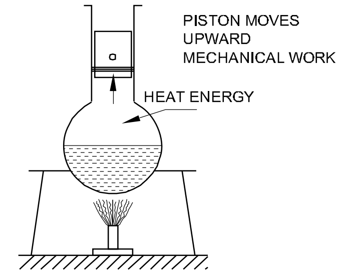
Heat & Temperature - Concept of heat and temperature, effects of heat, difference between heat and temperature, boiling point & melting point of different metals and non-metals   Exercise 1.6.26

Heat

It is a form of energy. Heat energy can be transformed into other forms of energies. Heat flows from a hotter body to a colder body. (Fig 1)

Fig 1



Units of heat

Calorie: It is the quantity of heat required to raise the temperature of 1 gram of water through 1°C.

BTHU: It is the quantity of heat required to raise 1 lb of water through 1°F. (British thermal unit).

C.H.U; It is the quantity of heat required to raise 1 lb of water through 1°C.

Joule : S.I. Unit (1 Calorie = 4.186 joule)

Effects of heat

- Change in temperature
- Change in size
- Change in state
- Change in structure
- Change in Physical properties

Specific heat

The quantity of heat required to raise the temperature of one gm of a substance through 1^0C is called specific heat. It is denoted by the letter 's'.

Specific heat of water	= 1
Aluminium	= 0.22
Copper	= 0.1
Iron	= 0.12

Thermal capacity:

It is the amount of heat required to raise the temperature of a substance through 1^0C is called the thermal capacity of the substance.

Thermal capacity = ms calories.

Calorific value: The amount of heat released by the complete combustion of unit quantity of the fuel (Mass or volume) is known as calorific value of fuels.

Water equivalent

It is the mass of water which will absorb the same amount of heat as the given substance for the same temperature rise. Water equivalent = Mass of the substance x specific heat of the substance.

Therefore water equivalent = ms

Types of heat

1 Sensible heat and

2 Latent heat

1 Sensible heat

Sensible heat is the heat absorbed or given off by a substance without changing its physical state. It is sensible and can be obsorbed by the variation of temperature in the thermometers.

2 Latent heat

The heat gained or given by the substance during a change of state (from solid to liquid to gas) is called latent heat or hidden heat. The heat absorbed or given off does not cause any temperature change in the substance.

Types, 1. Latent heat of fusion of solid

2. Latent heat of vaporisation of solid.

1 Latent heat of fusion of solid

The amount of heat required per unit mass of a substance at melting point to convert it from the solid to the liquid state is called latent heat of fusion of solid. Its unit is cal/gram.

Latent heat of fusion of ice

The amount of heat required to convert per unit mass of the ice into water at 0^0C temperature is called latent heat of fusion of ice.

Latent heat of fusion of ice(L) = 80 cal/gram

2 Latent heat of vapourisation of liquid

The amount of heat required to vaporise a unit mass of liquid at its boiling point is called latent heat of vapourisation.

Latent heat of vaporisation of water or latent heat of steam

The amount of heat required to convert into steam of a unit mass of water at its boiling point (100^0C) is called latent heat of vaporisation of water or latent heat of steam.

Latent heat of steam(L) = 540 cal/gram

Temperature

It is the degree of hotness or coldness of a body. The temperature is measured by thermometers.

Difference between heat and temperature

Heat	Temperature
1 It is a form of energy.	This tells the state of heat.
2 Its unit is calorie.	Its unit is degree.
3 Heat is measured by calorimeter.	Temperature is measured by thermometer.
4 By adding quantity of heat of two substances their total heat can be calculated.	By adding two temperatures we cannot find the temperature of the mixture.
5 By heating a substance the quantity of heat is increased regardless of increase in temperature.	Two substances may read the same temperature though they might be having different amount of heat in them.

Boiling point

Any substance starts turning into a gas shows the temperature at which it boils this is known as the boiling point. The boiling point of water is 100^0C.

Melting point

The temperature at which any solid melts into liquid or liquid freezing to solid is called the melting point of substance. ` The melting point of ice is 0^0C.

