Chemistry Fundamentals

LECTURE 4: Temperature

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Temperature - Understanding Thermal Energy

Fundamental Definition

Temperature is a measure of the average kinetic energy of particles in a substance.

Temperature vs. Heat

Temperature: Intensive property - doesn't depend on amount of substance

Heat: Extensive property - depends on both temperature and amount

Thermal Equilibrium

When two objects reach the same temperature. Heat always flows from higher to lower temperature until equilibrium is reached.

Kinetic Energy Connection

- Higher temperature: Particles move faster
- Lower temperature: Particles move slower
- Gases: Molecules move in straight lines until collision
- Solids: Atoms vibrate around fixed positions

Measurement Methods

- Liquid thermometers: Expansion of mercury or alcohol
- Digital thermometers: Electrical resistance changes
- Infrared thermometers: Measure electromagnetic radiation
- Thermocouples: Voltage changes with temperature

Temperature Scales - Different Ways to Measure the Same Thing

1

Celsius Scale (°C)

- Developed by Anders Celsius (1742)
- 0°C = freezing point of water, 100°C = boiling point of water
- Widely adopted internationally
- Used for weather reports, cooking, most scientific applications

2

Fahrenheit Scale (°F)

- Developed by Daniel Gabriel Fahrenheit (1724)
- 32°F = freezing point of water, 212°F = boiling point of water
- Used primarily in the United States
- 180 degrees between freezing and boiling of water

3

Kelvin Scale (K)

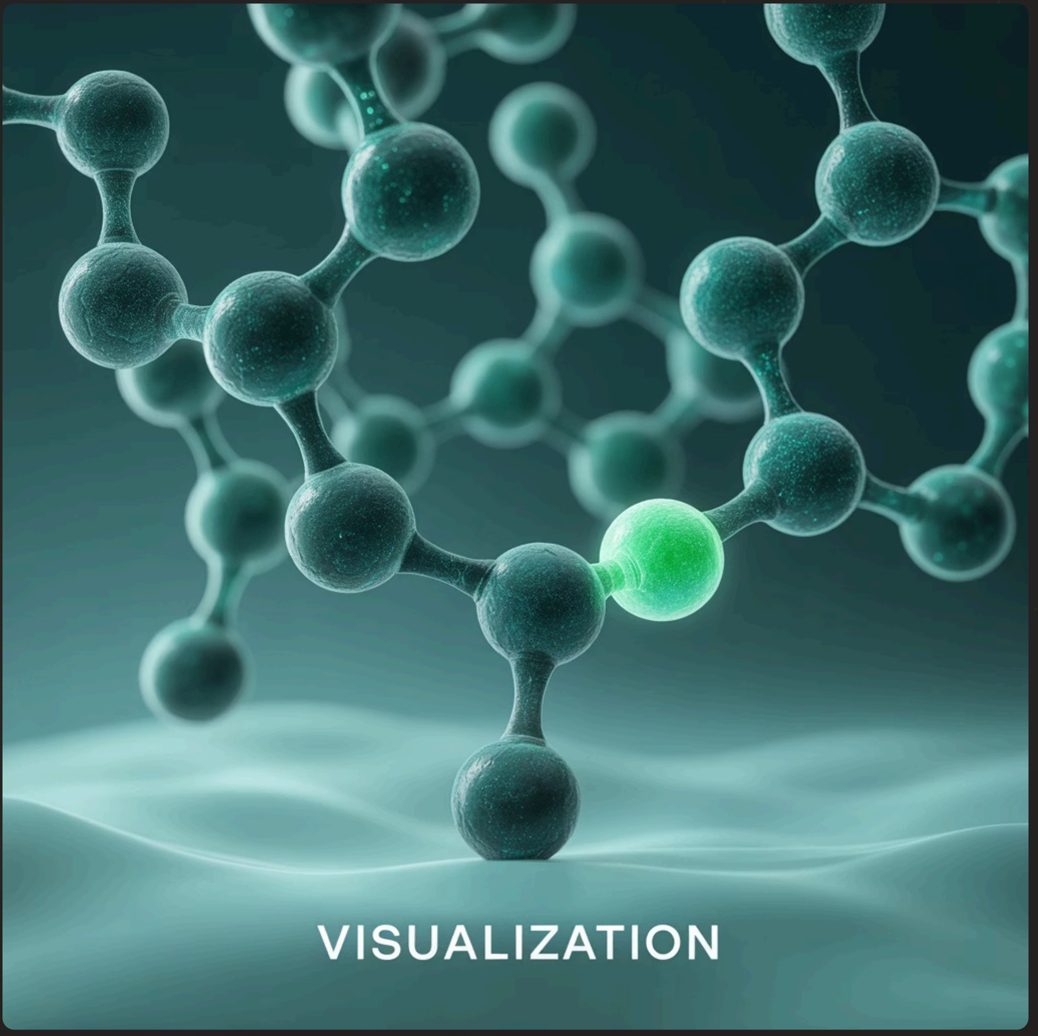
- Developed by Lord Kelvin (William Thomson, 1848)
- 0 K = absolute zero (-273.15°C)
- No negative temperatures
- Same degree size as Celsius (1 K = 1°C interval)
- Used in gas law calculations and thermodynamics

Absolute Zero - The Ultimate Cold

Definition & Significance

Absolute zero is the theoretical temperature at which all molecular motion ceases.

- 0 K = -273.15°C = -459.67°F
- Theoretically, all kinetic energy is removed
- Some motion still exists due to quantum effects
- Third Law of Thermodynamics states absolute zero cannot be reached



Approaching Absolute Zero

Closest achieved: About 0.000000001 K (1 billionth of a degree above absolute zero)

Methods: Laser cooling, magnetic cooling, dilution refrigerators

Strange Phenomena

Superconductivity: Electrical resistance drops to zero

Superfluidity: Liquids flow without friction

Bose-Einstein condensates: Atoms behave as single quantum entity

Temperature Conversion Formulas - The Mathematical Relationships

Celsius to Kelvin

$$K = {}^\circ C + 273.15$$

Add 273.15 to account for the difference between absolute zero and Celsius zero

Kelvin to Celsius

$${}^\circ C = K - 273.15$$

Subtract 273.15 to convert from absolute scale to Celsius

Celsius to Fahrenheit

$${}^\circ F = (9/5 \times {}^\circ C) + 32$$

Multiply by 9/5 to adjust degree size, then add 32 to adjust zero point

Fahrenheit to Celsius

$${}^\circ C = (5/9) \times ({}^\circ F - 32)$$

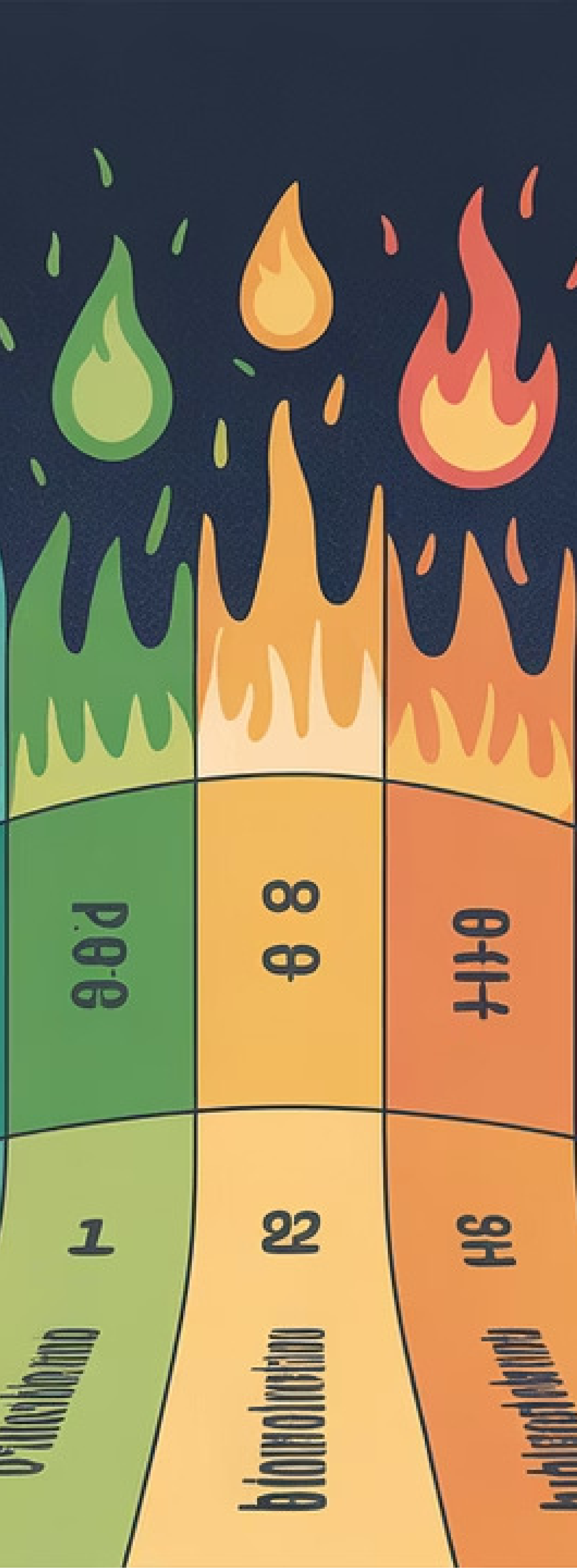
First subtract 32 to adjust zero point, then multiply by 5/9 to adjust degree size

Understanding the relationships: Celsius and Kelvin have the same degree size but different zero points. Celsius and Fahrenheit have different degree sizes and zero points. Kelvin and Fahrenheit combine both differences.

Temperature Conversion Examples - Step by Step

Example	Conversion	Calculation	Result
Room temperature	25°C to K	K = 25 + 273.15	298.15 K
