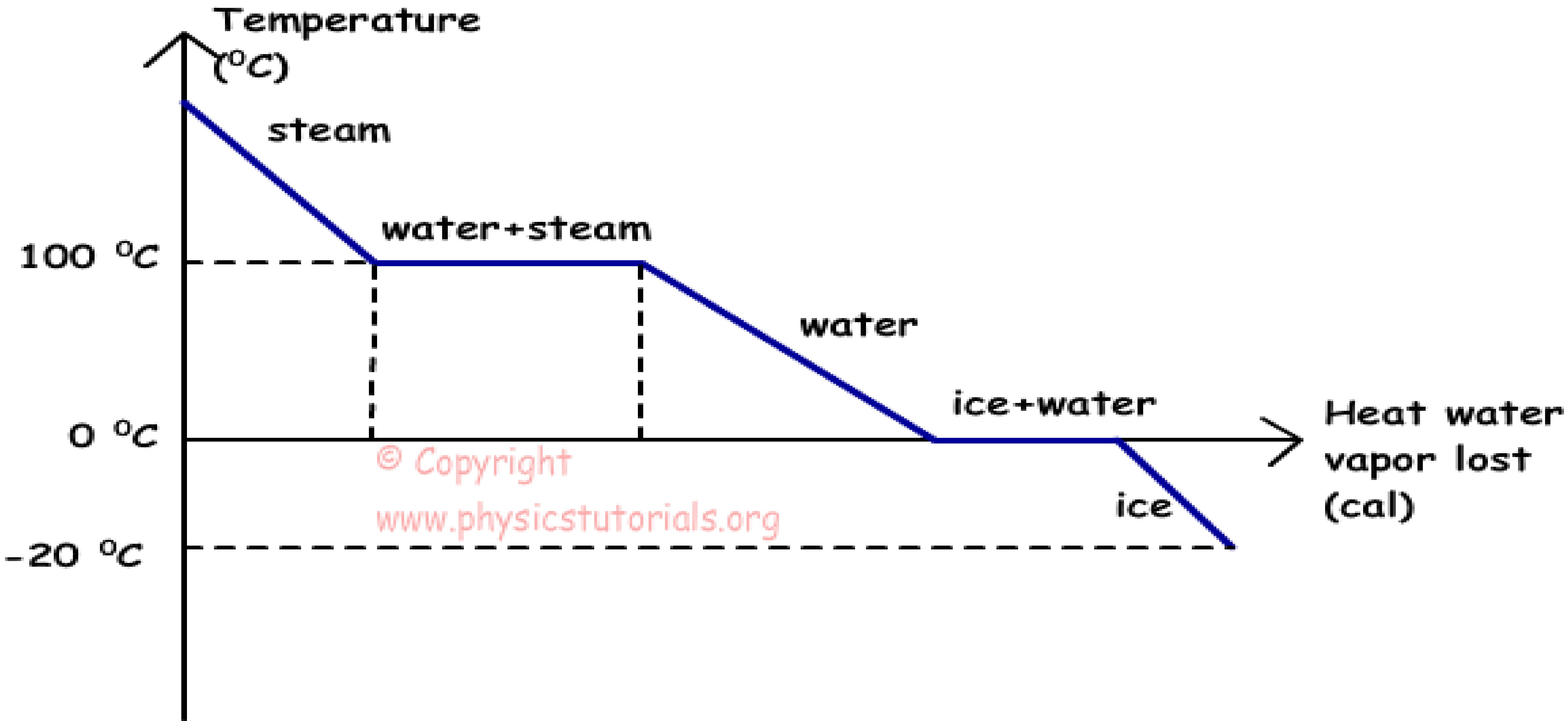
a. The phase of a particular piece of matter is the form that it is currently in. Examples are solid, liquid or gas. A phase change is when the form becomes different. Examples include melting or condensation.



