HEAT

Heat

The Concept of Heat and Temperature (Heat in macroscopic sense)

- Heat is a form of energy
- that causes an increase in temperature of a body to which it is added
- and a decrease in temperature of a body from which it is removed,
- provided the body does not change state during the process.

Internal Energy
(heat in microscopic sense)

- Internal energy of a body is the sum of the kinetic energy and potential energy

- due to the random motion of the atoms and molecules of which the body is composed.

Heat as Energy

- Since heat is a form of energy,
- it is found either as potential or stored energy
- or kinetic or active energy

food — **25%** — **75%**

Potential energy → **mechanical work in muscle movement** + **heat for body warmth**

Units of heat (ΔQ)

SI	**-J , kJ , MJ**	**1cal**	**-4.186 J**
CGS	**-cal**	**1kcal**	**-4186 J**
MKS	**-kcal**		
FPS	**-Btu**		

The Heat Balance of Human Body

If a human body had no means of losing heat, it has been calculated that the body temperature will rise by nearly $1^{\circ}C$ every hour until in a few hours a person would collapse with heat stroke.

The final balance of heat losses and gains

Heat gain

a. Metabolism or burning food in the tissue
b. Shivering or muscle action
c. Hot food and drink
d. Warm surrounding (climate or home warmth)

Heat loss

a. convection ,conduction ,radiation
b. sweating
c. cold food and drinks
d. faeces / urine
e. Lung moisture evaporation

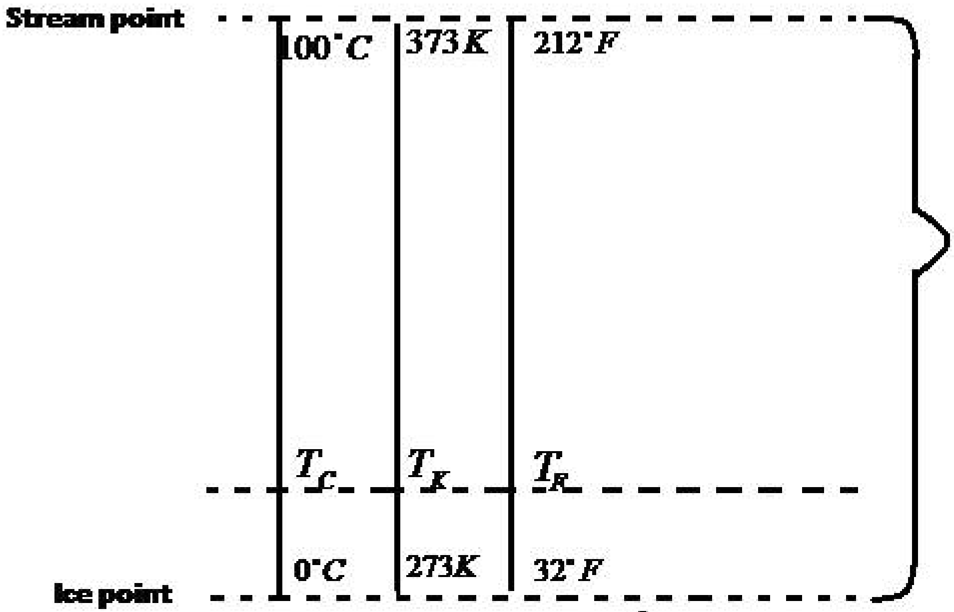
Temperature

- The temperature of a body in macroscopic sense is an indicator of the direction of internal energy flow.
- In a microscopic sense it is a measure of average molecular kinetic energy.

The Temperature scales

The three scales commonly used are

1. Celsius scale or Centigrade scale
2. Fahrenheit scale
3. Kelvin scale or Absolute scale



$$\frac{T_K - 273}{373 - 273} = \frac{T_K - 0}{100 - 0}$$

$$100\,(T_K - 273) = 100\,(T_C)$$

$$T_K = T_C + 273$$

$$\frac{T_C - 0}{100 - 0} = \frac{T_F - 32}{212 - 32}$$

$$180\,(T_C) = 100\,(T_F - 32)$$

$$T_C = \frac{5}{9}(T_F - 32)$$

$$\frac{\Delta T_C}{100\ ^\circ C} \rightarrow \frac{\Delta T_F}{180\ ^\circ F}$$

