CHAPTER 12

Temperature and Heat

CONTENTS

1. TEMPERATURE AND THERMAL EQUILIBRIUM

Temperature

- A number that corresponds to the warmth or coldness of an object.

- measured by a thermometer based on the thermal equilibrium.

- Temperature is proportional to the average translational kinetic energy per particle in a substance.

2. THERMOMETERS AND TEMPERATURE SCALES

thermometers

- Measures temperature by expansion or contraction of a liquid (mercury or colored alcohol).

Temperature Scales

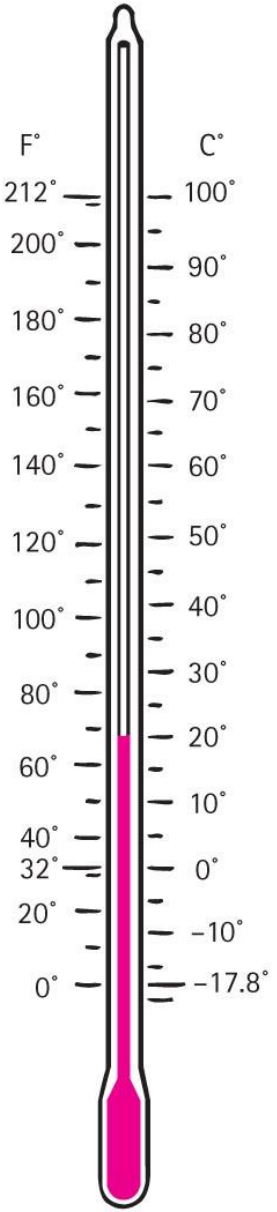
- Celsius scale (T_c): $0℃$ for freezing point of water to $100℃$ for boiling point of water.

- **Fahrenheit scale (T_f): $32°F$ for freezing point of water to $212°F$ for boiling point of water.**

$$T_f = \frac{9}{5} T_c + 32 \qquad T_c = \frac{5}{9} (T_f - 32)$$

- **Kelvin scale(T_K): $273\ K$ for freezing point of water to $373\ K$ for boiling point of water.**

$$T_K = T_c + 273 \qquad T_c = T_K - 273$$



Examples: 12 -1

1. What is the temperature of freezing water?

A) $0°F$ B) $0°C$ C) $0K$ D) all the above E) none the above

2. What is the temperature of boiling water?

A) $100°C$ B) $212°F$ C) $373K$ D) all the above E) none the above

3. How many Celsius units are between the boiling and freezing points of water?

A) 100 B) 180 C) 273 D) 212 E) all the choices

4. How many Fahrenheit's units are between the boiling and freezing points of water?

A) 373 B) 100 C) 212 D) 273 E) 180

Examples: 12- 2

1) Express the temperature 105.8 °F to Celsius scale?

$$T_c = \frac{5}{9}(T_f - 32) = \frac{5}{9}(105.8 - 32) = 41^oC$$

2) On a cold winter day, the temperature is –15°C. What is that temperature in °F?

$$T_f = \frac{9}{5}T_c + 32 = \frac{9}{5}(-15) + 32 = 5°F$$

3) Change 18^0C to kelvin.

$$T_K = T_c + 273 = 18 + 273 = 291\,K$$

4) If a body temperature in kelvin scale is 310 K, express this temperature in Celsius scale?

$$T_c = T_K - 273 = 310 - 273 = 37^oC$$

3. QUANTITY OF HEAT

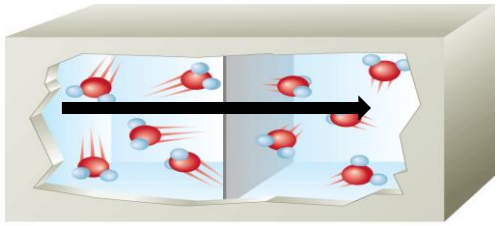
Heat: the heat Q is energy transferred from one object to another because of a difference in temperature

Heat is measured in energy units -- Joules or calories

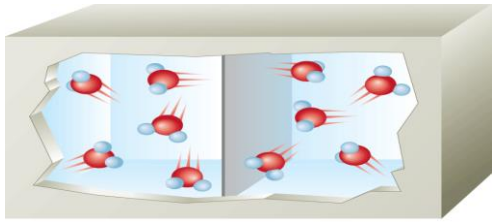
$$1 calorie = 4.19\ joules.$$

Heat flows from the object with a higher temperature to the object with a lower temperature

The direction of heat energy transfer



Hot water (90. ℃) Cold (10. ℃)



Hot water (50. ℃) Cold (50. ℃)

SPECIFIC HEAT:

Specific heat (c) is amount of energy required to raise the temperature of one kg of material by one Celsius. It is a characteristic of the material.

