Chapter –1 Heat

S.NO	Name of the Physical Quantity	Units	
		C.G.S	S.I
1.	Temperature	0^oC (Degree configurable)	Kelvin (k)
2.	Heat (Q)	Calorie (cal)	Joule (J)
3.	Specific Heat $S = \frac{Heat\ energy(Q)}{Mass\ (m) \times temperature\ difference}$	Cal/g - ^oC	J/kg – k
4.	Latent Heat $L = \frac{Heat\ energy(Q)}{mass}$	Cal/g	J /kg

Summary

Heat is a form of energy which transfers from high temperature body to low temperature body. The temperature of a body determines whether or not the body is in thermal equilibrium with the neighbouring systems. Thermometer is the instrument to measure the temperature. When heat is supplied to the body the internal energy increases.

The average kinetic energy of molecules of the body is directly proportional to the absolute temperature. The amount of heat energy absorbed by substances depends on the Mass of the body, temperature of the body and specific heat of the substances.

The specific heat of a substance gives us an idea of the degree of reluctance of a substance to change its temperature. The specific heat of a body determines with the principle of "Method of Mixtures".

When a liquid is exposed to air, the molecules at the surface keep on escaping the surface till the entire liquid disappears in air. This process is called evaporation. The reverse process of evaporation is condensation.

The amount of water vapour present in air is called humidity. In the winter when temperature goes down, the water vapour condensed on the grass and flowers. The water droplets condense on such surfaces is known as dew. If the temperature falls further, the water molecules condense on the dust particles in air forms fog.

The liquid state matter converts into gases state at a temperature. This temperature is known as boiling temperature and the processed is called boiling. The temperature is kept at constant during this process. The heat energy required to convert the liquid state matter into gases state at constant temperature is called "Latent heat of vaporization".

The process in which the solid phase changes to liquid phase at a constant temperature is called melting. This constant temperature is called melting point. The heat energy required to convert "1gram" of solid completely into liquid at a constant temperature is called Latent heat of fusion.

Freezing is the process to convert liquid to solid. In this process internal energy of the system decreases.

Problems

Formulae

1. Temperature in Kelvin = 273 + [Temperature in degree Celsius]

   $K = 273 + t^{o}c$

2. Heat energy $Q = ms\Delta T = ms\,(T_2 - T_1)$

3. Principle of method of mixtures

   Net Heat lost (Q_1) = Net Heat gained (Q_2)

4. Specific Heat of solid

   $$s_l = \frac{\left[m_1 s_c + (m_2 - m_1)s_w\right](T_3 - T_1)}{(m_3 - m_2)(T_2 - T_3)}$$

5. Latent Heat $L = \frac{Q}{m}$.

1. What would be the final temperature of a mixture of 50g of water at 20^0c temperature and 50g of water at 40^0c temperature (As_1)?

Sol:

Mass of hot water (m_1) = 50g

Temperature of hot water (t_2) = 40^0c

Specific heat of water (s) = 1 cal/g -^{0}c

Final temperature of hot water (T_1) = T (say)

Heat lost by hot water (Q_1) = $m_1 s\,(T_2 - T_1)$

$Q_1 = 50 \times 1 \times (40 - T)$

Mass of cold water (m_2) = 50g

Temperature of cold water (T_1) = 20^0c

Final temperature of cold water (T_2) = T

Heat gained by cold water $Q_2 = m_2 s(T_2 - T_1)$

$Q_2 = 50 \times 1 \times (T - 20)$

According to principle of method of mixture $Q_2 = Q_1$

$50 \times 1 \times (40 - T) = 50 \times 1 \times (T - 20)$

$40 - T = T - 20$

$40 + 20 = 2T$

$2T = 60$

$T = \frac{60}{2} = 30^0$

$1T = 30^0c$

Final temperature of mixture = 30^0c

2. Answer these (AS_1)

(a) How much energy is transferred when 1gm of boiling water at 100^0c condenses to water at 100^0c?

Sol: We know that latent heat of vaporization of water (L) = 540 cal/g

Mass of water (m) = 1g

Energy transfer (Q) = mL

$= 1 \times 540$

$= 540$ cal.

Hence heat energy required to transferred 1gm boiling water at 100^0c condenses to water at 100^0c is 540 cal

(b) How much energy is transferred when 1 gm of boiling water at 100^0c cools to water at 0^0c?