$$1\ ^\circ C \rightarrow \frac{9}{5}\ ^\circ F$$

$$\left[\ eg.\ 6\ ^\circ C = 6 \times \frac{9}{5}\ ^\circ F\ \right]$$

Measurement of Temperature

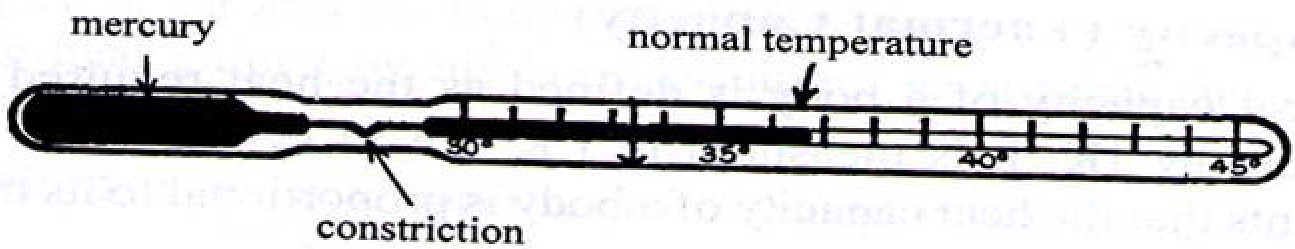
Thermometer

An instrument, which measures the temperature , is called a thermometer.

Types of Thermometer

1. Clinical thermometers
2. Electronic thermometers

1.Clinical Thermometer



- This is a mercury-in-glass thermometer with a range between 30°C and 45°C.
- Normal body temperature is 36.8°C.
- An important feature of this thermometer is the constriction in the capillary tube , which breaks the mercury thread when the thermometer is removed from the patient.
- This prevents the mercury returning to the bulb as it cools once a patient's temperature has been taken.
- Therefore the temperature need not be read immediately.

2. Electronic Thermometer

(a) Thermocouples

- A thermocouple is a temperature is a temperature sensor which consists of a junction between two different metals.

- When dissimilar metals are brought together, a contact voltage is generated which is proportional to the temperature of the junction.

- The voltage can be calibrated and converted to a temperature indication on a meter or digital display.

(b) The Electrical Resistance Thermometer

- The thermal agitation of the atoms of a metal increases with temperature , its resistance to electric current flow increases.

- The fact that the resistance is proportional to temperature is used to advantage by construction temperature sensors of platinum wire or tape.

- If a constant , controlled voltage is placed across the sensing element , then the current flowing through the sensor can be calibrated in terms of temperature.

(c) The thermistor

- The thermistor sensor is similar to the reisitance thermometer in that the electrical resistance changes with temperature.

- However with the thermistor the resistance decreases with temperature increase.

- The thermistor is made of a compressed mixture of metal oxides.

- The material can be molded into many shapes and can be miniaturized.

- Temperature difference as small as 0.01°C are measurable.

Specific Heat Capacity and Measurement of Heat

Heat Capacity (Thermal Capacity)

Heat capacity of a body is defined as the heat required to raise its temperature by 1K (by one degree).

$$C = \frac{\Delta Q}{\Delta T}$$

C= heat capacity

SI unit - JK^{-1}

- It is found from experiments that the heat capacity of a body is proportional to its mass.

Specific Heat Capacity

The specific heat capacity of a body is defined as the heat required to raise the temperature of unit mass of the body through 1K (through one degree).

$$c = \frac{1}{m}\frac{\Delta Q}{\Delta T}$$

m = mass of the body

c = specific heat capacity

$$\Delta Q = m\, c\, \Delta T$$

Unit of Specific Heat Capacity

SI………… $Jkg^{-1}K^{-1}$

CGS……… $cal\ g^{-1}\ {}^{\circ}C^{-1}$

MKS……. $kcal\ kg^{-1}\ {}^{\circ}C^{-1}$

FPS……… $Btu\ lb^{-1}\ {}^{\circ}F^{-1}$

Thermal Equilibrium

If the two bodies are said that there will be no transfer of internal energy , then the two bodies have the same temperature , they are said to be in thermal equilibrium.

Law of Heat Exchange (energy conservation)

If the system is completely isolated the heat lost by one part of the system is equal to the heat gained by the other part.