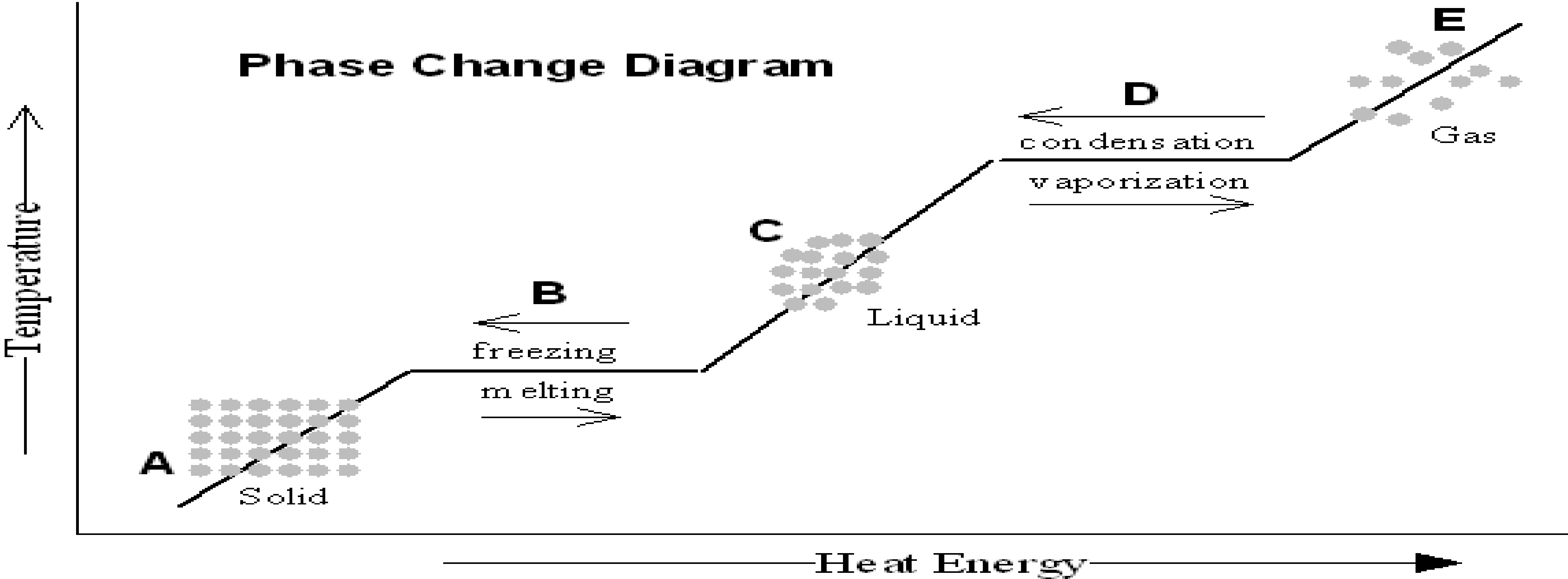
b. The picture below shows a generic heating curve. If this was for water, A → B would occur at 0°C and C→ D would occur at 100°C. You can see that the phase changes occur at the plateaus. For example, you can see that between A → B, the solid and liquid phases occur at the same time during the change over from solid to liquid.



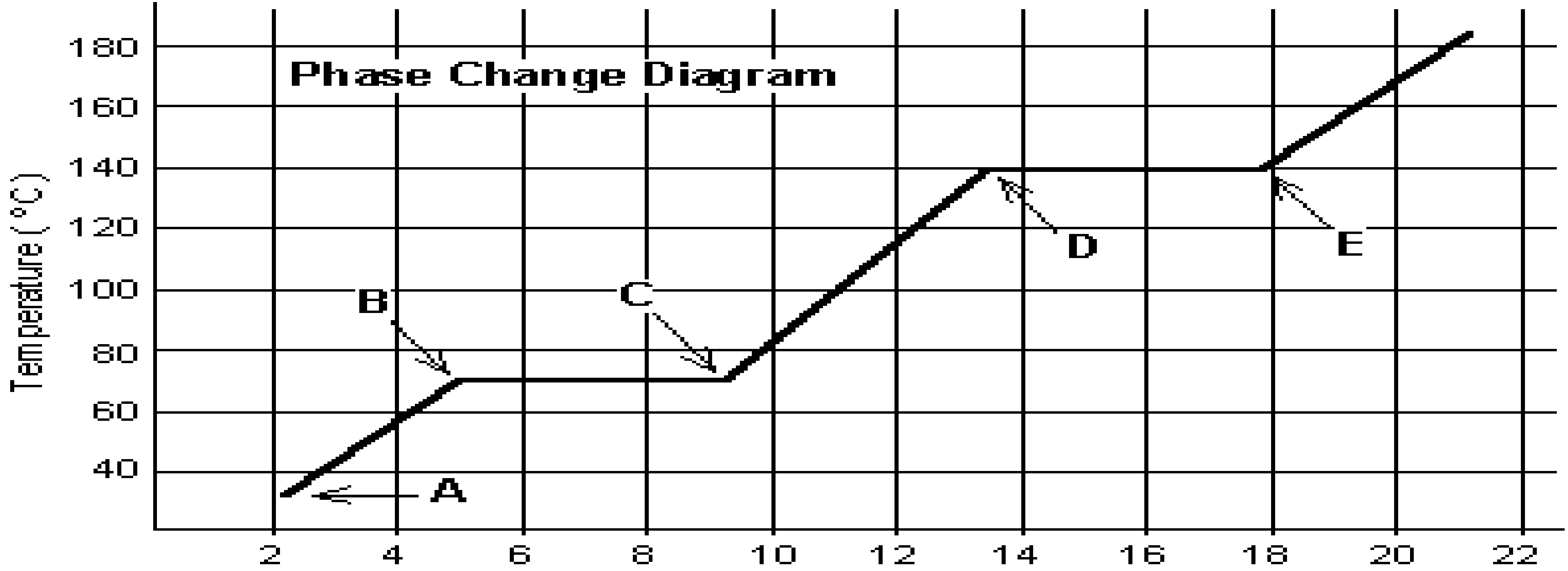
c. The following curve is a cooling curve. Notice that the plateaus occur at the same spots (0°C and 100°C) in the heating and cooling diagrams.