Sol: Mass of the water (m) = 1g

Initial temperature (T_1) = 0^0c

Final temperature (T_2) = 100^0c

Specific Heat of water (s) = 1 cal /g - ^oc

Heat energy transferred $Q = ms(T_2 - T_1)$

$Q = 1 \times 1 \times (100 - 0)$

$Q = 100$ cal

(c) How much energy is released or absorbed when 1 gm of water at 0^0c freezes to ice at 0^0c.

Sol: Latent heat of ice = 80 cal

Mass of ice = 1 g

Heat energy Released Q = mL

$Q = 1 \times 80$

$Q = 80$ cal.

(d) How much energy released or absorbed when 1 gm of steam at 100^0c turns to ice at 0^0c.

Sol: we know that

Latent Heat of steam (L_s) = 540 cal / g

Latent Heat of ice (L_i) = 80 cal / g

Specific Heat of water (s_w) = 1 cal / g- ^{o}c

Mass of steam (m) = 1g

There are three stages for formation of ice.

1) 100^0c steam to 100^0c water

Heat released $Q_1 = m L_s$

$= 1 \times 540 = 540$ cal

2) 100^0c water to 0^0c of water

Heat energy released $Q_2 = ms(T_2 - T_1)$

$= 1 \times 1 \times (100 - 0)$

$= 100$

3) 0^0c of water to 0^0c of ice

Heat released $Q_3 = m L_i$

$= 1 \times 80$

$= 80$

Total heat energy released

$Q = Q_1 + Q_2 + Q_3$

$Q = 540 + 100 + 80$

$Q = 720$ cal

3. Convert 20^0c into Kelvin scale? (AS_1)

Kelvin scale = 273 + centigrade scale

K = 273 + 20

K = 293

$\therefore 20^0$**c** = 293 k

4. Suppose that 1l of water is heated for a certain time to rise and its temperature by 2^0c. If 2l of water is heated for same time, by how much will its temperature rise? (AS_7)

Sol: Given volume of the water = 1 lt

Mass of the 1lt water (m) = 100g (llt = 1000g)

Specific heat of water (s_w) = 1 cal/g- ^{o}c

Temperature difference $\left(\Delta \bar{F}\right) = 2°c$

Heat energy required $Q = ms_w\Delta T$

Q = 100 × 1 × 2 = 2000 cal

Volume of the water = 2lt

Mass of the water (m_2) = 2 × 1000 = 2000g

Specific heat of water (s_w) = 1 cal / g – ^{0}c

Temperature difference $(\Delta T) = ?$

Heat energy supplied in same time is same for two cases

$\therefore$ Heat energy (Q_2) = 2000 cal

$\therefore$ 2000 = 2000 × 1 × ΔT

ΔT = 1^0c.

1 Mark Questions

1. Define temperature?

A. **Temperature:** The degree of hotness or coldness.

2. What is thermal equilibrium?

A. The state of a thermal equilibrium denotes a state of body where it neither receives nor gives out heat energy.

3. What is "Heat"?

A. **Heat:** It is a form of energy in transit that flows from a body at higher temperature to a body at lower temperature.

4. Define "Calorie"?

A. **Calorie:** The amount of heat required to raise the temperature of 1 gram of water by 1^0c is called calorie. It is the C.G.S. unit of "Heat".

5. Write the definition of "Specific Heat" (S).

A. **Specific Heat(S):** The specific heat of a substance is the amount of heat required to raise the temperature of unit mass of the substance by one unit.

6. How much heat energy is required to raise the temperature of 1g mass of water to 14.5^0c to 15.5^0c?

A. One calorie

7. What is evaporation?

A. "The process of escaping of molecules from the surface of a liquid at any temperature is called evaporation"

8. What is "dew"?

A. **Dew:** The water droplets condensed on window panes, flower, grass etc during the winter nights is dew.

9. What is "Fog"?

A. **Fog:** During the low temperature, the water molecules presents in vapour condense on the dust particles in air and form small droplets of water. These droplets keep floating in the air and form a thick mist. This thick mist is called fog.

10. Define Boiling?

A. "Boiling is a process in which the liquid phase changes to gaseous phase at a constant temperature at a given pressure."