$$Q = mc(T_f - T_i)$$

where Q: heat energy (J) m: mass of an object (kg)

c: specific heat (J/kg ·°C)

Examples: 12- 3

A 3.0-kg aluminum pan is heated on the stove from 20°C to 120°C. How much heat had to be transferred to the aluminum? (Given a Specific heat of aluminum is 900 J/(kg·°C))

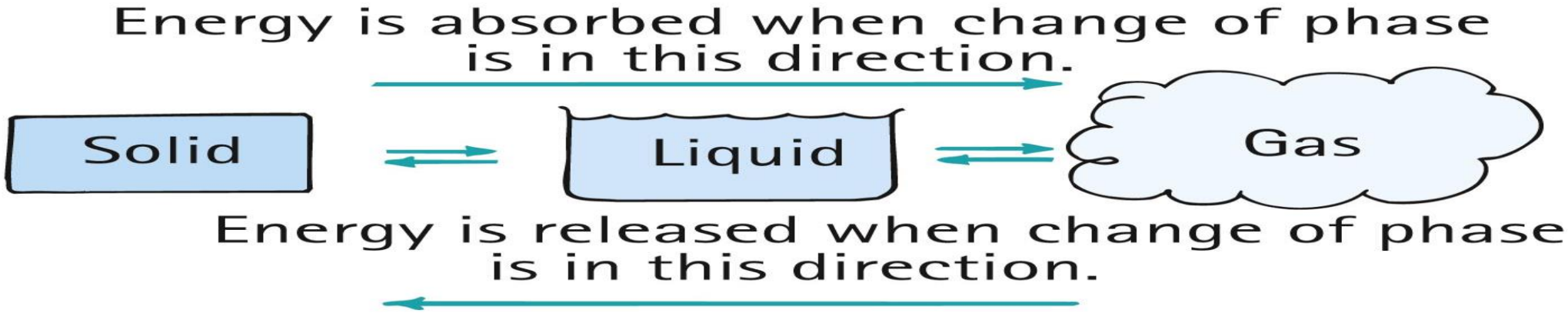
$$Q = mc(T_f - T_i) = (3)(900)(100) = 270000\text{J}$$

4. CALORIMETRY AND PHASE CHANGES

Calorimetry: means "measuring heat." We have discussed the energy transfer (heat) involved in temperature changes.

Heat is also involved in phase changes, such as the melting of ice or boiling of water.

Phase Change is a change in a substance from one form of matter (solid, liquid, or gas) to other.



Phase Changes

Description of Phase Change	Term for Phase Change	Heat Movement During Phase Change
From Solid to Liquid	Melting	Heat goes into the solid as it melts.
From Liquid to Solid	Freezing	Heat leaves the liquid as it freezes.
From Liquid to Gas	Vaporization; which includes boiling and evaporation	Heat goes into the liquid as it vaporizes
From Gas to Liquid	Condensation	Heat leaves the gas as it condenses
From Solid to Gas	Sublimation	Heat goes into the solid as it sublimate

Examples: 12 - 4

1. The change of Phase in a substance from Liquid to Solid is called?

A) Melting B) Condensation C) Freezing D) Vaporization E) Sublimation

2. The change of Phase in a substance from Gas to Liquid is called?

A) Freezing B) Condensation C) Melting D) Vaporization E) all choices

3. The change of Phase in a substance from Solid to Liquid is called?

A) Condensation B) vaporization C) Sublimation D) Freezing E) Melting

4. The change of Phase in a substance from Liquid to Gas is called?

A) Vaporization B) Condensation C) Sublimation D) Freezing E) Melting

5. The change of Phase in a substance from Solid to Gas is called?

A) Melting B) Sublimation C) Vaporization D) Freezing E) Condensation

5. MECHANISMS OF HEAT TRANSFER

There are three mechanisms of heat transfer are conduction, convection, and radiation.

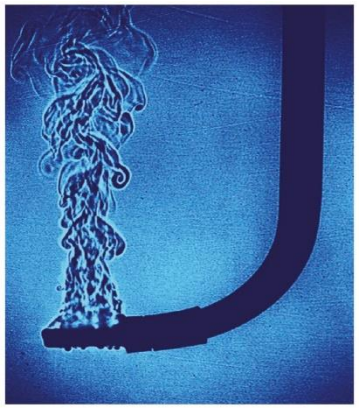
Conduction:

Transfer of internal energy by electron and molecular collisions within a substance

Convection:

Transfer of heat involving only bulk motion of fluids

Example: Visible shimmer of air above a hot stove or above asphalt on a hot day



Radiation:

Transfer of energy via electromagnetic waves that can travel through empty space