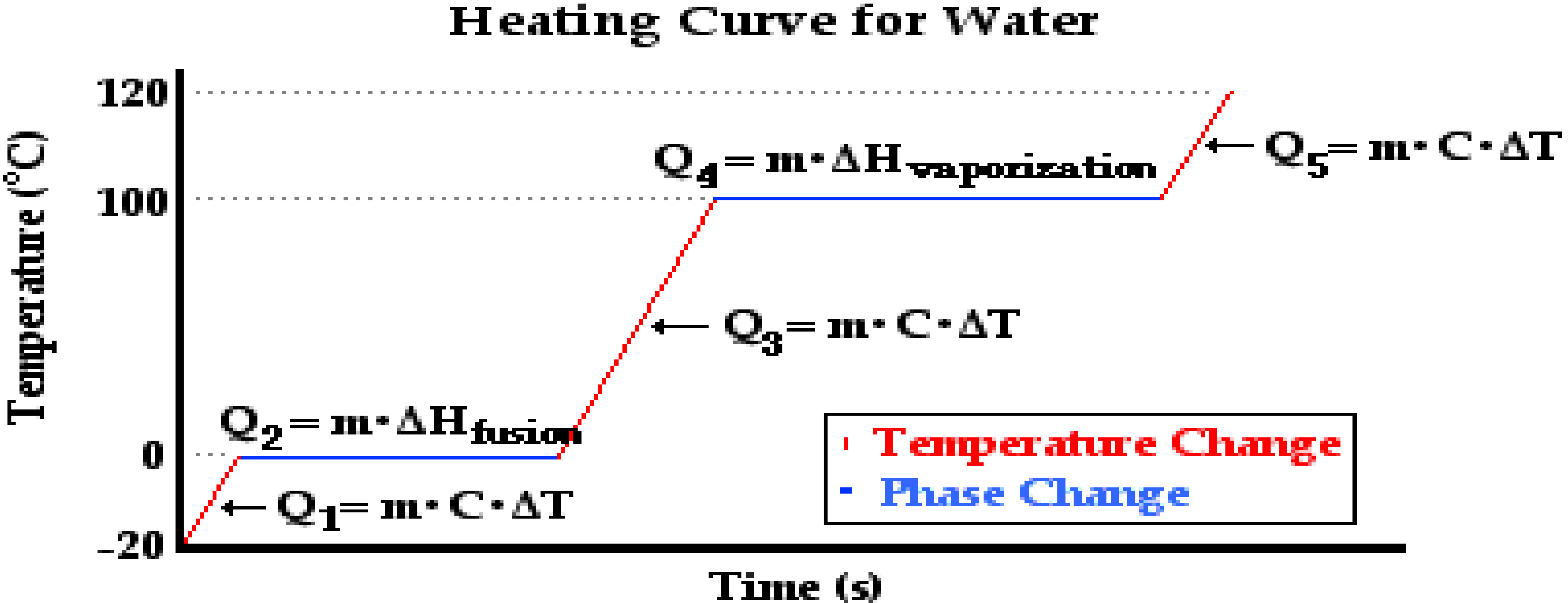
d. The following heating curve shows the spacing, the potential energy (PE) of the atoms during the phases and the changes. It also names the phase changes. For example, solid to liquid is called melting, but liquid to solid is called freezing. Energy is lost when a material condenses or freezes (cooling) and is gained when a material melts or vaporizes (heats).



e. The following diagram can be used to show the temperature points. Point B is called the melting point since that is the point in the process at which the solid is warm / ↑ KE / fast enough to melt. Point D is called the boiling point since that is the point in the process at which the liquid is warm / ↑ KE / fast enough to vaporize. If you reverse the direction of the curve to make it a cooling curve, point E is called the condensation point b/c that is the point in the process at which the gas is cool / ↓ KE / slow enough to condense. Point C is called the freezing point b/c that is the point in the process at which the liquid is cool / ↓ KE / slow enough to freeze.



f. This last diagram shows the heat changes referencing values for water. To calculate Q_1, you would use 0.48 cal/g°C or you could use 2.03 J/g°C for the value of C. You choose your value of specific heat depending on what your heat unit is in. The heat of fusion for Q_2 is 80 cal/g or 334 J/g. To calculate Q_3, you would use 1.0 cal/g°C or 4.186 J/g°C for the value of C. The heat of vaporization for Q_4 is 540 cal/g or 2257 J/g. To calculate Q_5, you would use 0.48 cal/g°C or 2.03 J/g°C for the value of C.