11. What is Latent Heat of Fusion?

A. "Heat energy required to converted 1g of solid completely into liquid at a constant temperature is called Latent Heat of fusion"

12. What happens to the water when wet clothes dry? (AS_3)

A. Water present in the clothes changes to vapour state.

2 Mark Questions

1. Write the principle of Mixture?

A. "When two or more bodies at different temperature are brought into thermal contact, then Net heat lost by the hot bodies is equal to Net heat gained by the cold bodies until they attain thermal equilibrium".

Net heat lost = Net heat gain

2. Differentiate between evaporation and Boiling? (As_1)

Evaporation	Boiling
1.It takes place at any temperature	1. Boiling occurs at a definite temperature called Boiling point
2.The temperature of liquid falls during evaporation	2.The temperature remains constant until all of the liquid has boiled away

3. Explain why dogs pant during hot summer days using the concept of evaporation? (AS_1)

A. Evaporation is the cooling phenomenon when dogs pant, the water molecules present on the tongue and in the mouth evaporate. This helps to cool the interior parts of the body.

4. Why do we get dew on the surface of a cold soft drink bottle kept in open air?

A. Cold soft drink bottle is almost at below 0^{o}c temperature. When it is kept in open air, the water vapour in air condenses and forms water droplets on it.

5. Equal amounts of water are kept in a cap and a dish. Which will evaporate faster? Why?

A. The state of evaporation of a liquid depends on its surface area, temperature and amount of vapour already present in the air.

The surface area of the liquid in cap is less than the surface area of the liquid in dish.

Hence the liquid in dish evaporates quickly.

6. If you are chilly outside the shower state, why do you feel warm after the bath if you stay in the bathroom?(AS_7)

A. We feel warm after finish our bath under the shower. In the bathroom, the number of vapor molecules per unit volume is greater than the number of vapour molecules per unit volume outside the bathroom. When we try to dry ourselves with a towel, the vapour molecules surrounding us condense on our skin. This condensation makes us feel warm.

7. How do you appreciate the role of the higher specific heat of water in stabilizing atmospheric temperature during winter and summer seasons?

A. Earth receives huge amount of heat energy from the Sun every day. With this heat, the Earth must have been heated beyond the level that it can withstand. But this is not actually happen because of the water bodies such oceans, seas and rivers. Oceans act as store houses of heat energy from the Sun.

During the winter and summer the water acts as balancing factor for controlling the temperature with its high specific heat.

8. What role does specific heat play in keeping a watermelon cool for a long time after removing it from a fridge on a hot day? [AS7]

A. Water has greater specific heat (1cal/g-^{o}c or 4180 J/kg – k). Greater the specific heat, the rate of rise or fall in temperature is low.

Watermelon contains large percentage of water. When it is in fridge the temperature of watermelon becomes very low. If it is taken out temperature (low), it will be remain low for a longtime.

4 Mark Questions

1. The surrounding air becomes warm or cool when vapour phase of H_2o condenses. Explain?

A. Place a glass tumbler on the table and pour cold water up to half its height. After 2 or 3 minutes water droplets form on the glass tumbler.

Air surrounding us contains water vapour. It is of high temperature than the water in the tumbler.

During their motion, the water molecules of air strike the surface of the glass tumbler which is at low temperature (cool) and they lose their kinetic energy which lowers their temperature and they get converted into droplets. The kinetic energy lost by the water molecules in air is gained by water molecules in glass through tumbler. Hence the temperature of water in glass increases. This process is called condensation. It is a warming process.

Hence the surrounding air becomes warm.

2. Explain the procedure of finding specific heat of solid experimentally. (AS_1)

A. Aim: To find the specific heat of given solid.

Material Required: Calorimeter, thermometer, stirrer water, steam heater, wooden box and lead shots.