- The specific heat capacity of water $(c_w) = 1.0 cal g^{-1} {}^{\circ}C^{-1} (or)$ $4.2 kJ kg^{-1} K^{-1}$

- Since the human body contains over 70% of water , the specific heat of human body is also $4.2 J kg^{-1} {}^{\circ}C^{-1}$

Example

A man weights 70kg and his temperature rises from $37^{\circ}C$ to $39^{\circ}C$ in 1hr , calculate the heat gained by his body assuming its specific heat capacity is $4.2 kJkg^{-1} {}^{\circ}C^{-1}$.

Heat gained = mass × specific heat capacity × temperature change

$$\Delta Q_{gained} = m\, c\, \Delta T$$

$$= 70 \times 4.2 \times 2$$

$$= 588\ kJ$$

The Energy Value of Foods:

It is defined as the quantity of heat liberated per unit mass (or unit volume) when the substance is completely burned.

- Food is essentially a source of energy for the body , in addition to being a substance , which builds up the body and protects it from certain diseases.

The heat energy value for one-gram protein of

Pure carbohydrate	$= 17\ kJ\ g^{-1}$
Protein	$= 17\ kJ\ g^{-1}$
Ethanol	$= 29\ kJ\ g^{-1}$
Fat	$= 37\ kJ\ g^{-1}$

Example

1. A 30g of chocolate contains 1.3g of protein, 9.2g of fat and 15.0g of carbohydrate.

   The calorific or heat energy value of 30g of chocolate can be calculated as follows;

   protein $= 13 \times 17 = 22 kJ$

   lipid(fat) $= 9.2 \times 37 = 340 kJ$

   carbohydrate$= 15.0 \times 17 = 266 kJ$

   Therefore total kilojoules in 30g of chocolate = 618 kJ

2. Bread has the following composition per 30g: 2.3g protein , 0.2g fat and 15.6g carbohydrate. What will be the energy value of 120g of bread?

The energy value of 30g of bread

$$\text{protein} = 2.3 \times 17 = 39.1 kJ$$

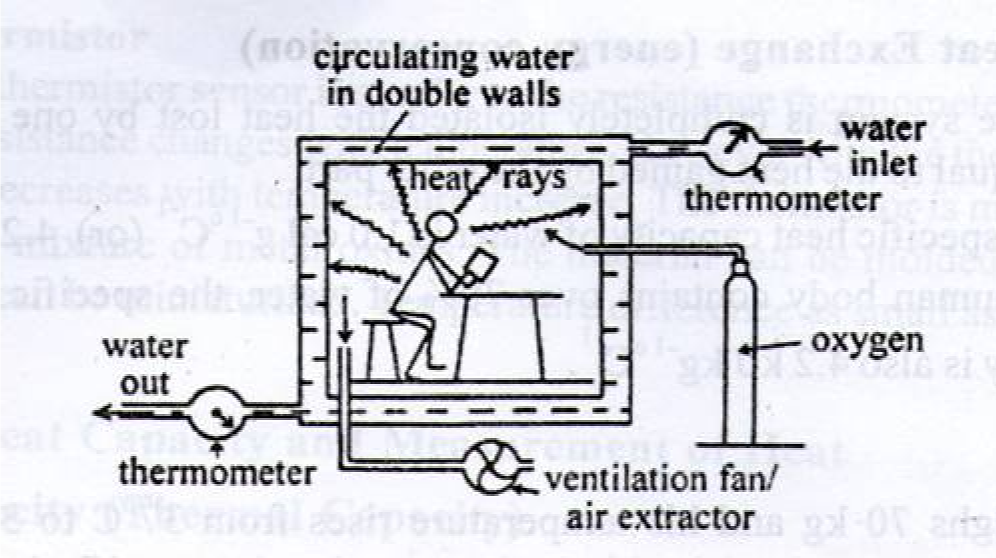
$$\text{fat} = 0.2 \times 37 = 7.4 kJ$$

$$\text{carbohydrate} = 15.6 \times 17 = 265.3 kJ$$

$$\therefore \textit{Total kilojoules in } 30g \textit{ of bread} = 311.7 kJ$$

$$\textit{Total kilojoules in } 120g \textit{ of bread} = \frac{120}{30} \times 311.7 kJ$$

$$= 1246.8 kJ$$



A normal man of 70kg will gain about 300 kJ of heat energy per hour. This can be measured using the human calorimeter.

Some recommended daily in takes of energy values:

Babies up to one-year-old 3.3MJ

Boys 15 to 18 years 12.6MJ

Girls 15 to 18 years 9.6MJ

The daily intake of energy will depend on age, bodyweight, health, occupation and other factors such as climate.