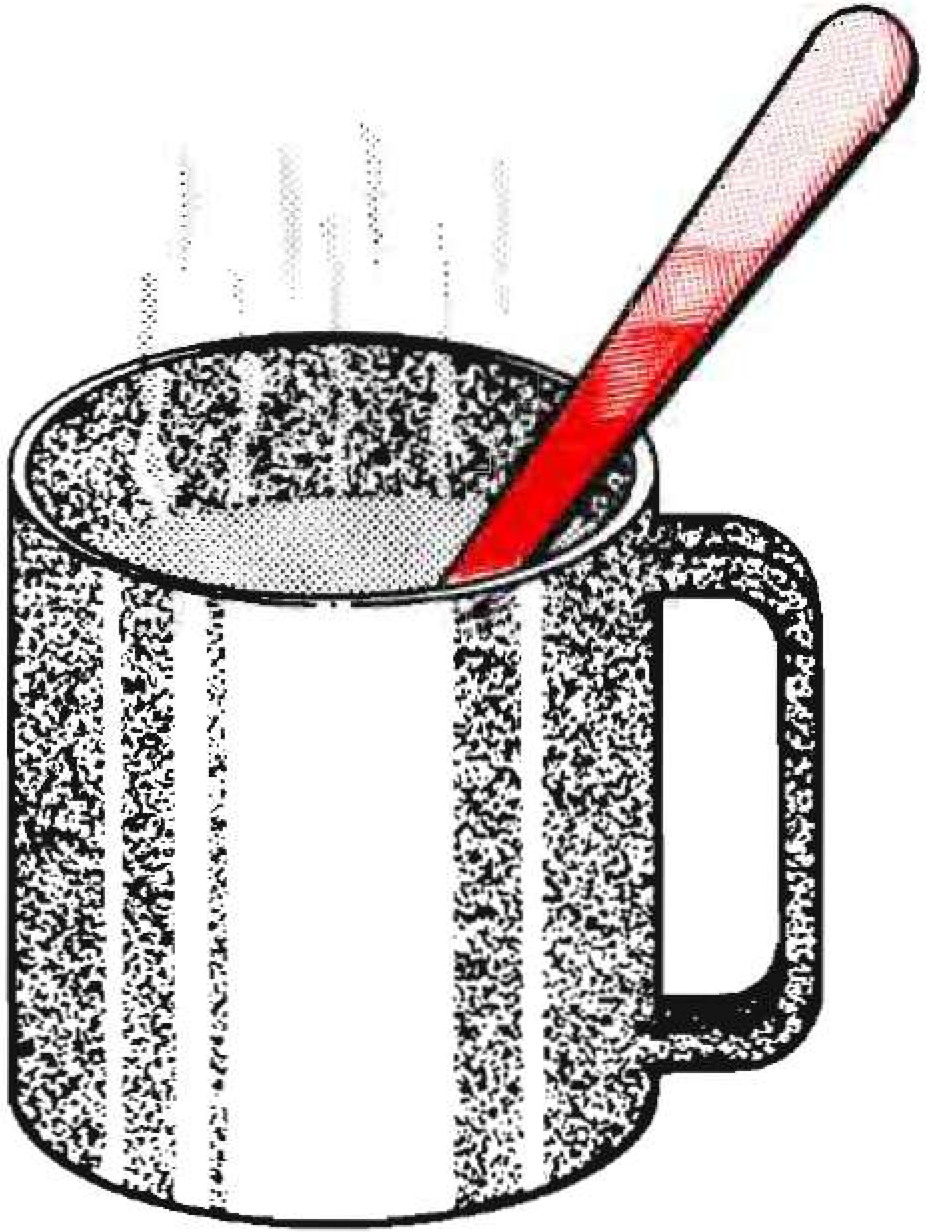


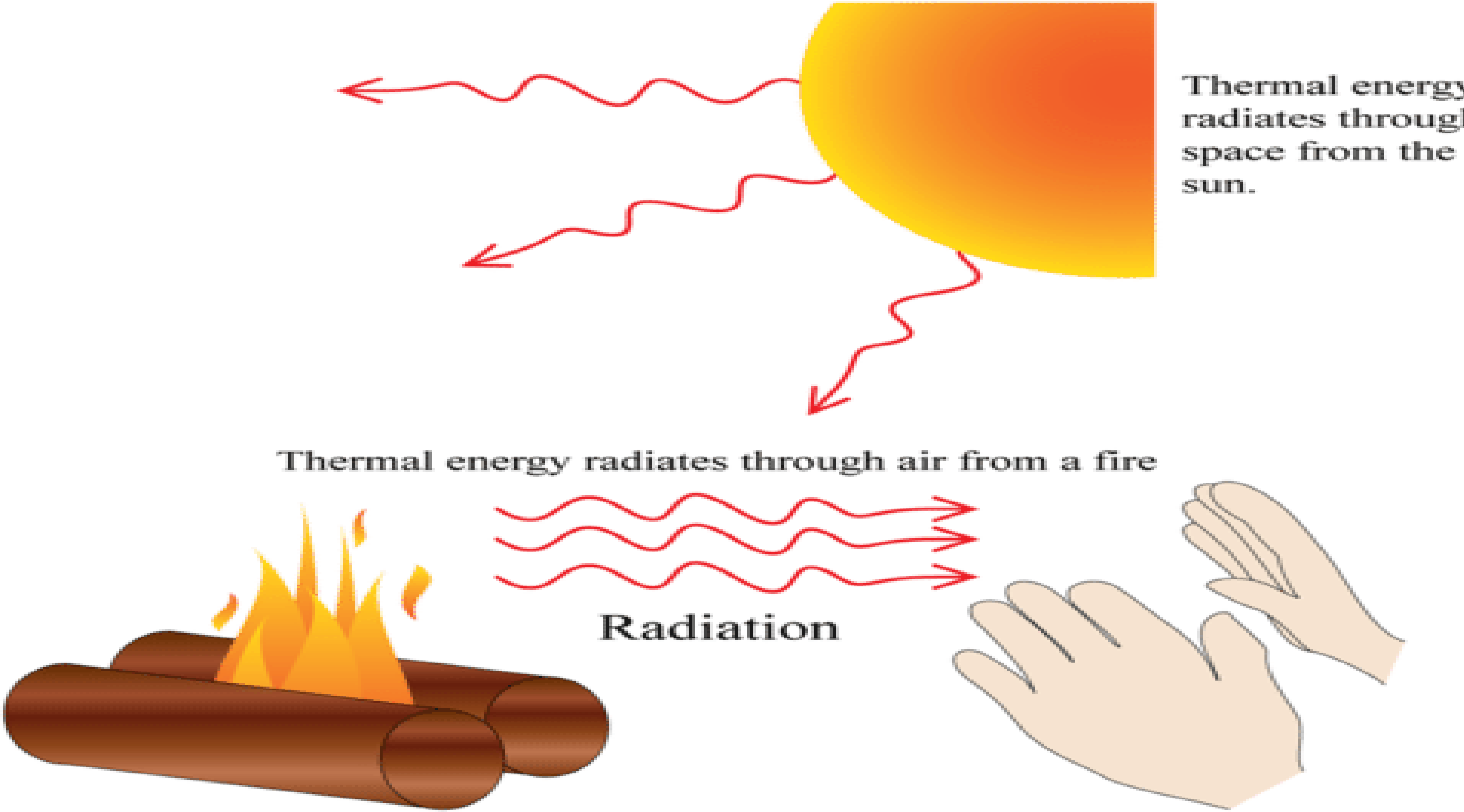
2. Heat movement during phase changes.