List of melting point and boiling point of metals and Non -metals

Metals and Non-metals	Melting point °C	Boiling point °C
Aluminium	660.25	2519
Argon	-189.19	-185.85
Arsenic	817	614
Barium	729	1897
Beryllium	1287	2469
Bromine	-7.1	58.8
Cadmium	321.18	767
Calcium	839	1484
Carbon (diamond)	3550	4827
Carbon (graphite)	3675	4027
Chlorine	-100.84	-34.04
Cobalt	1495	2927
Copper	1084.6	2562
Gold	1064.58	2856
Helium	-	-268.93
Hydrogen	-259.98	-252.87
Iodine	113.5	184.3
Iridium	2443	4428
Iron	1535	2861
Lead	327.6	1749
Lithium	180.7	1342
Magnesium	650	1090

Metals and Non-metals	Melting point °C	Boiling point °C
Manganese	1246	2061
Mercury	-38.72	357
Molybdenum	2617	4639
Nickel	1453	2913
Nitrogen	-209.86	-195.79
Oxygen	-226.65	-182.95
Phosphorus (white)	44.1	280
Plutonium	640	3228
Potassium	63.35	759
Radium	700	1737
Silicon	1410	3265
Silver	961	2162
Sodium	98	883
Sulfur	115.36	444.6
Tin	232.06	2602
Titanium	1660	3287
Tungsten (wolfram)	3422	5555
Uranium	1132	4131
Zinc	419.73	907

Heat & Temperature - Scales of temperature, celsius, fahrenheit, kelvin and conversion between scales of temperature — Exercise 1.6.27

Temperature Scales

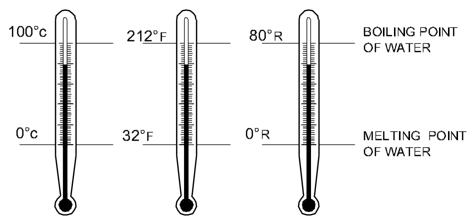
Temperatures are caliberated between two fixed reference points namely the freezing point of water, and the boiling point of water. These two fixed points on different temperature scales are:

Scale	Freezing point	Boiling point
Centigrade (°C)	0°C	100°C
Fahrenheit (°F)	32°F	212°F
Kelvin (K)	273°K	373°K
Reaumur (°R)	0°R	80°R

Heat is a form of energy. Temperature is the degree of hotness or coldness of a body. The relationship for conversion from one temperature scale to the others is

$$\frac{^0R}{80} = \frac{^0C}{100} = \frac{^0K - 273}{100} = \frac{^0F - 32}{180}$$