CHANGE OF PHASE

The term change of phase used hear is related to the fact that matter exits either as a solid, liquid or gas.

Transition from one state to another are accompanied by the absorption or liberation of heat.

During the change in state from a solid to a liquid, or liquid to vapour and a vice versa, the temperature mysteriously remains constant, even through heat is being added continually to a substance.

Specific Latent Heat of Fusion (L_f)

The specific latent heat of fusion of a substance is the quantity of heat required to change a unit mass of the substance from solid to liquid state without change in temperature.

In SI unit – The specific latent heat of fusion of ice = $336 kJ kg^{-1}$

In CGS unit-The specific latent heat of fusion of ice= $80 cal\, g^{-1}$

Specific Latent Heat of Vaporization

The specific latent heat of vaporization of a substance is the quantity of heat required to change a unit mass of the substance from liquid to vapour state without change in temperature.

In SI unit – The specific latent heat of vaporization of water $= 2260 kJkg^{-1}$

In CGS unit-The specific latent heat of vaporization of water$= 540 cal g^{-1}$

Evaporation of sweat from the skin

When a liquid changes to vapour or when a liquid evaporates heat is taken from the remaining liquid and the surrounding bodies. The temperature therefore decreases.

For this reason evaporation of sweat from the skin lowers the temperature of the body.

If normal body temperature is $37^{\circ}C$, the temperature use of the body, without heat loss would be as follows:

one hour	$38^{\circ}C$
two hours	$39^{\circ}C$
three hours	$40^{\circ}C$
four hours	$41^{\circ}C$

Therefore it is essential to lose heat from the body in order that the normal body temperature is $37^{\circ}C$ is maintained.

Thus heat loss is achieved by a number of ways such as Hypothermia or artificial body cooling.

Hypothermia (Artificial body cooling)

Hypothermia is lowering the body temperature; cooling the body in crushed ice or ice water (bringing the body temperature from $37^\circ C$ down to $32^\circ C$ or $30^\circ C$) allows operations to be performed on the heart or in the treatment of brain in juries.

If a kilogram portion of ice is allowed to melt on the body, it is found that 336kJ of Heat could be drawn from the body.

$(L_f = 336 kJkg^{-1})$

When a normal man of 70kg is cooled from $37^{\circ}C$ to $32^{\circ}C$ the total heat to be removed will be equal to

$$m\,c\,\Delta T \quad = \Delta Q$$

$$70 \times 4.2 \times 5 = 1470 \ kJ$$

Since, 336 kJ required 1kg of ice

1470 kJ required $\frac{1470}{336} \times 1 \quad = 4.375$ kg of ice

That is 4.375kg of crushed ice will be required to cool the body from $37^{\circ}C to 32^{\circ}C$.

Ice is, of course, much more effective in cooling a system than just cold water because of internal energy required to melt the ice.

Evaporation

Evaporation is the escape of molecules from the liquid surface, which can take place at any temperature. The condition that evaporation takes place more quickly (Some factors influence the rate of evaporation from an open liquid)

Evaporation takes place more quickly

- When the air above the liquid surface is blown (or)
- When the surface area of the liquid is increased (or)
- As the temperature of the liquid is raised.

Saturation vapour pressure

- If the container is closed, the evaporation process will reach equilibrium. When the number of molecules bouncing back into the surface is equal to the number leaving.

- The vapour is then said to be saturated and the pressure exerted on the container walls is the saturation vapour pressure.

Saturation vapour density

The mass of water vapour per unit volume under saturated conditon is the saturation vapour density.

(The saturation vapour density and pressure increase with temperature as shown in table.)

Boiling

The liquid will boil when its saturated vapour pressure equals the applied pressure acting on the liquid.

Boiling point

The boiling point of a liquid may be defined as the temperature at which the saturated vapour pressure of the liquid is equal to the applied pressure.

An increase in pressure raise the boiling point above $100^{\circ}C$ and allows the water to be superheated, as in a pressure cooker or instrument sterilizer (autoclave).

Cooling the body by evaporation of perspiration is an efficient process because during evaporation the large latent heat of vaporization, $L_V = 580\, cal\, g^{-1}\ at\ 37^\circ C$, is extracted from the skin.

Even when no perspiration is evident, evaporation from the skin and exhaled water vapour are on the order of 600g per day.