There are 3 ways in which heat moves

(a) Conduction – heat moves along, particle by particle.

(b) Radiation – heat moves in the form of waves




Thermal energy
radiates through
space from the
sun.
Thermal energy radiates through air from a fire
Radiation

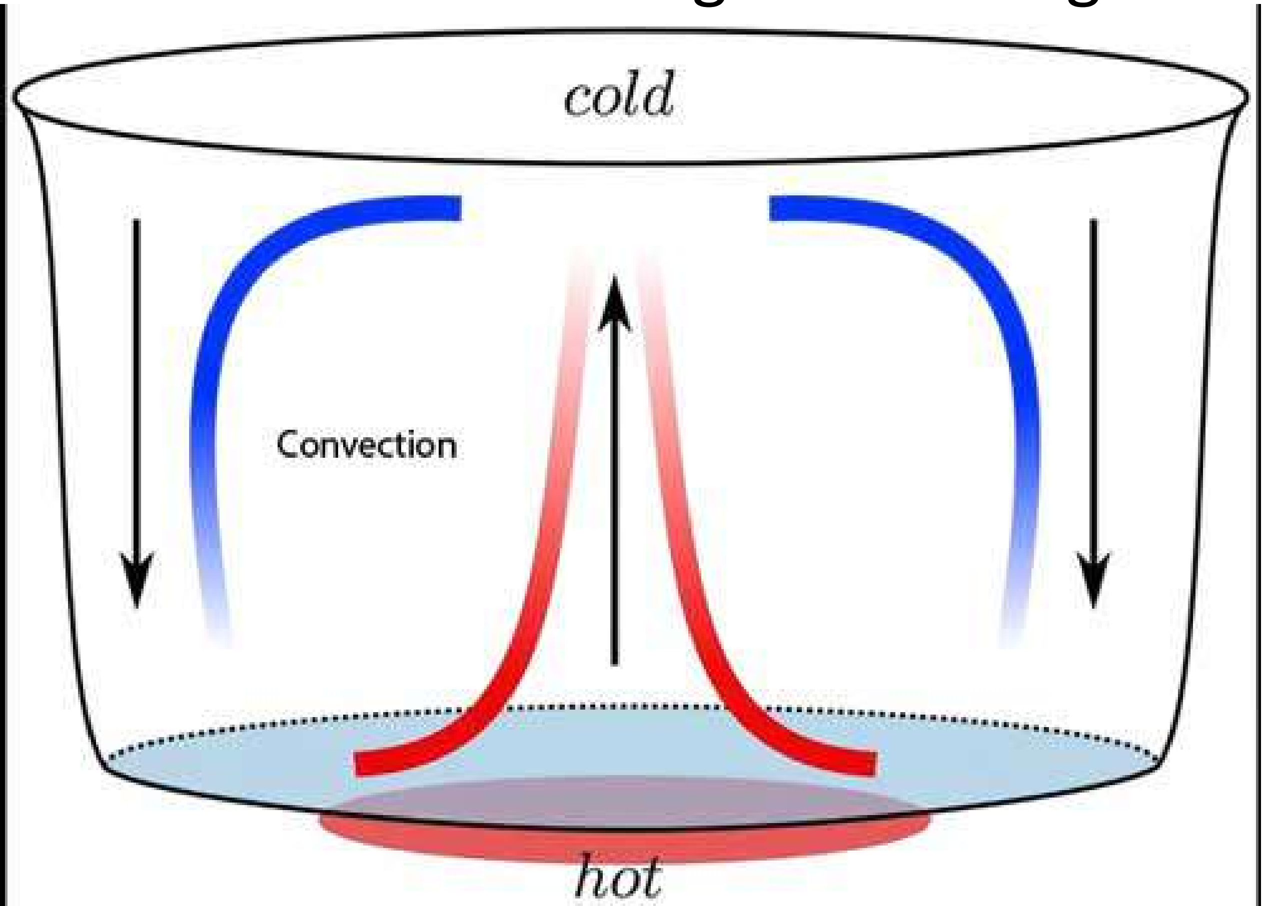
2. Heat movement during phase changes.