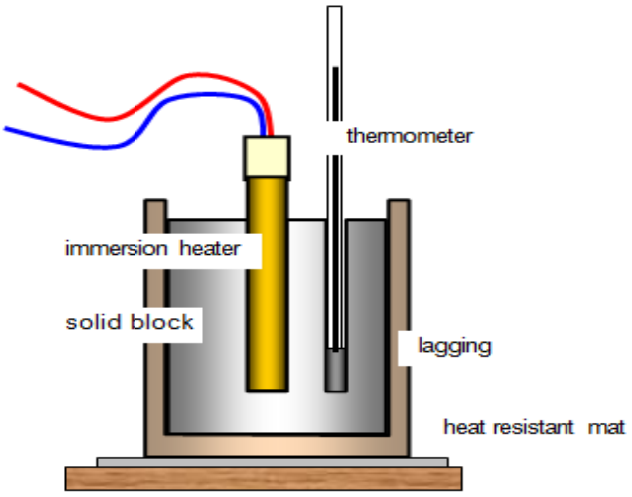


Figure 1

Procedure: Measure the mass of the calorimeter along with stirrer (m_1). Now fill one third of the volume of calorimeter with water as (m_2). Its temperature is T_1.

Take a few lead shots and place them in hot water or steam heater. Heat them up to a temperature 100^0c. Let this temperature be T_2.

Transfer the hot lead shots quickly into the calorimeter. Measure the temperature of water and lead shots. Note the resultant temperature as T_3. Now measure the mass of calorimeter along with content as m_3.

Mass of the water = $m_2 - m_1$

Mass of the lead shots = $m_3 - m_2$

Specific heat of calorimeter = S_c

Specific heat of water = S_w

Specific Heat of lead shots= s_l

Initial temperature of water = T_1

Temperature of Lead shots = T_2

Final temperature of the system = T_3.

According to the method of mixtures we know that

Heat lost by the solid = Heat gain by the calorimeter + Heat gained by the water

$(m_3 - m_2)s_l (T_2 - T_3) = m_1 s_c (T_3 - T_1) + (m_2 - m_1) s_w (T_3 - T_1)$

$$s_l = \frac{\left[m_1 s_c + (m_2 - m_1) s_w\right](T_3 - T_1)}{(m_3 - m_2)(T_2 - T_3)}$$

By the above formula one can calculate the specific heat of the lead shots (solid)

3. Your friend is asked to differentiate between evaporation and boiling. What Questions could you ask to make him to know the differences between evaporation and boiling? (As_2)

A. i. Does evaporation take place at all temperatures?

ii. Does boiling take place at all temperatures?

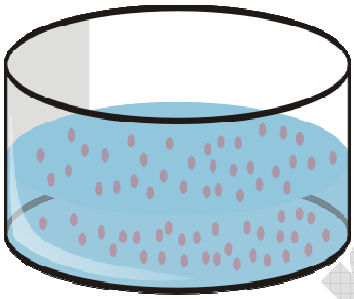
iii. Is boiling surface phenomena?

iv. Is evaporation a surface phenomena?

v. Is evaporation a cooling process or warming process?

4. Suggest an experiment to prove that the rate of evaporation of a liquid depends on its surface are and vapour already present in surroundings?

A. 1. Rate of evaporation depends on surface Area:



Take 10 ml of volatile liquid in a cap and another 10 ml of volatile liquid in

dish. The surface area of liquid in a dish is more than the area of liquid in a cap.

After some time, the liquid disappears in dish whereas in cap liquid remains. This is only due to difference in area of liquid.

2. **Rate of evaporation depends on vapour already present in it**

Take a few drops of spirit in two Petri dishes separately. Keep one of the dishes containing spirit under a ceiling fan and switch on the fan. Keep another dish with its lid closed. Observe the quantity of spirit in both dishes after 5 minutes.

We will notice that spirit in the dish that is kept under the ceiling fan disappears, where as we find some spirit left in the dish that is kept in hidden dish.

This produced that evaporation faster at no vapour present in surrounding air.

5. Place a Pyrex funnel with its mouth down in a sauce pan full of water in such a way that the stem tube of the funnel is above the water or pointing upward into air. Rest the edge of the bottom portion of the funnel on a nail or on a coin so that water can get under it. Place the pan on a stove and heat it till it begins to boil. Where do the bubbles form first? Why? Can you explain how a geyser works using this experience?

