

Relation b/w C & C'

C' - heat capacity of substance
 C - Sp. heat capacity of substance.

$$C' = \frac{Q}{\Delta t} \text{ and } C = \frac{C'}{m}$$

m - mass of substance

DISTINCTION BETWEEN THE HEAT CAPACITY AND SPECIFIC HEAT CAPACITY

Heat capacity

1. It is the amount of heat energy required to raise the temperature of entire body by 1°C .
2. It depends both on the substance and mass of the body. More the mass of the body, more is its heat capacity.
3. Heat capacity $C' = \frac{Q}{\Delta t}$
 $= \text{mass } m \times \text{specific heat capacity } c$
4. Its unit is J K^{-1} .

Specific heat capacity

1. It is the amount of heat energy required to raise the temperature of unit mass of the body by 1°C .
2. It does not depend on the mass of the body, but it is the characteristic property of the substance of the body.
3. Specific heat capacity $c = \frac{Q}{m \Delta t} = \frac{\text{heat capacity } C'}{\text{mass } m}$
4. Its unit is $\text{J kg}^{-1} \text{K}^{-1}$.

Specific heat Capacities of Common Substances

- A good conductor has Low sp. heat capacity
- A poor conductor has a high sp. heat capacity
- $c_w = 4200 \text{ J kg}^{-1} \text{K}^{-1}$ - A very high value.
- The sp. heat capacity of the same substance is different in different phases.

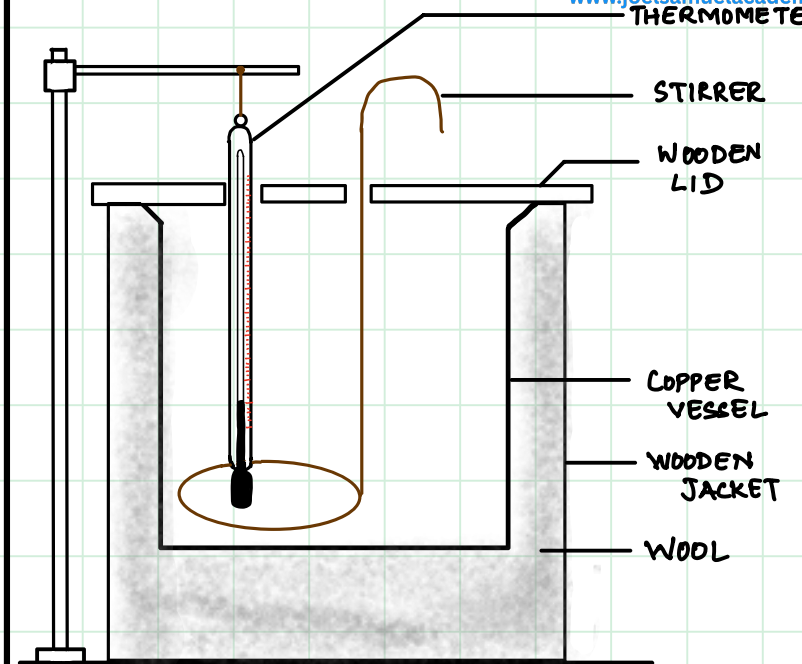
Phases	c
Solid (ice)	$2100 \text{ J kg}^{-1} \text{K}^{-1}$
Liquid (water)	$4200 \text{ J kg}^{-1} \text{K}^{-1}$
Gas (steam)	$460 \text{ J kg}^{-1} \text{K}^{-1}$

- Maximum value of Sp. heat capacity is that of hydrogen: $14630 \text{ J kg}^{-1} \text{K}^{-1}$

Specific heat capacity of some common substances

Substance	Specific heat capacity	
	in $\text{J kg}^{-1} \text{K}^{-1}$	in $\text{cal g}^{-1} \text{ }^\circ\text{C}^{-1}$
1. Lead	130	0.031
2. Mercury	139	0.033
3. Brass	380	0.092
4. Zinc	391	0.093
5. Copper	399	0.095
6. Iron	483	0.115
7. Glass (flint)	504	0.12
8. Aluminium	882	0.21
9. Kerosene oil	2100	0.50
10. Ice	2100	0.50
11. Sea water	3900	0.95
12. Water	4180	1.0

Calorimeter



Function: A calorimeter is a cylindrical vessel, used to measure the heat gained or lost by a body when it is mixed with another body.

Construction:

- Made of thin sheet of copper.
- Outer & inner surfaces are polished
- Placed in a wooden jacket.
- Space b/w calorimeter & jacket is packed with wool.
- Covered with wooden lid.

Why Copper → Low sp. heat capacity

Why polish → To reduce heat loss by radiation

Why jacket → For insulation

Why wool → To avoid heat loss by conduction

Why wooden lid → To avoid heat loss by convection

10. 45 g of water at 50°C in a beaker is cooled when 50 g of copper at 18°C is added to it. The contents are stirred till a final constant temperature is reached. Calculate the final temperature. The specific heat capacity of copper is $0.39 \text{ J g}^{-1} \text{ K}^{-1}$ and that of water is $4.2 \text{ J g}^{-1} \text{ K}^{-1}$. State the assumption used.