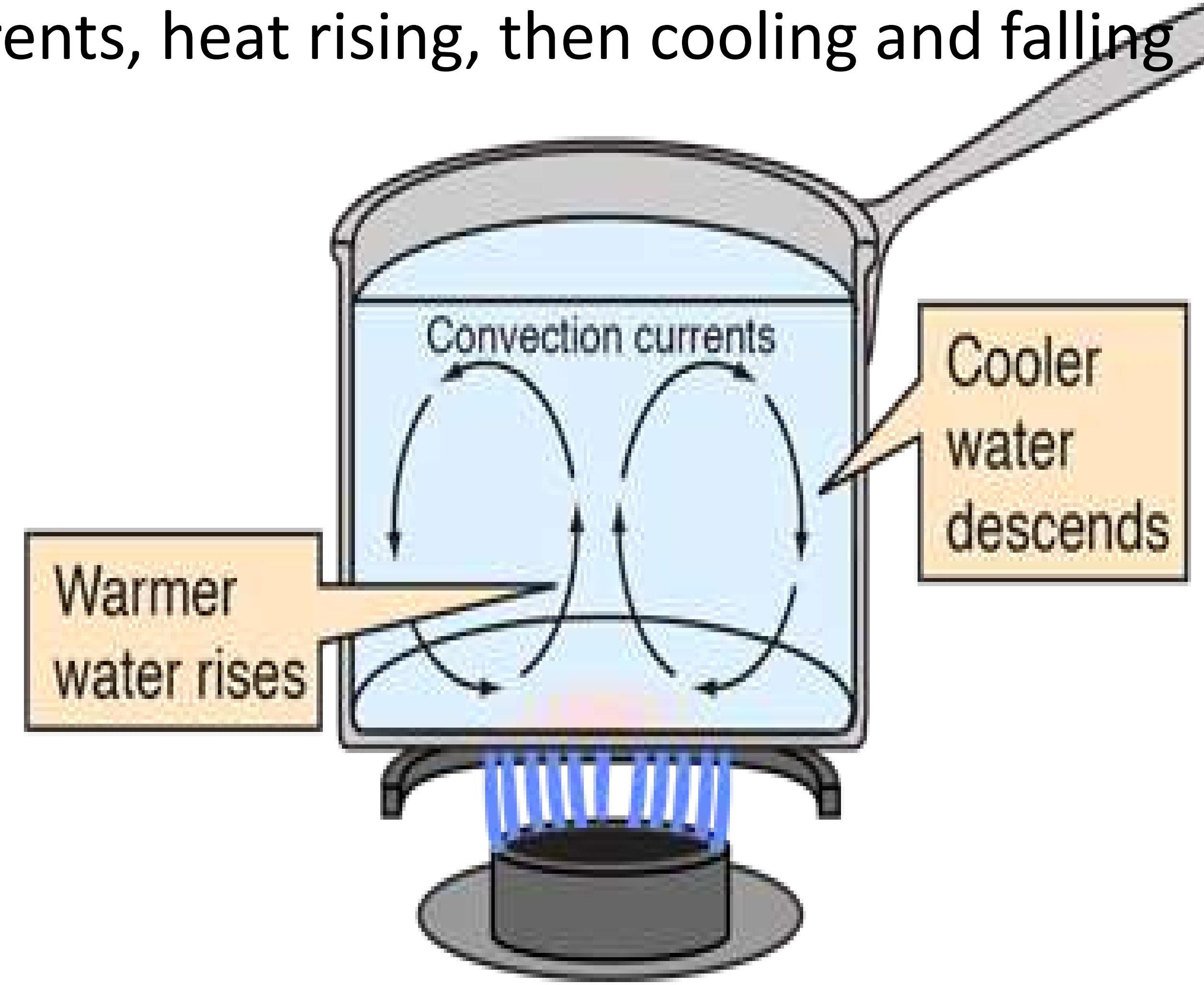
There are 3 ways in which heat moves

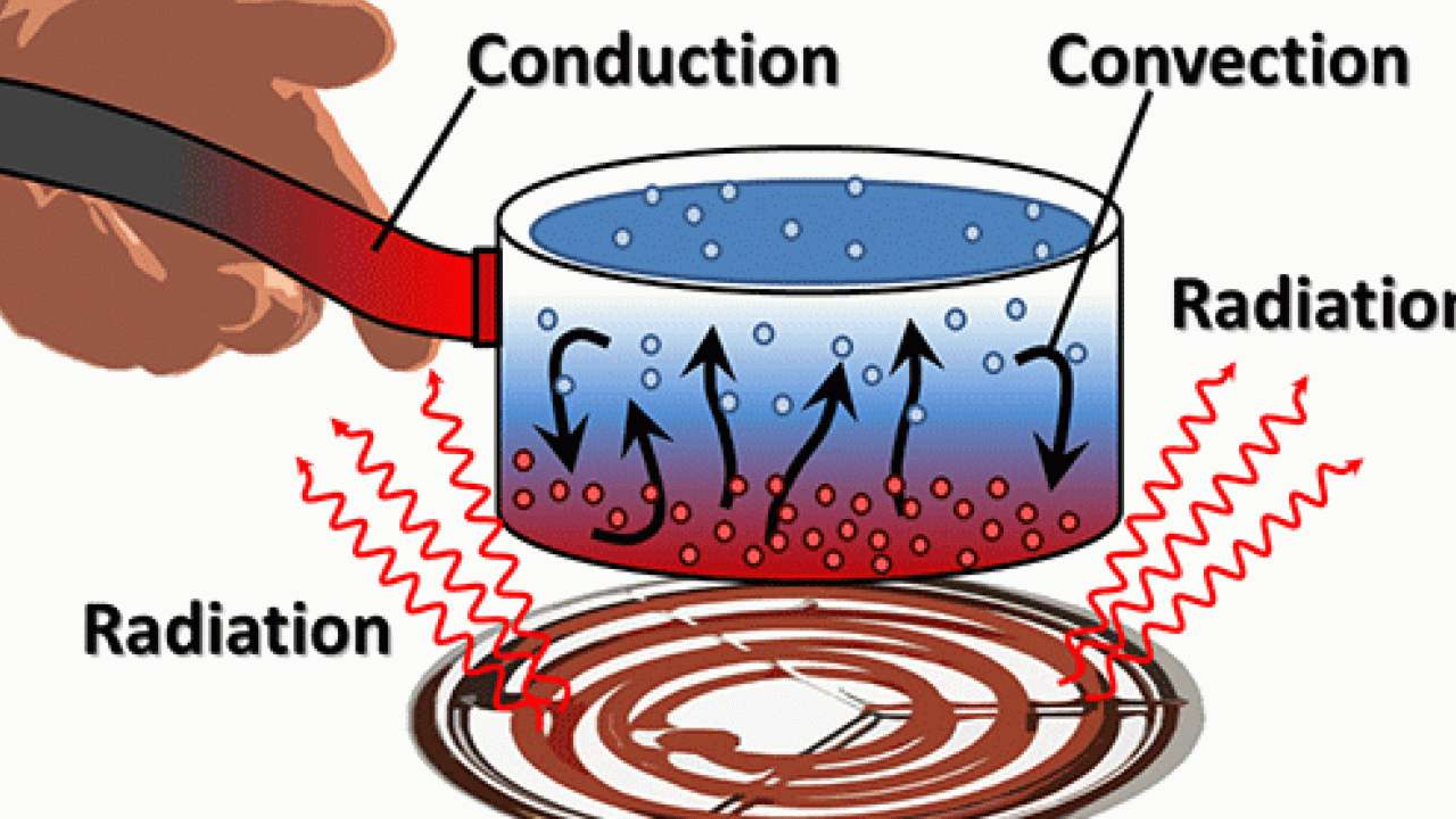