Room temperature	77°F to °C	°C = (5/9) × (77 - 32)	25°C
Unique point	-40°C to °F	°F = (9/5 × -40) + 32	-40°F
Extreme cold	100 K to °C	°C = 100 - 273.15	-173.15°C
Body temperature	98.6°F to °C	°C = (5/9) × (98.6 - 32)	37.0°C

Interesting fact: -40°C = -40°F is the only temperature where both scales give the same number!



Temperature in Everyday Life and Science

Human Body and Health

- Normal body temperature: 37°C (98.6°F)
- Fever: Above 38°C (100.4°F)
- Hypothermia: Below 35°C (95°F)
- Protein denaturation: Above 42°C (108°F)

Food and Cooking

- Water boiling: 100°C (212°F) at sea level
- Baking: Typically 175-200°C (350-400°F)
- Meat safety: 74°C (165°F) for poultry
- Freezing preservation: -18°C (0°F)

Weather and Climate

- Comfortable room: 20-22°C (68-72°F)
- Hot summer day: 35°C (95°F)
- Cold winter day: -10°C (14°F)
- Antarctica record: -89°C (-128°F)
- Death Valley record: 57°C (134°F)

Scientific Applications

- Liquid nitrogen: -196°C (-321°F)
- Superconductor cooling: Below -200°C
- Steel melting: Around 1500°C (2700°F)
- Outer space: About 3 K (-270°C)

Key Takeaways

1 Temperature Fundamentals

Temperature measures average kinetic energy of particles. Higher temperature means faster particle movement.

2 Temperature Scales

Celsius (0-100°C water freezing to boiling), Fahrenheit (32-212°F), and Kelvin (starts at absolute zero, 0K = -273.15°C).

3 Conversion Formulas

$K = °C + 273.15$, $°F = (9/5 \times °C) + 32$, $°C = (5/9) \times (°F - 32)$

4 Real-World Applications

From human health to cooking, weather, and scientific research, temperature affects countless aspects of our lives.

Next Lecture:

Density

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