A. i) The boiling point of water increases with increase in pressure.

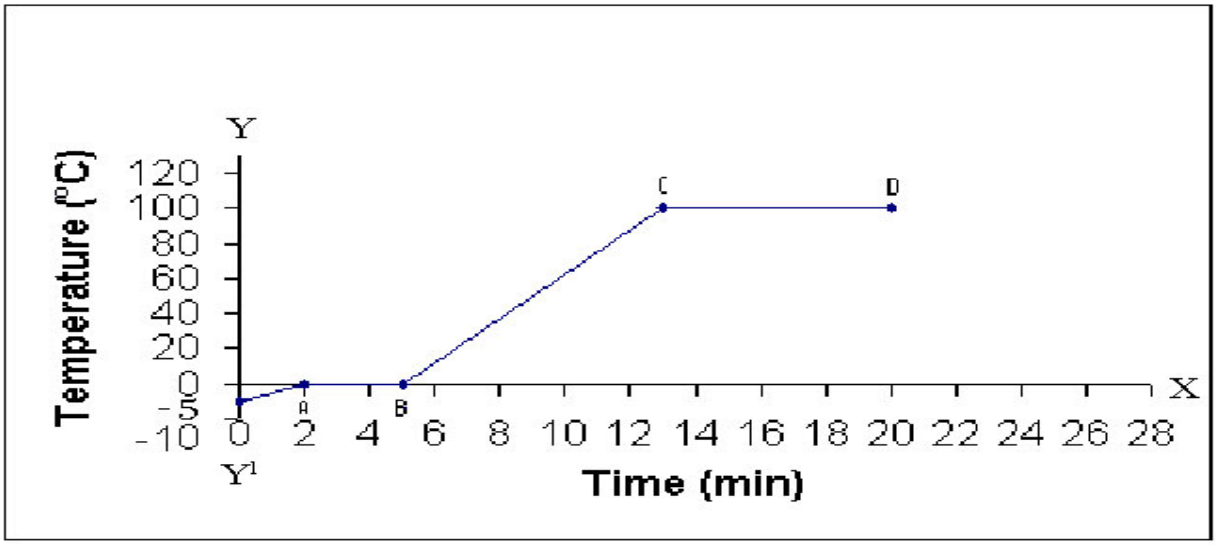
ii) So the bubbles start from the bottom at the sauce pan where the nail or coin arranged.

iii) In geyser, boiling begins near the bottom and the bubbles that are raising above push the water out starting the eruption.

iv) This is the laboratory demonstration of working of natural geyser.

6. Assume that heat is being supplied continuously of 2kg of ice at -5^0c. You know that ice melts at 0^0c and boils at 100^0c. Continue the heating till it starts boiling. Note the temperature every minute. Draw the graph between the temperature and time using the values you get. What do you understand from the graph? Write the conclusions (AS_5).

A.



1) OA region tells the temperature of ice increases from -5^0c to 0^0c.
2) In AB region, the supplied heat energy is utilized for conversion of ice to water.
3) In BC region, water temperature increases from 0^0c to 100^0c.
4) Between C and D, water converts to steam at constant 100^0c.

Important Table

Substance	Specific heat	
	In cal/g-°C	In J/kg-K
Lead	0.031	130
Mercury	0.033	139
Brass	0.092	380
Zinc	0.093	391
Copper	0.095	399
Iron	0.115	483
Glass(flint)	0.12	504
Aluminum	0.21	882
Kerosene oil	0.50	2100
Ice	0.50	2100
Water	1	4180
Sea water	0.95	3900

Fill in the Blanks

1. Heat is a form of _____. **(Energy)**
2. Hot and cold are _____ terms. **(Relative)**
3. When heat energy enters, our body we get a feeling of _____. **(Hotness)**
4. Heat energy transferred from the _____ body to the _____ body. **(Hotter, Colder)**
5. _____ is a measure of thermal equilibrium. **(^{0}c)**
6. The S.I. unit of heat is _____. **(Joule, J)**
7. C.G.S. unit of heat is _____. **(Calorie(cal))**
8. 1 calorie = _____ joules. **(4.186)**
9. Temperature measured on Kelvin scale is called _____ temperature. **(Absolute)**
10. The average kinetic energy of molecules of a hotter body is ____than that of colder body. **(Greater)**
11. S.I unit of specific heat is _____. **(J/kg - k)**
12. 1cal/g-^{0}c = _____ J/kg – k. **(4.2×10^3)**
13. _____ gives us of a substance to change its temperature. **(specific heat)**
14. The total energy of the system is called _____ of the system. **(Internal energy)**
15. Evaporation is a _____ phenomenon. **(Surface)**
16. _____ is a cooling process. **(Evaporation)**
17. _____ is a warming process. **(Condensation)**
18. The amount of water vapour in air is called _____. **(Humidity)**
19. When water is heated, the solubility of gases contains _____**(reduces)**
20. Heat energy utilized to change the state of liquid to vapour _____. **(latent heat of vaporization)**
21. _____ is the S.I. unit of vaporization. **(J/kg)**
22. Latent heat of vaporization of water is _____. **(540 Cal/g)**
23. Ice melting point _____. **(0^0c or 273 k)**

