Heat

Atom and Molecule

- **Atom** - It is the smallest unit of a substance. The identity of a substance will be destroyed if its atom is further divided. Different substances will have different types of atoms. All atoms are made up of a number of *protons*, *neutrons* and *electrons*.
- **Molecules** - This is the smallest unit of a compound. For example, water is H_2O *di hydrogen oxide*. The water molecule consists of two hydrogen atoms and one oxygen atom which bind together by *covalent bonds.*

Element and compound

- **Element** - It is a substance that cannot be further resolved into simpler substances by chemical means. It consists of a single type of atom of *same* number of protons. For example, gold and copper are elements with 100% gold atoms and 100% copper atoms, respectively.
- **Compound** - It is a substance made of more than one type of atoms. They are usually formed by a chemical process and atoms are bound together by *chemical bonds*.

The Kinetic Theory of Matter

- The **Kinetic Theory of Matter** states that all of the particles that make up matter are constantly in motion.
  - The particles in a solid are not free to move around very much. They vibrate back and forth and are held tightly together by the forces of attraction.
  - The particles in a liquid move more freely then a solid. They are sliding around and tumbling over each other..
  - The particles in a gas are far apart and move around at high speeds. Particles might collide with one another, but otherwise they do not interact much.

Gas

Liquid

Solid

Heat

- Heat is the total energy of molecular motion in a substance.

Temperature

- Temperature is a measure of the average energy of molecular motion in a substance. Temperature does not depend on the size or type of object.
- The degree of hotness or coldness of any body.

Difference between Heat and Temperature

Heat energy depends on the speed of the particles, the number of particles (the size or mass), and the type of particles in an object. Temperature does not depend on the size or type of object. For example, the temperature of a small cup of water might be the same as the temperature of a large tub of water, but the tub of water has more heat because it has more water and thus more total thermal energy.

Cont….

- It is heat that will increase or decrease the temperature. If we add heat, the temperature will become higher. If we remove heat the temperature will become lower. Higher temperatures mean that the molecules are moving, vibrating and rotating with more energy.

Temperature and Kinetic Energy

- **Temperature** is a measure of the average kinetic energy of all the particles in an object

- If a liquid has a high temperature, particles in the liquid are moving very fast/have a high average kinetic energy
- If a liquid has a low temperature, particles are moving more slowly/have a lower average kinetic energy

Temperature Scales

- Fahrenheit
- Celsius
- Kelvin

Fahrenheit Scale

- Develop in early 1700s by G. David Fahrenheit
- Zero is the lowest temperature that salt water will freeze
- 32° F is freezing point of pure water
- 212° F is boiling point of pure water
- F scale used in US for surface temperatures

Celsius Scale

- Developed in 1700s
- Also called Centigrade scale
- Zero is the freezing point of pure water
- 100 is the boiling point of pure water at sea level
- A change of 1 C° = 1.8F°

Kelvin Scale

- Absolute zero – molecules stop moving
- Lowest possible temperatures
- Zero K = -459° F
- Zero K = -273° C
- °K = °C + 273
- Kelvin scale used for all scientific equations

Temperature Scales

F	C	K
-40	-40	233
-20	-29	244
0	-18	255
20	-7	266
32	0	273
40	4	277
60	16	289
80	27	300
100	38	311

Thermometers

- A **thermometer** measures temperature through the variation of some physical property of material inside the thermometer
- Ex: a mercury or alcohol thermometer can measure temperature because the liquid inside the thermometer always expands or contracts by a certain amount in response to a change in temperature

Heat is Different than Temperature

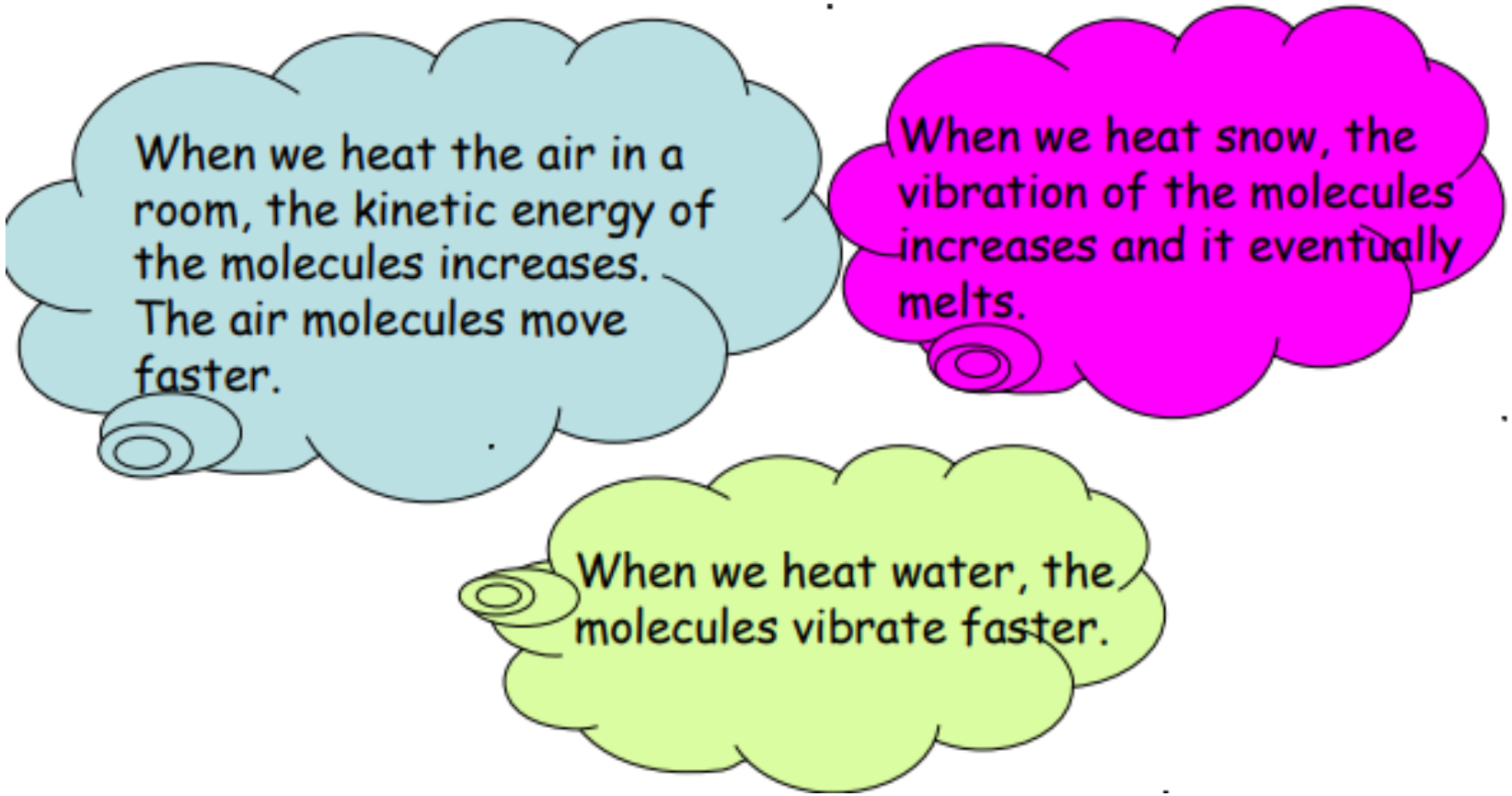
- **Heat** is the flow of energy from an object at a higher temperature to an object at a lower temperature
- **Thermal Energy** is the total kinetic energy of the molecules
- **Temperature** is the average kinetic energy of the molecules