(a) Conduction – heat moves along,particle by particle.

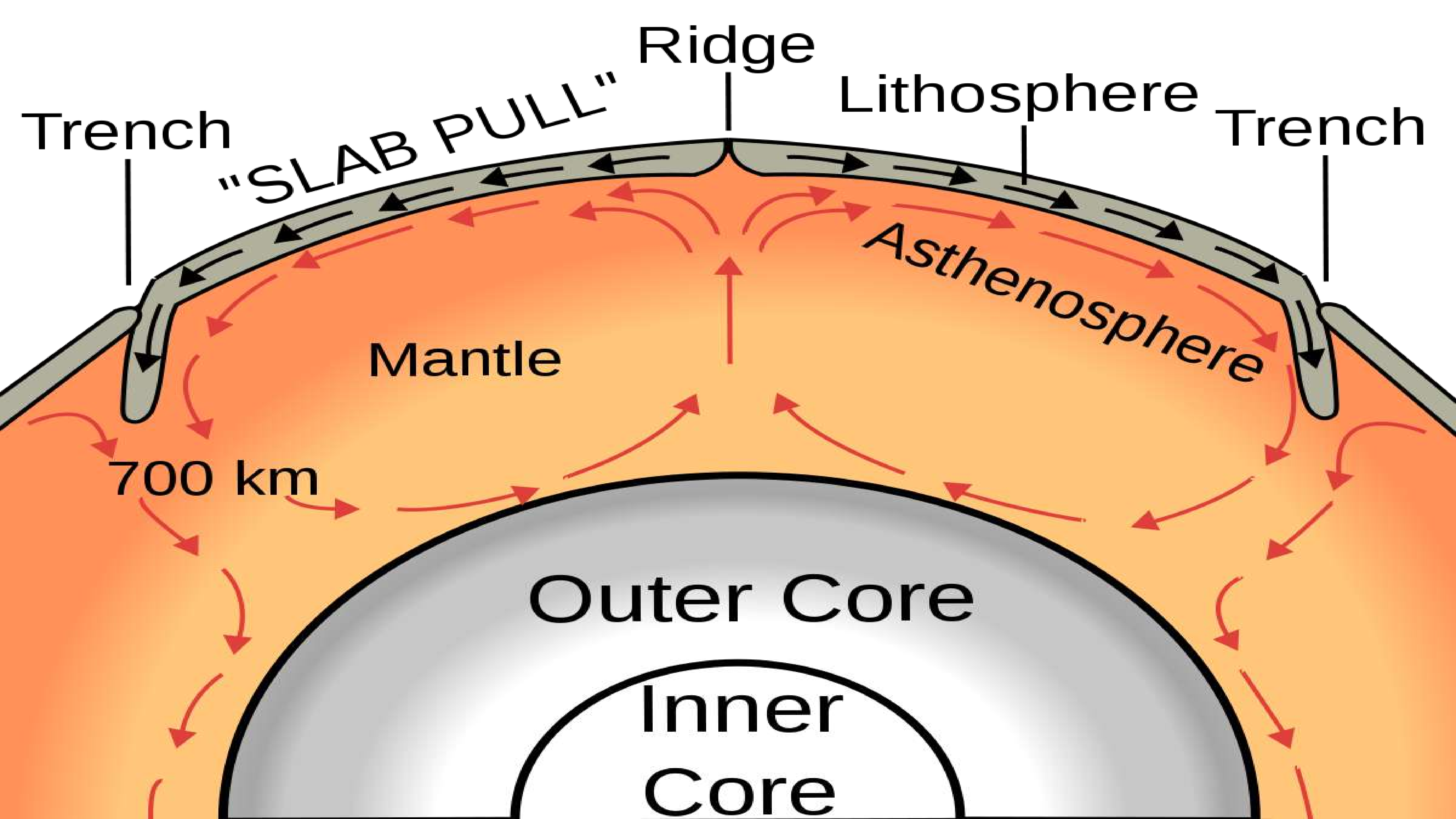
(b) Radiation – heat moves in the form of waves