24. Freezing of water takes place at _____ temperature and normal pressure. **($0^{o}c$)**

25. On freezing volume of the water _____. **(increases)**

26. Temperature of a body is directly proportional to _____ **(average kinetic energy)**

27. According to the principle of method of mixture, the net heat lost by the hot bodies is equal to _____ by the cold bodies. **(Heat gained)**

28. The sultriness in summer days is due to _____. **(Humidity)**

29. _____ is used as coolant. **(water)**

30. Ice floats on water becomes _____. **(lesser density)**

Multiple Choices

1. If K_B: is the average kinetic energy of the molecules and "T" is the absolute temperature. Then **(b)**

a) $K_B = T$ b) $k_B \alpha T$ c) $k_B \alpha \frac{1}{T}$ d) $k_B \alpha \sqrt{T}$

2. Of the following which determines the direction of heat flow. **(b)**

a) Thermometer b) Temperature

c) Specific heat d) Latent Heat

3. 'Q' is heat energy, 'S' is specific Heat 'ΔT' is the temperature difference, 'm' is the Mass of the substance than Q = **(a)**

a) $ms\Delta T$ b) $\frac{m}{S\Delta T}$ c) $\frac{ms}{\Delta T}$ d) $\frac{1}{ms\Delta T}$

4. C.G.S. unit of specific heat is - **(c)**

a) J/kg – k b) J/g – k c) cal/g – ^{o}c d) Cal/kg – ^{o}c

5. The specific heat(s) of a substance depends on its- **(c)**

a) Temperature b) Mass c) Nature d) All the above

6. Of the following which has more specific heat? **(d)**

a) Kerosene oil b) Iron c) Copper d) Water

7. "Store Houses" for the earth are- **(d)**

a) Animals b) Forests c) Hills d) Oceans

8. What happens to the temperature during evaporation? **(a)**

a) Falls b) Rise c) Constant d) Not linear

9. Rate of evaporation of a liquid depends on its- **(d)**

a) Surface area b) Temperature

c) Amount of water vapour d) All the above

10. C.G.S. unit of latent heat of vaporization- **(c)**

a) J/kg b) J – kg c) Cal/g d) Cal – kg

11. Boiling point of water at 1 atm- **(d)**

a) 100k b) 273^0c c) 3073k d) 373 k

12. Of the following, which parameter increases when heat energy supplied to the ice? **(a)**

a) Temperature b) Volume

c) Internal energy d) All the above

13. The process of converting solid into a liquid is- **(a)**

a) Melting b) Boiling c) Freezing d) None of the above

14. The value of Latent heat of fusion of ice- **(a)**

a) 80 cal/gm b) 80j – k/gm c) 80 j/kg d) 100 cal /gm

15. During the process conversion from liquid to solid, the internal energy of water- **(c)**

a) Remains constant b) Increases

c) Decreases d) None of the above

16. Which of the following is a warm process- **(b)**

a) Evaporation b) Condensation

c) Cooling d) All the above

17. Melting is a process in which solid phase changes to- **(b)**

a) Liquid phase b) Liquid phase at constant temperature

c) Gaseous phase d) Any phase

18. Three bodies A, B and C are in thermal equilibrium. The temperature of B is 45^{o}c then the temperature of c is ___ **(a)**

a) 45^{0}c b) 50^{0}c c) 40^{0}c d) Any temperature

19. The temperature of a steel rod is 330k. Its temperature in ^{0}c is _____ **(b)**

a) 55^{0}c b) 57^{0}c c) 59^{0}c d) 53^{0}c

20. When ice melts, it temperature- **(a)**

a) Remains constant b) Increases

c) Decreases d) Cannot say