General Physics

Lecture Three / Practical

Specific Heat

First stage

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Definition and math

Definition

Temperature is the measure of hotness or coldness expressed in terms of any of several scales, including Fahrenheit and Celsius. It has many medical applications such as thermometers.

Specific heat capacity is the amount of heat energy required to raise the temperature of one gram of a substance by one degree Celsius (or one Kelvin).

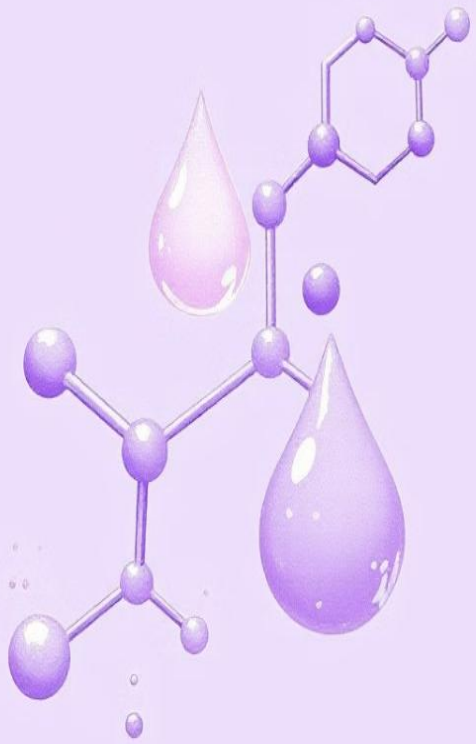
Mathematically

$$c = \frac{Q}{m\,\Delta T}$$

Where:

- C = specific heat capacity,
- Q = heat energy transferred (in joules),
- m = mass of the substance (in kilograms),
- ΔT = change in temperature (in kelvin or degrees Celsius).

Factors Affecting Specific Heat



1

Molecular Structure

The complexity and arrangement of molecules within a substance influence its specific heat. More complex molecules with greater degrees of freedom can store more energy.

2

Phase of Matter

Specific heat varies depending on the phase of matter (solid, liquid, gas). Solids generally have lower specific heats than liquids, and gases have the lowest specific heats.

Specific Heat of Solids

Metals

Metals generally have high specific heat values. This is why they are used in cookware and heat sinks, as they can absorb and distribute heat effectively.

Wood

Wood has a lower specific heat than metals, which is why it is used in furniture and construction where heat resistance is less critical.

Stone

Stone, like granite and marble, has relatively low specific heat, making it suitable for building materials where heat insulation is less important.

Specific Heat of Liquids

Oceans

Oceans have a massive thermal inertia due to water's high specific heat. They act as heat reservoirs, moderating climate and absorbing excess heat from the atmosphere.

Climate Regulation

Water's high specific heat significantly impacts global climate patterns. It allows for the gradual release and absorption of heat, creating a more stable environment.

Q/ What is the specific heat capacity of water?

Specific Heat of Gases

1

1. Air

Air has a relatively low specific heat, meaning it heats up and cools down quickly. This impacts weather patterns and the effectiveness of heat transfer through convection.

2

2. Greenhouse Gases

Certain gases, like **carbon dioxide**, have higher specific heats than air. They trap heat within the atmosphere, contributing to **the greenhouse** effect and **climate change**.

3

3. Heat Transfer

Understanding specific heat differences between gases is crucial in engineering applications, such as designing insulation systems and optimizing heat exchangers.

The concept of specific heat has several important applications in the medical field

1. Thermoregulation of the Human Body

The human body maintains a stable internal temperature (around 37°C) despite external temperature fluctuations. Water, which makes up about 60% of the human body, has a high specific heat capacity (~4,186 J/kg· ^{0}C).

Application :

- Understanding specific heat helps explain how the body regulates temperature during fever, exercise, or exposure to extreme environments.
- Medical interventions like cooling blankets or warming pads are designed based on the principles of specific heat to manage body temperature effectively.

2. Design of Medical Devices

•Many medical devices involve heat transfer, and their efficiency depends on the specific heat of the materials used:

- **Surgical Tools :** Instruments like cautery devices generate heat to cut or seal tissues. The specific heat of the materials ensures that the tools can maintain their functionality without overheating or damaging surrounding tissues.
- **MRI Machines** : These machines use superconducting magnets that require cooling systems. The specific heat of the coolant (e.g., liquid helium) is crucial for maintaining the magnet's stability.

H.W

3. Hyperthermia and Hypothermia Treatments (Explain)
4. Drug Delivery Systems (Explain)
5. Cryopreservation (Explain)
6. Thermal Imaging and Diagnostics (Explain)
7. Burn Treatment (Explain)
8. Blood Transfusions and IV Fluids (Explain)
9. Physical Therapy and Rehabilitation (Explain)
10. Artificial Organs and Prosthetics (Explain)
11. Radiation Therapy (Explain)
12. Neonatal Care (Explain)

Comprehensive Set of MCQs

1.What is specific heat capacity?

A) The heat required to change the state of a substance

B) The amount of heat energy required to raise the temperature of one gram of a substance by one degree Celsius

C) The total heat energy in a substance

D) The heat required to melt a substance

E) The heat required to vaporize a substance

Answer:

2.Which material generally has a high specific heat capacity?

A) Wood

B) Metals

C) Stone

D) Air

E) Water

Answer:

3. Why is wood used in furniture?

A) It has a high specific heat capacity
B) It has a low specific heat capacity
C) It is very heavy
D) It is very expensive
E) It is very durable

Answer:

4. What does ΔT represent in the context of specific heat?

- A) The mass of the substance
- B) The specific heat capacity
- C) The change in temperature
- D) The amount of heat energy
- E) The density of the substance

Answer:

5. Which of the following has a relatively low specific heat capacity?

- A) Water
- B) Metals
- C) Stone
- D) Wood
- E) Gases

Answer:

6. What is the role of specific heat in surgical tools?

- A) To increase the weight of the tools
- B) To ensure tools do not overheat
- C) To make tools more durable
- D) To reduce the cost of production
- E) To enhance the aesthetic appeal

Answer:

7. Which material is commonly used in MRI machines for cooling?

- A) Water
- B) Liquid helium
- C) Air
- D) Oil
- E) Alcohol

Answer:

8. What factor influences the specific heat of a substance?

- A) The color of the substance
- B) The complexity and arrangement of molecules
- C) The temperature of the substance
- D) The pressure of the substance
- E) The volume of the substance

Answer:

9. What is the specific heat capacity of water?

- A) 1 J/g°C
- B) 4.18 J/g°C
- C) 2 J/g°C
- D) 0.9 J/g°C
- E) 3.5 J/g°C

Answer:

10. Which of the following is NOT a factor in determining specific heat?

- A) Molecular structure
- B) Temperature
- C) Pressure
- D) Color
- E) Phase of matter

Answer:

11. What is the primary reason for using specific heat in designing medical devices?

- A) To enhance aesthetics
- B) To ensure safety and functionality
- C) To reduce costs
- D) To increase weight
- E) To improve user experience

Answer:

12. What is the effect of specific heat on temperature changes in substances?

- A) It has no effect
- B) It determines how quickly a substance can change temperature
- C) It only affects solids
- D) It only affects liquids
- E) It only affects gases

Answer: