Specific heat and enthalpy

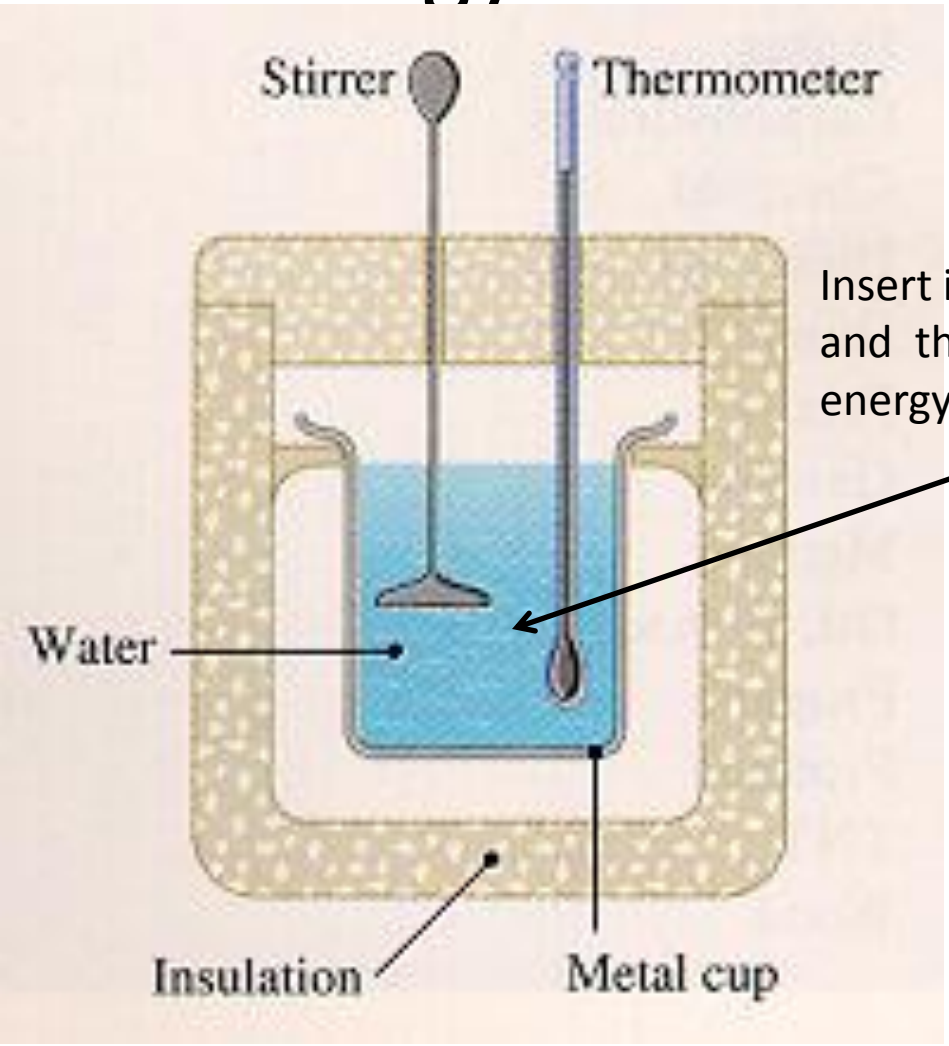
Schweitzer

Q:How do you know how much energy is released from a reaction.

- 1st you need to have some way to collect and quantify the energy.
- This is done using what is called a calorimeter.

- 2nd you will need to understand the concept of specific heat.

Calorimeter: device that insulates from energy loss.



Insert item into calorimeter and the water will collect energy

Specific heat

- Specific heat = amount of energy needed to raise 1 gram of a substance 1 degree Celsius.
- The specific heat of water is 1 cal/g C or

  4.18J/gC

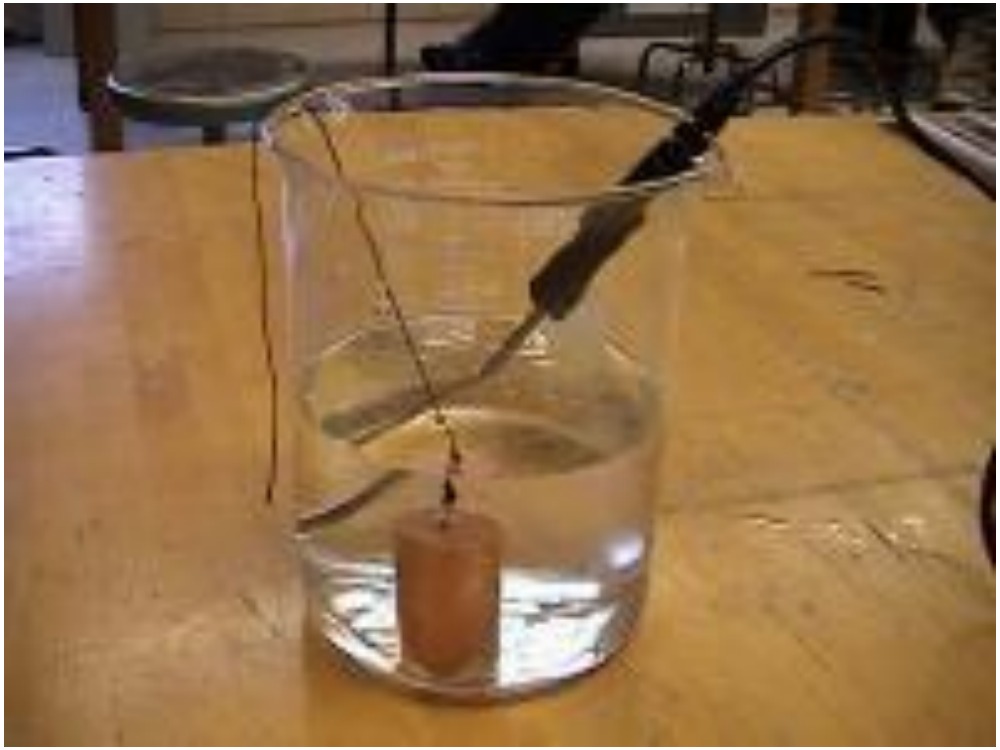
Important: As different objects absorb energy the increase in temperature is not equal.

-- So specific heat relates Temperature change to energy change.

Specific heat Conceptually

- Example:
  - A snowmobiler who falls into 32F water can only last minutes before death.
  - A person sits on their front porch (32F) in shorts can last hours.
  - What is the difference?
    - The water has a very high specific heat requiring a lot of energy to raise it up in temperature.

- A body will transfer or absorb energy to its surrounding until the temperature between the body and its surroundings are equal.



- WHAT EVER ENERGY IS LOST BY THE BLOCK IS GAINED BY THE WATER.

In order to determine an unknown you must have a known to compare it to.

- As a substance loses/gains energy we must have a known substance to absorb/release the energy.

- With a known substance collecting energy we will be able to quantify the energy using the following equation

$q = m * c * \Delta T$

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- q = energy (joules or calories)
- M = mass (grams)
- C = specific heat (J/g C or cal/g C)
- T = Change in temperature

Simple Specific Heat Question

In Reality, given the appropriate data one could solve for any of these variables

A 250g block of Copper (specific heat = .386J/gC) at 25C gains 3Kj of energy. What is the final temperature?

Block	Variable	
	Mass	
	Specific heat	
	Temp – initial	
	Temp – Final	
	Energy	

Simple Specific Heat Question

In Reality, given the appropriate data one could solve for any of these variables

A 250g block of Copper (specific heat = .386J/gC) at 25C gains 3Kj of energy. What is the final temperature?

$q = m (T_f - T_i) * c$ Solve for T_f or just solve for ΔT

$3000J = 250 * \Delta T * .386$ $\Delta T = 31.0C$ $T_f = 56$

Block	Variable	
250g	Mass	
.386	Specific heat	
25C (273)	Temp – initial	
?	Temp – Final	
3000J	Energy	3000J

Simple Specific Heat Question

If the same amount of energy is applied to an aluminum block. What happens to the change in temperature of that block.

A 250g block of Aluminum (specific heat = .90J/gC) at 25C gains 3Kj of energy. What is the final temperature?

$q = m (T_f - T_i) * c$ Solve for T_f or just solve for ΔT

$3000J = 250 * \Delta T * .90$ $\Delta T = 13.3C$ $T_f = 38\ C$

Block	Variable	
250g	Mass	
.90	Specific heat	
25C (298)	Temp – initial	
?	Temp – Final	
3000J	Energy	3000J

Lab Calculation

A 100C 50g block is placed in 100g of water at 25 C after the temperatures have come to equilibrium the final temperature of the system is measured to be 28C. What is the specific heat of the metal

Block	Variable	Water
50	Mass	100
?	Specific heat	4.18
100	Temp – initial	25
28	Temp – Final	28
?	Energy	?