Measuring Heat

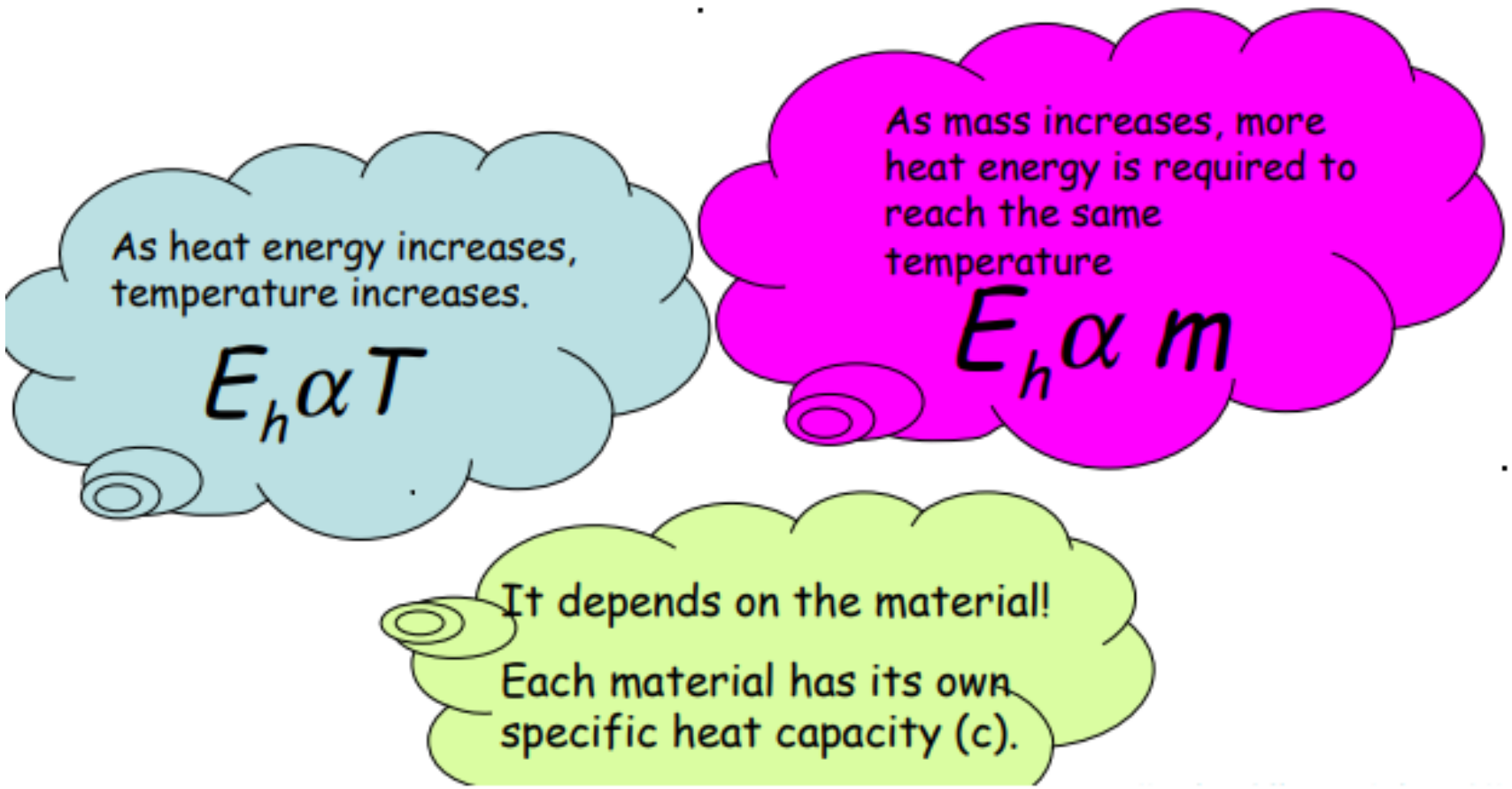
- One **calorie** is the amount of energy needed to raise temperature of 1 g of water by 1° C

- The **joule** (J) is the standard scientific unit in which energy is measured.
- 1 Calorie = 4.18 joules

What happens when we heat a substance?



How much heat is needed to raise the temperature of an object?



Heat Capacity

Heat capacity is a physical property of matter, defined as the amount of heat to be supplied to an object to produce a unit change in its temperature. Heat capacity is also named thermal capacity.

For understanding heat capacity first and foremost we want to get heat. Heat is a sort of energy that passes from objects of higher temperature to protest of lower temperature. For instance, in the event that we contact a hot cup of espresso, we will feel hot in light of the fact that the cup moves its energy (heat) into our body. Then again, on the off chance that we contact glass of cold water, the heat energy moves from our body to the glass making it feels cold. Besides, the SI unit for heat is Joules (J). Furthermore, it is noted as Q in the situation.

Mathematical derivation:

When heat is absorbed by the body, its temperature changes. The temperature change is directly proportional to the amount of supplied heat.

$$q \propto T$$

$$q = C.T$$

where,

- C= heat capacity
- q= heat absorbed by the body
- T=change in temperature

$$C = q / T$$

The unit of heat capacity is J/°C. It is an intrinsic property of a substance since it is the potential of a substance to absorb heat.

Specific Heat and Mass

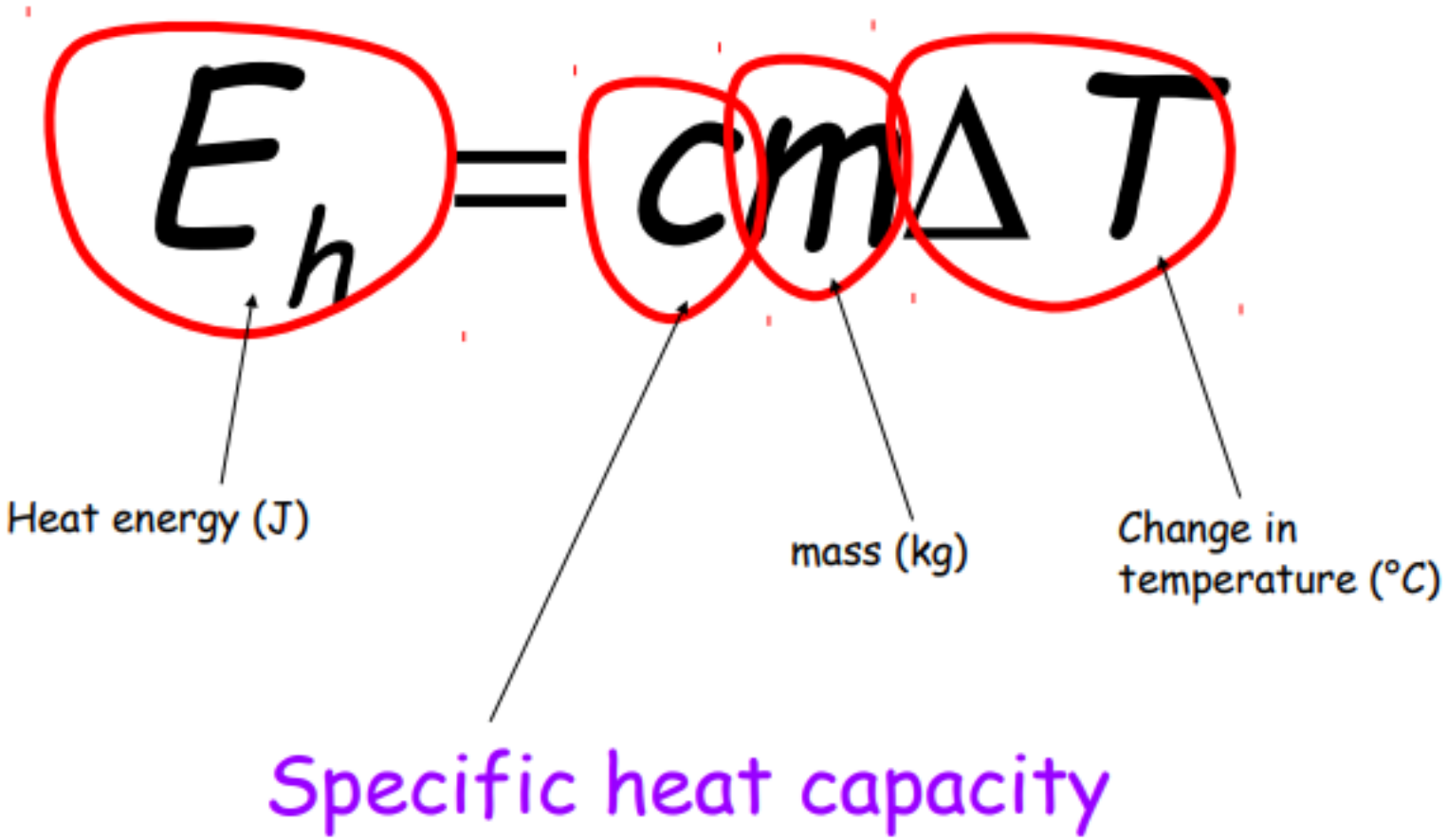
- Recall that thermal energy is the total kinetic energy of all particles in an object
- Thermal energy depends on the object's mass
- Water in a glass has the same specific heat as water in a bathtub
- If the water in the bathtub and coffee cup are the same temperature, the bathtub will have to release more thermal energy because of its mass