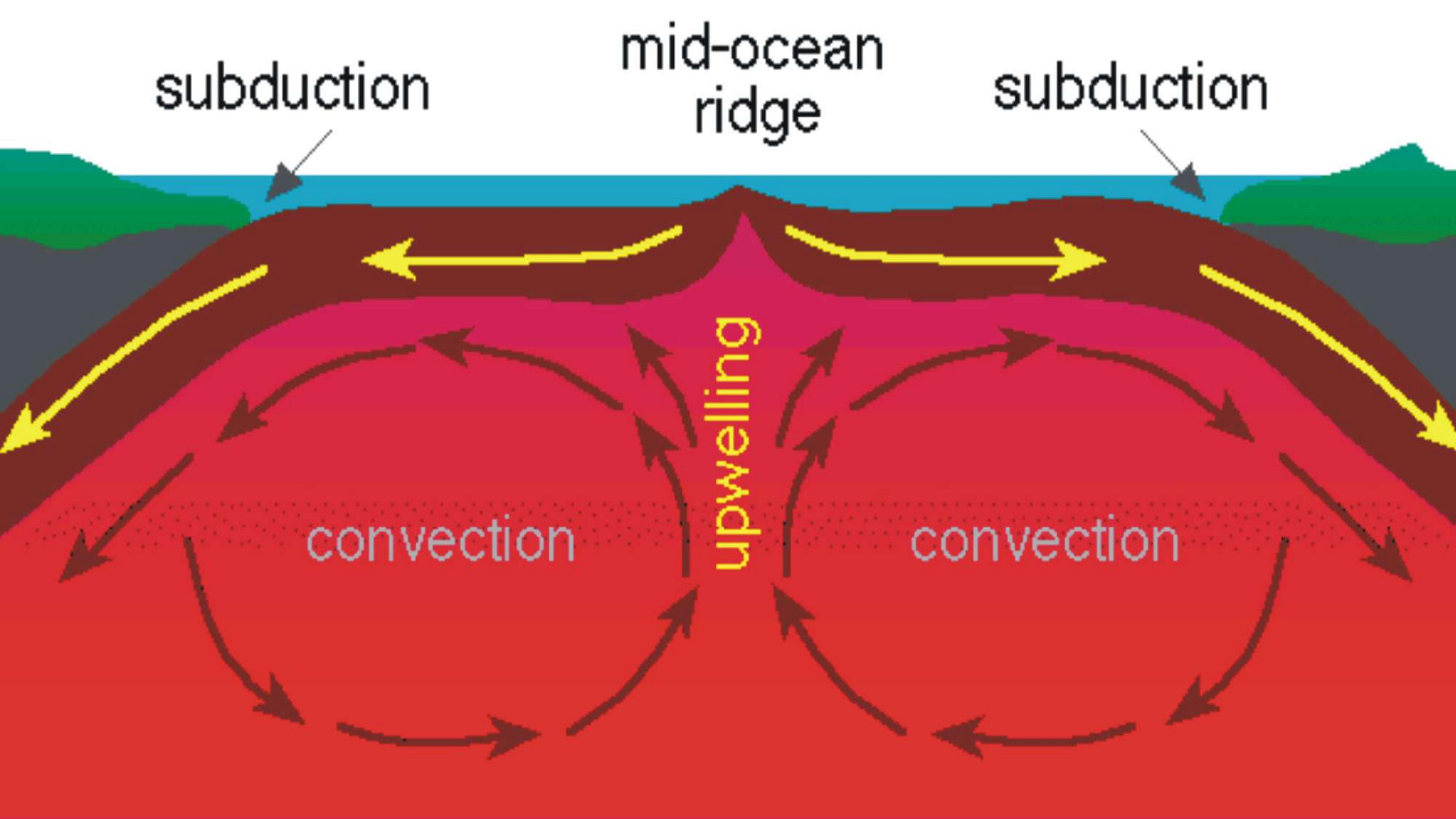
(c) Convection – heat moving in currents, heat rising, then cooling and falling and reheating and rerising.






Conduction
Convection
Radiation
Radiation


Ridge
Lithosphere
Trench
"SLAB PULL"
Trench
Asthenosphere
Mantle
700 km
Outer Core
Inner
Core


subduction
mid-ocean ridge
subduction
upwelling
convection
convection

https://www.britannica.com/video/185603/roles-convection-currents-forces-movement-tectonic-plates
2:22

https://www.youtube.com/watch?v=w-jgjkTHICk
1:45

https://www.youtube.com/watch?v=ZzvDlP6xd9o
1:12

https://www.youtube.com/watch?v=e7ho6z32yyo
2:57

https://www.youtube.com/watch?v=VNGUdObDoLk
4:58

https://www.youtube.com/watch?v=AYla6q3is6w
3:48