Ans. 47°C

Water
 $m_1 = 45 \text{ g}$
 $t_1 = 50^{\circ}\text{C}$
 $c_w = 4.2 \text{ J g}^{-1} \text{ K}^{-1}$

Copper
 $m_2 = 50 \text{ g}$
 $t_2 = 18^{\circ}\text{C}$
 $c_c = 0.39 \text{ J g}^{-1} \text{ K}^{-1}$

Let final temp. be $t^{\circ}\text{C}$

As per Principle of Calorimetry: Heat lost by hot body = Heat gained by cold body

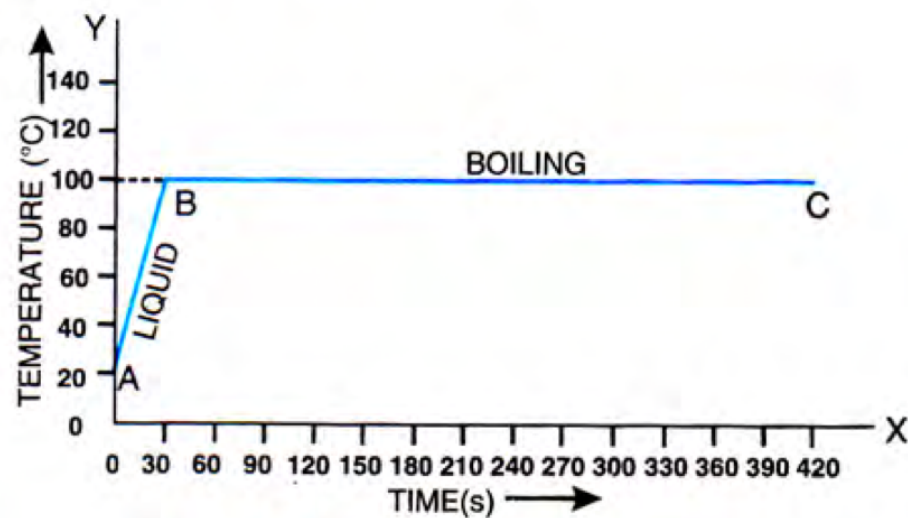
$$m_1 c_1 (t_1 - t) = m_2 c_2 (t - t_2)$$

$$45 \text{ g} \times 4.2 \frac{\text{J}}{\text{g K}} \times (50 - t) = 50 \text{ g} \times 0.39 \frac{\text{J}}{\text{g K}} \times (t - 18)$$
$$t = 47^{\circ}\text{C}$$

Final temp. of mix. = 47°C

Assumption: No heat is lost to the surrounding

Heating Curve for Water



Experiment:

- Heat water (at 20°C) in a flask and note temp. every half minute.
- Plot a graph of temp. against time.

Conclusion (from graph)

- From A to B, the temp. of water increases from 20°C to 100°C .
- Once water attains 100°C , the temp. remains constant (part BC).

Volume change on Boiling

- All liquids expand on boiling.
- 1m^3 of water at 100°C becomes 1760cm^3 of steam at 100°C

Pressure on Boiling Point

- Boiling point of a liquid increases with presence of impurities and vice-versa. (760mm Hg)
- Boiling pt. of water = 100°C at 1 atm.
- In a pressure cooker, the pressure is approx. 1.75 atm. , due to which the B.pt. of water rises to $120-125^{\circ}\text{C}$.
- This helps cook food faster.
- At high altitudes, the atm. pressure being low, the B.pt. of water falls to below 100°C , due to which food items do not cook well (water vaporises below 100°C .)

Impurities & Boiling point

- B.pt. of a liquid increases by addition of impurities to it.
 - If common salt is added, water boils at a temp. $> 100^{\circ}\text{C}$.
- Q. Why do we add salt to water while cooking?
- a.) Adding salt raises the B.pt. of water above 100°C . This provides more heat for the food to cook properly.

2. How much heat energy is released when 5.0 g of water at 20°C changes into ice at 0°C ? Take specific heat capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$, specific latent heat of fusion of ice = 336 J g^{-1} .

$$m = 5\text{g}$$

$$T_1 = 20^{\circ}\text{C}$$

$$T_2 = 0^{\circ}\text{C}$$

$$c_w = 4.2 \text{ J g}^{-1} \text{ K}^{-1} \text{ or } 4.2 \text{ J g}^{-1} ^{\circ}\text{C}^{-1}$$

$$L = 336 \text{ J g}^{-1}$$

$$Q = Q_1 + Q_2$$

Total heat Energy = Heat to change water at 20°C to water at 0°C + Heat to convert water at 0°C to ice at 0°C

$$Q = mc\Delta T + mL$$

$$= 5\cancel{\text{g}} \times 4.2 \frac{\text{J}}{\cancel{\text{g}}^{\circ}\text{C}} \times (20-0) + 5\cancel{\text{g}} \times 336 \frac{\text{J}}{\cancel{\text{g}}}$$

$$Q = 420 \text{ J} + 1680 \text{ J}$$

$$\text{Total heat released} = 2100 \text{ J}$$