Specific Heat Capacity

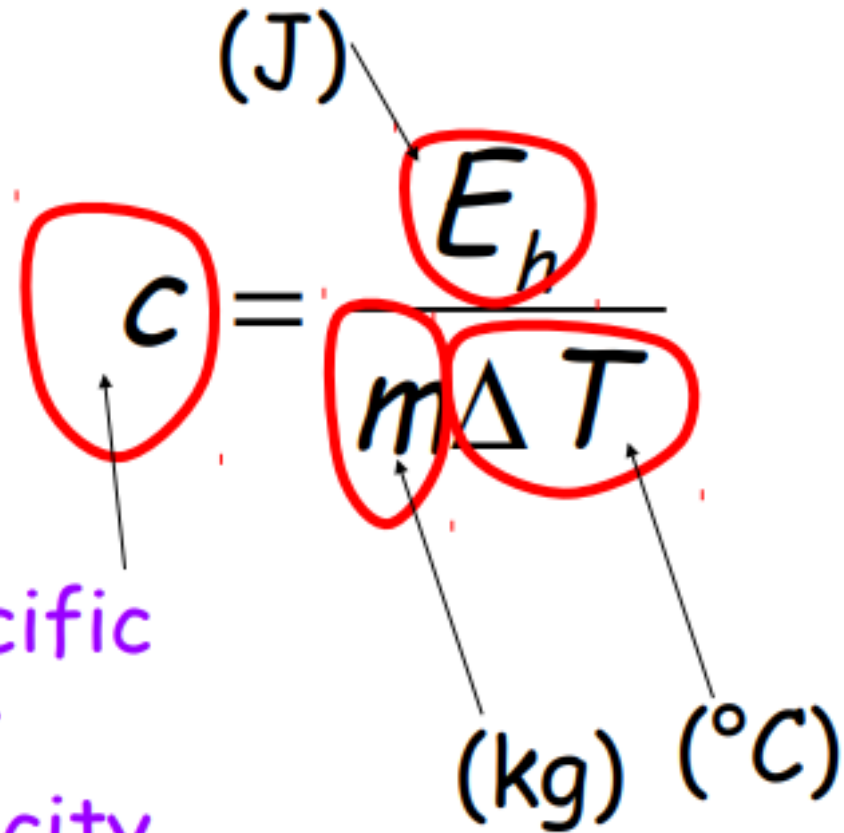
The specific heat capacity of a material is the amount of heat energy required to change the temperature of 1kg of the substance by 1°C.

$$E_h = cm\Delta T$$

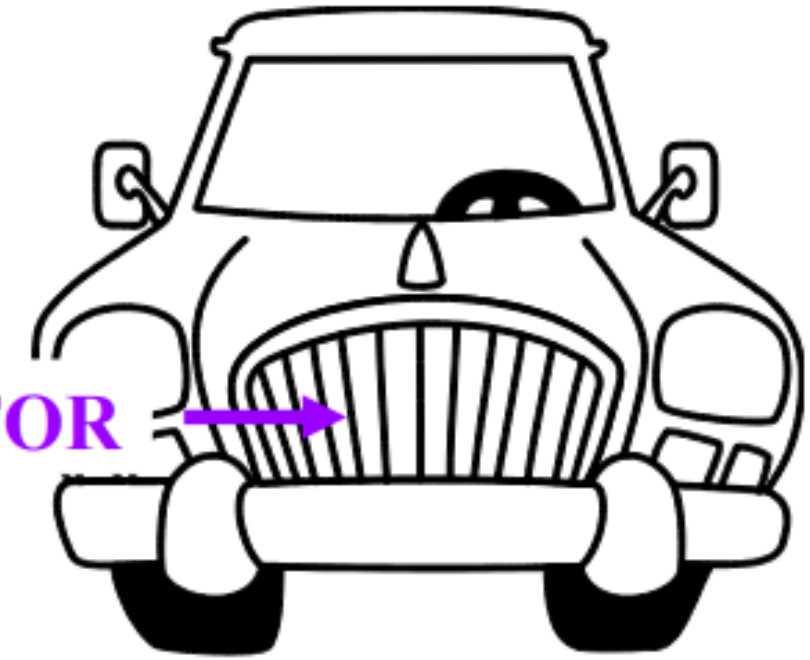
Specific Heat Capacity



Units of Specific Heat Capacity



Specific heat capacity J/kg °C



Why is water used as the coolant?

Because water has a high specific heat capacity, it can take away a lot of energy without boiling away.

Categories	Specific Heat Capacity	Heat capacity
Definition	The amount of heat required to raise the temperature of 1g of substance through 1 °K	The amount of heat required to raise the temperature of the body through 1 °K
Formula	c = q / m.T	C = q / T
Explanation	Amount of heat added or removed to change the temperature	It is the ability of the body to absorb heat
Intrinsicality	Non- intrinsic property	Intrinsic property
Unit	J / g °C	J / °C
Property	It is an intensive property	It is an extensive property.
Specificity	Highly specific	Non-specific
Examples	Water = 1 calorie or 4.182 J/g°C Copper = 0.385 J/g°C	1 liter of water = 4182 J/kg°C 100 g of copper = 38.5 J/ °C

Is heat capacity a state function?

Heat capacity is not a state function as it does not depend on the initial and final state of the system. It is a path function and depends on the path taken by the system to bring a change.

What are the advantages of low specific heat capacity?

Low specific heat capacity means that less energy is required to increase the temperature. The materials having low specific heat capacity get warmed and cooled quickly as they cannot hold a greater amount of energy. Therefore these materials are used in making cooking utensils such as frying pans, kettles, etc for quicker food preparation.

Why does specific heat increase with temperature?

Specific heat is the amount of heat that a body absorbs. When the body absorbs energy in the form of heat, the collision between particles increases which increases the kinetic energy of the molecule. As the temperature is the measure of the average kinetic energy of molecules, temperature increases here as well.

Is heat capacity an extensive property?

Heat capacity depends on the size and mass of the object so it is an extensive property.