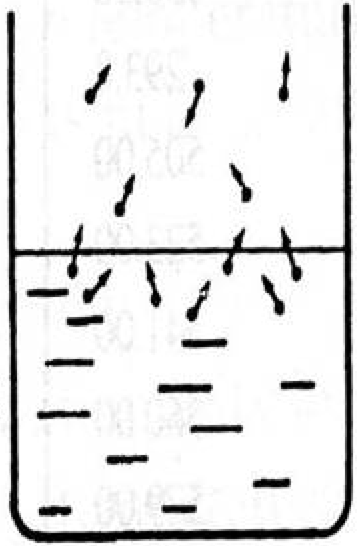
The associated energy loss rate is

$$\frac{\Delta Q}{t} = \frac{m L_v}{t}$$ (mass of vapour per day=600g)

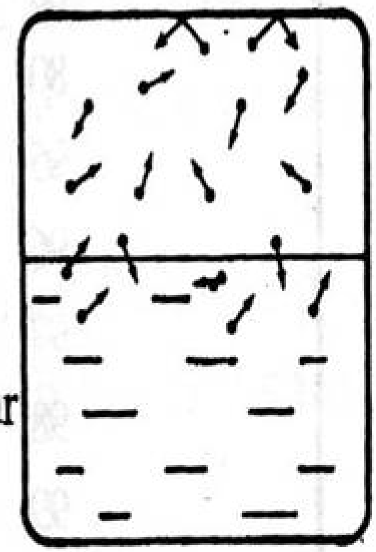
$$= \frac{600\, g \times 580\, cal\, g^{-1}}{24\, hr \times 3600\ sec}$$

$$= 17\, W$$

Therefore perspiration heat loss is a significant fraction of the basic 90W energy loss rate.



(a) evaporation from an open liquid surface



(b) saturation of a vapour in a closed volume

Problems of heat

1.

$$efficiency = 25\%$$

$$Power\ \ output\ \ of\ \ the\ heat = P_{out} = 1.1W$$

$$t = 24\,hr = 24 \times 3600\ s$$

$$\Delta Q_{output} = P_{out} \times t$$

$$= 1.1 \times 24 \times 3600\ J$$

$$\Delta Q_{food} = \Delta Q_{input} = ?$$

$$Efficiency = \frac{\Delta Q_{output}}{\Delta Q_{input}} \times 100\%$$

$$25 = \frac{1.1 \times 24 \times 3600}{\Delta Q_{input}} \times 100$$

$$\Delta Q_{input} = 380160J = \frac{380160}{4186}\,kcal$$

$$\underline{\Delta Q_{input} = 90.8kcal}$$

2.(a) $m = 50\,kg$ $\quad W = mgh$

$h = 1600\ m$ $\quad = 50 \times 10 \times 1600$

$g = 10\,ms^{-2}$ $\quad = 8 \times 10^5\,J$

$W = ?$

$$= \frac{8 \times 10^5}{4186}$$

$$= 191.11\,kcal$$

(b) $For\ 1kcal\ of\ mechanical \rightarrow 4kcal\ \ food\ energy\ need$

$For\ 191.113\,kcal \rightarrow ?$

$$= \frac{191.113}{1} \times 4$$

$$= 764.452\,kcal\ (\Delta Q_{food})$$

$$= 764.452 \times 10^3\,cal \leftarrow$$

(c) $\Delta Q_{heat} = 75\% \text{ of the food energy}, \quad \Delta T = ?$

$$= \frac{75}{100} \times \Delta Q_{food} \qquad c = 0.8 cal\, g^{-1}\,{}^{\circ}C^{-1}$$

$$= \frac{75}{100} \times 746.452 \times 10^{3} \qquad m = 50 kg = 50 \times 10^{3}\, g$$

$$\Delta Q_{heat} = 573 \times 10^{3}\, cal$$

$$\Delta Q_{heat} = mc\Delta T$$

$$\Delta T = \frac{\Delta Q}{mc}$$

$$= \frac{573 \times 10^{3}}{50 \times 10^{3} \times 0.8}$$

$$\Delta T = 14.33^{\circ} C \leftarrow$$

(d) $W = 8 \times 10^{5}\ J \qquad P = \frac{W}{t}$

$$t = 1\, hr = 3600\ s \qquad = \frac{8 \times 10^{5}}{3600}$$

$$P = ? \qquad = 222.22\ W \leftarrow$$

3. $m = 70\ kg = 70 \times 10^{3}\ g = 7 \times 10^{4}\ g$

$$\Delta Q_{input} = 250\ kcal = 250 \times 10^{3}\ cal$$

$$= 25 \times 10^{4}\ cal$$

$\Delta Q_{heat} = ?$

$\Delta T = ?$

$$efficiency = \frac{\Delta Q_{heat}}{\Delta Q_{input}} \times 100\ \%$$

$$80 = \frac{\Delta Q_{heat}}{25 \times 10^{4}} \times 100$$

$$\Delta Q_{heat} = \frac{80 \times 25 \times 10^{4}}{100}$$

$$= 2 \times 10^{5}\ cal$$

$$\Delta Q_{heat} = m\ c\ \Delta T$$

$$\Delta T = \frac{\Delta Q_{heat}}{m\ c}$$

$$= \frac{2 \times 10^{5}}{7 \times 10^{4} \times 1}$$

$$= 2.857\ ^{\circ}C \leftarrow$$

4.

$c = 1020 J\, kg^{-1} K^{-1}$

Mass of 1 litre = m = 1.3 x $10^{-3} kg$

Mass of 0.5 litre(for 1 breath)= m $= \frac{1.3x10^{-3}}{2} = 0.65x10^{-3} kg$

Initial temperature $= T_1 = -30°C$

Final temperature $= T_2 = 37^0 C$

$\Delta T = T_2 - T_1 = 37 — 30 = 67°C = 67K$

$\Delta Q_{heat} (for\ 1\ hour) = ?$

<u>**Heat lost for one breath**</u>

$\Delta Q_{heat} = m\, c\, \Delta T$

$= 0.65x10^{-3} x 1020 x 67 = 44.421 J$

Number of breaths in 60 min (1 hour)

In 1 minute $\rightarrow 12\ breaths$

In 60 minutes $\rightarrow ?$

$$= 12 \times 60 = 720\ \text{breaths}$$

Heat lost for 720 breaths (1 hour)

1 breath $\rightarrow 44.421\ J$

720 breaths $\rightarrow ?$

$$= 44.421 \times 720 = \underline{31982.12\ J}$$

5

ΔQ = 100 million calories=100xcal

V = 80,000 litre = 80,000 x 10^3 cm^3

m = ρ V = 80,000 x 10^3 x 1 g

Let m_1 = mass of evaporation

(a) ΔT = ?

$$\Delta Q = m c \Delta T$$

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

$$= \frac{100 \times 10^6}{80000 \times 10^3 \times 1}$$

$$= \underline{1.25^0C}$$

(b) Evaporated volume = V = ?

By the law of heat exchange,

Heat gained by evaporation = Heat lost by water

$$\Delta Q_{gained} = \Delta Q_{lost}$$

$$m_1 \times l_v = (m - m_1) \times c_w \times \Delta T$$

$$m_1 \times 580 = (80000 \times 10^3 - m_1) \times 1 \times 1.25$$

$$m_1 = 1.72 \times 10^5 \text{ g}$$

$$\rho = \frac{m_1}{V}$$

$$V = \frac{m_1}{\rho} = \frac{1.72x10^5 g}{1 g cm^{-3}}$$

$$= 1.72x\ 10^5 cm^3$$

$$= \frac{1.72x10^5}{10^3} litre$$

$$V = \underline{172 \text{ litre}}$$

6.

$m = 10\ g$

$\Delta Q = 1000\ cal$

$l_f = 80\ calg^{-1}$

$C = 1\ calg^{-1}{}^{o}C$

$T_1 = 0\ {}^{o}C$

$T_2 = ?$

$\Delta Q_1 = ml_f = 10 \times 80 = 800\ cal$

$\Delta Q = \Delta Q_1 + \Delta Q_2$

$\Delta Q_2 = \Delta Q - \Delta Q_1$

$1000 - 800 = 200\ cal$

$$\Delta Q_2 = m c \Delta T$$

$$\Delta T = \frac{\Delta Q_2}{m\,c}$$

$$\Delta T = \frac{200}{10x1}$$

$$T_2 - T_1 = 20$$

$$T_2 - 0 = 20$$

$$T_2 = \underline{20^0C}$$

7. $m = 200\ g$

Let m_1 = mass of evaporation, $m_1 = 5\ g$

$L_v = 540$ calg-1

$T_{initial} = T_1 = 100^0C$, $T_{final} = T_2 = ?$

By the law of heat exchange,

Heat gained by evaporation = Heat lost by water

$\Delta Q_{gained} = \Delta Q_{lost}$

$m_1 l_v = (m - m_1) c\, \Delta T$

$5 \times 540 = (200 - 5) \times 1 \times \Delta T$

$\Delta T = 13.8^0C$

$T_1 - T_2 = 13.8^0C$

$100 - T_2 = 13.8^0C$

$T_2 = 86.2\ ^0C$

Relative Humidity

-The amount of water in the air is usually less than the saturation density.

