Heat

Mr. Sudbury

Heat

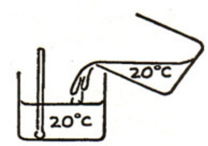
- ***Heat*** is when thermal energy is transferred from one object to another because of a temperature difference.
- The direction of thermal energy transfer is always from a ***warmer*** substance to a ***cooler*** substance.

Heat Transfer

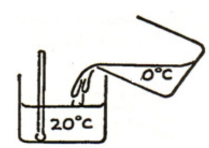
- When heat flows objects must be in ***thermal contact.***
- Remember heat flows from the higher temperature to the lower temperature.
- Heat transfer is complete at ***thermal equilibrium***–when both objects reach the same temperature.
- At thermal equilibrium ***no additional heat flows.***
- Substances DO NOT Contain heat, they only store it or transfer it.

Thermal Equilibrium

- If equal volumes of 20˚C water a mixed, what is the temperature when they react thermal equilibrium?

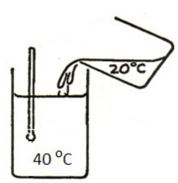


- What is the resulting thermal equilibrium temperature when equal volumes of water a mixed when 1 is 20˚C and the second is 0˚C?



Thermal Equilibrium

- What can you tell about the average and total KE resulting mixture of 2 beakers of water?



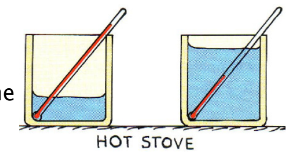
Internal Energy

- ***Internal energy*** is simply the total of all the energies within a substance.
  - KE of moving molecules.
  - KE due to movement of atoms within the molecules.
  - PE due to attractive and repulsive forces between atoms and molecules
- *A substance does not contain* **heat**, *it contains* **internal energy**.
- When a substance takes in or gives off heat, its internal energy changes.
- Absorb heat → particles move faster → more KE
- Release heat → particles move slower → less KE

Measuring Heat

- How do we know how much heat is transferred?
- Measure the temperature change. (ΔT)
- It also depends on mass (quantity) and what type of substance it is.

- If we put two pots of water on the stove, which one will heat the fastest?



100 Joules of thermal energy added…

Measuring Heat

- Which substance absorbs/releases heat the fastest?
- Grass…or
- Cement sidewalk

Measuring Heat

- You heat all three full cups for 30 sec. in microwave.
- Compare the temperature of each cup.

Measuring Heat in Physics

- Since heat is a form of energy, we will measure heat in ***Joules.*** (J)

- 4.184 Joules is the amount of heat needed to raise the temperature of 1 gram of water 1 °C.

- We can use either calories or Joules
- 1 calorie = 4.184 Joules

Specific Heat Capacity

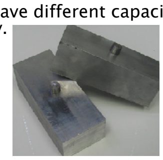
- ***Specific Heat Capacity*** (aka ***specific heat***) is the quantity of heat required to raise the temperature of a unit of mass of a substance by 1 °C.
- Units →

$$\frac{Joules}{gram \cdot {}^\circ C} \quad \text{or} \quad \frac{calories}{gram \cdot {}^\circ C}$$

- Different substances heat up faster or slower.
- Different substances cool off faster or slower.

Specific Heat Capacity

- Different substances have different capacities for storing internal energy.



100 gram samples of silver, gold, aluminum, & water are heated on a stove burner where 500 joules of heat are applied.

Compare their temperatures…

Are the all at the same temperature?

Specific Heat

Which heats to the highest temperature in the time?

- Gold
- Silver
- Aluminum
- Water

Specific Heats of Common Substances	
Substance	Joule/gram °Celsius
Water	4.2 J/g °C
Water (solid)	2.1 J/g °C
Water (gas)	2.0 J/g °C
Glass	0.8 J/g °C
Aluminum	0.9 J/g °C
Silver	0.23 J/g °C
Copper	0.39 J/g °C
Graphite	0.71 J/g °C
Gold	0.13 J/g °C
Benzene	2.0 J/g °C
Ethanol	2.1 J/g °C

Specific Heat

- A ***higher*** value means the substance requires more heat (Joules), but holds heat longer and cools off slower.
- A ***lower*** value means it requires less heat (Joules) to heat up, and does not hold its heat for long.

Specific Heats of Common Substances	
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Water (solid)	2.1 J/g °C
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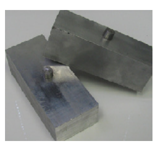
Ethanol	2.1 J/g °C

Specific Heat of Substances

- After 500 Joules of heat are applied to the 4 different substances (100 g each), lets check the temperature…

Silver Inc. 21.7 °C Gold Inc. 38.5 °C



Aluminum Inc. 5.5 °C

Water Inc. 1.2 °C

Heat Transfer Calculations

Heat transferred

=

mass x specific heat capacity x temperature change

$$Q = mc\Delta T$$

Heat; Mass (g); Specific heat (from Chart); Change in temperature ($T_{final} - T_{initial}$)

$$Q = mc\Delta T$$

$\Delta T =$ c = m =

Practice

- A 250-g sample of water is heated from 24 °C to 88 °C. How much heat was used?

$Q = mc\Delta T$

- A 25-g sample of glass has 17.5 Joules of heat applied. If it was initially at 24 °C, what is its new final temp?

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

Practice

- A 25-g sample of mercury is heated from 36 ˚C to 52 ˚C by applying 56 Joules of heat. What is the specific heat of mercury?

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

- What is the mass of a sample of benzene that is heated from 16 ˚C to 29 ˚C by applying 14 joules of heat?

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

Practice

- What heat is released when a 60 gram sample of water is placed in the freezer and the temperature is changed from 24˚C to 0 ˚C ?

$$Q = mc\Delta T$$

Calories or Joules

- Both are energy, both are heat.

Specific Heats of Common Substances		
Substance	**calorie /gram °Celsius**	**Joule/gram °Celsius**
Water	1.0 c/g°C	4.186 J/g °C
Water (solid)	0.51 c/g°C	2.13 J/g °C
Water (gas)	0.48 c/g°C	2.00 J/g °C
Glass	0.20 c/g°C	0.83 J/g °C
Aluminum	0.215 c/g°C	0.90 J/g °C
Silver	0.056 c/g°C	0.234 J/g °C
Copper	0.092 c/g°C	0.385 J/g °C
Graphite	0.170 c/g°C	0.711 J/g °C
Gold	0.0301 c/g°C	0.13 J/g °C
Benzene	0.48 c/g°C	2.0 J/g °C
Ethanol	0.50 c/g°C	2.09 J/g °C

Heat

The End