Calculations

What is the specific heat of the metal?

1st Calculate the energy the water absorbed.
q = m *(Tf-Ti) * c
100 * 3 * 4.18 = 1254J

Block	Variable	Water
50	Mass	100
?	Specific heat	4.18
100	Temp – initial	25
28	Temp – Final	28
?	Energy	1254

Calculations

What is the specific heat of the metal?

Since all the energy that the water gained came from the block the energy the block lost is equal to the water except it is negative because it loosing water.
Next solve for Specific Heat…..

Block	Variable	Water
50	Mass	100
?	Specific heat	4.18
100	Temp – initial	25
28	Temp – Final	28
-1254	Energy	1254

Calculations

What is the specific heat of the metal?
q = m* (Tf-Ti) * c

-1254 = 50 * (28-100) * ?
? = .34J/g C Check specific heat chart to verify identity

Block	Variable	Water
50	Mass	100
?	Specific heat	4.18
100	Temp – initial	25
28	Temp – Final	28
-1254	Energy	1254

Specific Heat chart

Substance	c in J/gm K
Aluminum	0.900
Bismuth	0.123
Copper	0.386
Brass	0.380
Iron	.340
Gold	0.126
Lead	0.128
Silver	0.233
Tungsten	0.134
Zinc	0.387
Mercury	0.140
Alcohol(ethyl)	2.4
Water	4.186
Ice (-10 C)	2.05
Granite	.790
Glass	.84

Does this make sense?

Make sure you look at the physical description!

Advanced Calorimetry

- 40 grams of NaOH is dropped in to a ½ liter of water. The temperature of the water increases from 25C to 85C.

- Determine the Energy/mole of NaOH.
- This is also the Enthalpy for the following reaction.

$$NaOH = Na^{+} + OH^{-}$$

Calculations

What are we trying to figure out.
-- Energy/mole = KJ/mol
Determine the energy gained by the water.

$q = m\ (t_f - t_i)\ c$
$= 500g * 60 * 4.18$
$q = 125400J$ or $125.4kJ$

Determine the moles of NaOH (molar mass = 40g/mol)
40g (1mol/40g) = 1 mole
Determine the kJ/mol
125.4kJ/1mole = 125.4kJ/mol

NaOH	Variable	Water
40	Mass	500
	Specific heat	4.18
	Temp – initial	25
	Temp – Final	85
?	Energy	?

What would be the final temperature if two liquids are mixed?

- You are given two 50 gram samples of water. One is 100 C(373K) and one is 0C.(273) What is the final temperature?
- Logically speaking the temperature is 50C.
- But how do you calculate the answer?

H_2O_{hot}	Variable	H_2O_{Cold}
50	Mass	50
4.18	Specific heat	4.18
373	Temp – initial	273
?	Temp – Final	?
-x	Energy	+x

Calculation

- Energy lost from hot water = energy gained by cold water
- M_{H*} $(Tf\text{-}Ti_H)$ * c_H = $-q_H$ = q_c = M_c * $(Tf\text{-}Ti_c)$ * c_c
- To drop out q's they must be equal
- M_{H*} $(Tf\text{-}Ti_H)$ * c_H = $-q_H$ = $-q_c$ = M_c * $(Tf\text{-}Ti_c)$ * c_c *-1
- M_{H*} $(Tf\text{-}Ti_H)$ * c_H = M_c * $(Tf\text{-}Ti_c)$ * c_c *-1 (Insert values)

- 50_* (Tf-373) * 4.18 = 50 * (Tf-273) * 4.18 *-1

Multiply, combine, simplify solve for Tf

Combine and simplify

- 50_* (Tf-373) * 4.18 = 50 * (Tf-273) * 4.18 *-1
- 50_* (Tf-373) * 4.18 = 50 * (Tf-273) * - 4.18
- 209.(Tf – 373) = -209(Tf-273) Distribute
- 209Tf - 77957 = -209Tf + 57057 Isolate Tf
- 418Tf = 135014
- Tf = 323 K = 50C