-The percentage of saturation humidity at given temperature is referred to as the relative humidity.

It can be calculated from the relationship

$$R.H = \frac{actual\ vapour\ density}{saturation\ vapour\ density} x100\%$$

The most common units for the vapour density – gm^{-3} (grams per cubic metre)

Example

1. If the actual vapour density is 10 gm^{-3} at 68ºF, what is the relative humidity? From table, the saturation vapour density at 68ºF is found to be 17.3 gm^{-3}. Find the relative mumidity.

Actual vapour density = 10 gm^{-3} (at 68ºF)

Saturation vapour density (68ºF) = 17.3 gm^{-3}

R.H = ?

$$R.H\ (68^0 F) = \frac{actual\ vapour\ density}{saturation\ vapour\ density} x100\%$$

$$= \frac{10\ gm^{-3}}{17.3gm^{-3}} x100\% = 57.8\%$$

-Since the saturation vapour density increases with the temperature, the same actual vapour density will represent a smaller relative humidity if the temperature of the air is increase.

$$R.H = \frac{Actual\ vapour\ density}{Saturation\ vapour\ density} x100\%$$

$$If\ actual\ vapour\ density = constant,$$

$$R.H \propto \frac{1}{Saturation\ vapour\ density}$$

$$\therefore R.H \propto \frac{1}{temperature}$$

Since the membranes of the body tend to be sensitive to the relative humidity, the air will seem dryer if it is heated without increasing the number of gm^{-3} of water vapour in the air.

Central heating systems which heat and circulate a closed volume of air will reduce the relative humidity in the process unless water is added to the air by mean of a humidifier.

Example(2) If the air in the previous example is heated to 77^{0}F without increasing the actual vapour density 10gm^{-3}, what will be the relative humidity after heating?

From table, Saturation vapour density(77^{0}F)=23gm^{-3}
Actual vapour density = 10gm^{-3}

$$R.H = \frac{Actual\ vapour\ density}{Saturation\ vapour\ density} x100\%$$
$$= \frac{10}{23} x100\% = 43\%$$

This is just above the 40% relative humidity recommended as a minimum for breathing. If the temperature of the air is decreased while holding the actual moisture content constant, the relative humidity will increase.

3. **If the relative humidity is 50% and the temperature is 77°F on a given day, what is the relative humidity in a cool basement which has the same actual vapour density but a temperature of 59°F?**

$$If\ R.H = 50\%\ , Actual\ vapour\ density = \frac{1}{2} x\ Saturation\ vapour\ density\ (at\ 77^0F)$$

$$R.H = \frac{Actual\ vapour\ density}{Saturation\ vapour\ density} x100\%$$

$$\frac{50}{100} = \frac{Actual\ vapour\ density}{Saturation\ vapour\ density}$$

$$Actual\ vapour\ density = \frac{1}{2} x\ Saturation\ vapour\ density$$

$$= 0.5 \times 23 = 11.5\ gm^{-3}$$

Since, saturation vapour density (59^0F) = 12.8 gm^{-3}

Actual vapour density (77^0F) = Actual vapour density(59^0F)

= 11.5gm^3(given)

$$R.H = \frac{Actual\ vapour\ density}{Saturation\ vapour\ density} x100\%$$

$$= \frac{11.5}{12.8} x100\% = 90\%$$

Dew point (Dew point temperature)

-If the air is gradually cooled while maintaining the moisture content constant, the relative humidity will rise until it reaches 100%.

-This temperature, at which the moisture content present in the air will saturate the air, is called dew point.

Humidity Problems

8.

For outside air,

saturation vapour density (30^0C) = 30.4 gm^{-3} (from table)

R.H (30^0C) = 50%

At inside, R.H (20^0C) =?

$$R.H\ (30^0C) = \frac{Actual\ vapour\ density}{Saturation\ vapour\ density} x100\%$$

$$50\% = \frac{Actual\ vapour\ density}{30.4} x100\%$$

Actual vapour density (30^0C)=15.2gm^{-3}

Since actual humidity is in equilibrium with the outside air,

∴ Actual vapour density (30^0 C)=actual vapour density (20^0C)=15.2gm^{-3}

$$R.H\ (20^0C) = \frac{Actual\ vapour\ density}{Saturation\ vapour\ density} x100\%$$

$$R.H = \frac{15.2}{17.3} x100\%$$

$$= \mathbf{87.86\ \%}$$

$$R.H \approx \mathbf{88\%}$$

9. Actual vapour density $(68°F) = 12 gm^{-3}$

Saturation vapour density $(68°F) = 17.3\ gm^{-3}$ (from table)

$$R.H\ (68^0 F) = \frac{Actual\ vapour\ density}{Saturation\ vapour\ density} x100\%$$

$$= \frac{12}{17.2} x100\%$$

$$= 69\%$$

If it reaches the dew point , relative humidity will rise 100%

$\therefore$ Actual vapour density = Saturation vapour density= $12\ gm^{-3}$

From table,

The temperature of saturation vapour density value($12 g\ m^{-3}$) is 57.2°F

The dew point temperature = 57.2°F

$\therefore \approx 57°F$

Heat Transfer

To warm water, to melt a solid, or to vaporize a liquid we increase the internal energy of the system by adding heat.

In all these cases heat is transferred from one body to another of from one part of a system to another.

This heat or internal energy transferred may occur by one or more of the following three mechanisms:

(1) conduction, (2) convection, and (3) radiation of heat

(1) Conduction

$$\frac{\Delta Q}{t} = \frac{K\,A\,\Delta T}{L}$$

$\frac{\Delta Q}{t}$ = rate of heat conduction

K= conductivity

A= surface area

ΔT= temperature difference

L = thickness

(2) Convection

$$\frac{\Delta Q}{t} = h\,A\,\Delta T$$

$\frac{\Delta Q}{t}$ =rate of heat convection

h = convection coefficient (cal s^{-1} cm^{-2} $^{0}C^{-1}$)

A = surface area

ΔT = temperature difference

(3) Radiation

$$\frac{\Delta Q}{t} = e\,\sigma\,A\,(T_1^4 - T_2^4)$$

$\frac{\Delta Q}{t}$ = rate of heat radiation

e = emissivity

σ =Stefan- Boltzmann constant = 5.67 x 10 $^{-8}$ W m^{-2} K^{-4}

A = surface area

$T_1 - T_2$ = the absolute temperature of the object and surroundings

In conduction internal energy is transferred from molecule to molecule.

In convection, the moving molecules carry the heat with them.

Both of these require material of some kinds to transport the energy.

In radiation heat travels as waves or rays, without the need for transportation using particles or molecules.

Therefore heat rays have the ability to pass through vacuum or empty space.

Hot bodies, especially at temperature above 100^0C give out little heat by radiation.

Heat rays; (a) are visible.

(b) are absorbed by objects causing them to heat up.

(c) can reflected from polished surfaces.

(d) can be refracted or bent through glass and other materials.

Applications:

1. Therapectic use

   Heat is frequently used in medical treatment.The heat source can be applied directly to the skin, if precautions are taken that it is at the right temperature to prevent burns.

   In nursing practice, hot towels poultices, hot water bottles, ice bags, cold compressed, electric heated pads and wax baths are all used as heat sources in heat therapy.

2. Hypothermia

Hypothermia is lowering the body temperature by artificial method.

(Cooling the body in order to perform surgery on the heart can be brought about by surface cooling, whereby the body is cooled by conduction using ice bags.)

3. Cryosurgery

In cryosurgery a probe filled with liquid nitrogen is used to lift thin walled cysts which would more than likely burst if lifted with forceps, or the eye lens can be attached to the cryoprobe in cataract removal.

The conduction of heat from the tissue causes the cyst to stick to the liquid nitrogen cooled probe.

The very low temperatures produced by the liquid nitrogen probe can be used to destroy living cells and therefore this finds further application in the destruction of cancer tissue.

Digital Thermometers In Three Ways

- Oral (in the mouth)
- Rectal (in the bottom)
- Axillary (under the arm)

Some example; of thermometer

- Electronic Ear Thermometers
- Forehead Thermometers
- Plastic Fever Strip Thermometers
- Pacifier Thermometers
- Glass and mercury thermometers

Infrared Thermometers (or) Laser Thermometers

Application

- SARS coronavirus
- Ebola Virus diseases