Fig 1



WSCN1113211

1 Convert 0^0C into ^0F

$$\frac{^0F - 32}{180} = \frac{^0C}{100}$$

$$^0F - 32 = \frac{^0C}{100} \times 180$$

$$^0F - 32 = \frac{0}{100} \times 180$$

$$°F = 0 + 32$$

$$= 32^0F$$

0^0C = 32^0F

2 Convert -40^0C into ^0F

$$\frac{^0F - 32}{180} = \frac{^0C}{100}$$

$$^0F - 32 = \frac{^0C}{100} \times 180$$

$$^0F - 32 = \frac{-40}{100} \times 180$$

$$F - 32 = -72$$

$$°F = -72 + 32$$

$$= -40^0F$$

$-40^0C = -40^0F$

3 Convert 37^0C into K

$$\frac{^0C}{100} = \frac{^0K - 273}{100}$$

$$°K - 273 = C$$

$$°K = C + 273$$

$$°K = 37 + 273$$

$$= 310\ K$$

37^0C = 310K

4 Convert 70^0C into Reaumer

$$\frac{^0C}{100} = \frac{^0R}{80}$$

$$^0R = \frac{C}{100} \times 80$$

$$^0R = \frac{70}{100} \times 80 = 56$$

$70^0C = 56^0R$

5 Convert -25^0F into ^{0}C

$$\frac{{}^0C}{100} = \frac{{}^0F - 32}{180}$$

$$\frac{{}^\circ C}{100} = \frac{-25 - 32}{180}$$

$$^0C = \frac{-57}{180} \times 100$$

$$^0C = \frac{-285}{9} = -31.66$$

- 25^{0}F = -31.7^{0}C

6 Convert 98.6^{0}F into ^{0}C

$$^0C = \frac{{}^0F - 32}{180} \times 100$$

$$^0C = \frac{98.6 - 32}{180} \times 100$$

$$= \frac{66.6}{180} \times 100$$

$$= \frac{6660}{180} = 37^0C$$

98.6^{0}F = 37^{0}C

Assignment

Convert the following

1 10.5^{0}C = ___^{0}F

2 40^{0}C = ___^{0}F

3 60^{0}C = ___^{0}F

4 80^{0}C = ___^{0}F

5 105^{0}C = ___^{0}F

6 -100^{0}C = ___^{0}F

7 77^{0}F = ___^{0}C

8 20^{0}F = ___^{0}C

9 428^{0}F = ___^{0}C

10 -210^{0}F = ___^{0}C

11 72^{0}R = ___^{0}C

12 143^{0}C = ___K

13 373^{0}K = ___^{0}C

14 746^{0}K = ___^{0}F

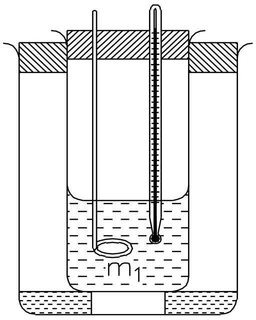
15 At what temperature will the reading of a fahrenheit thermometer be double of a centigrade one.

Heat &Temperature - Temperature measuring instruments, types of thermometer, pyrometer and transmission of heat - Conduction, convection and radiation Exercise 1.6.28

Measuring heat energy

Energy can be released in chemical reactions as light, sound or electrical energy. But it is most often released as heat energy. This allows us to easily measure the amount of heat energy transferred.

Fig 1



SIMPLE CALORIMETER

The apparatus used to measure the amount of heat by mixer method is called calorimeter. It is nothing but cylindrical shaped vessel and a stirrer made out of mostly copper.

In a calorimeter when the hotter solid/liquid substance are mixed with the cooler solid/liquid substances, heat transfer takes place until both substances reach the same temperature. By the same time calorimeter also reaches the same temperature. By mixing rule,

$$\left[\begin{array}{l}\text{Loss of heat}\\\text{by solid/}\\\text{liquid}\end{array}\right] = \left[\begin{array}{l}\text{Heat absorbed by}\\\text{solid / liquid}\\\text{substance}\end{array}\right] + \left[\begin{array}{l}\text{Heat absorbed}\\\text{by calorimeter}\end{array}\right]$$

Measurement

Temperature is generally measured in degrees Celsius. In this system the freezing point of water is defined as 0°C and the boiling point of water is defined as 100°C. The Kelvin temperature scale begins from absolute 0. i.e.— 273°. The temperature intervals are the same.

$\therefore$ 273K = 0°C, 20°C = 273K + 20°C = 293K.

Instruments

The instruments used to measure and read temperature takes into account changes in the properties of materials, electrical phenomena incandescence, radiation and melting.

Thermometer

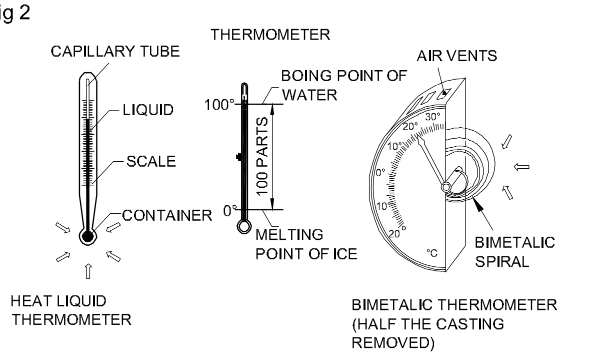
Types of thermometer

- Forehead strips
- Wearable thermometers
- Pacifier thermometers
- Ear thermometers (tympanic)
- Forehead thermometers (temporal)
- Digital thermometers
- Mom's hand or lips

They are based on the principle that liquids and solids expand when they are subjected to heat. Mercury and alcohol expand uniformly. When heat is applied the volume of the liquid increases and the liquid rises in the capillary tube integral with the container. Mostly mercury is used in this type of thermometers because of its properties (Shiny and will not adhere to the glass tubes and we can measure up to 300^0c.

The bimetal thermometer consists of metals with different coefficient of expansion. The bimetal is twisted into a spiral which curls when the temperature rises.

Fig 2

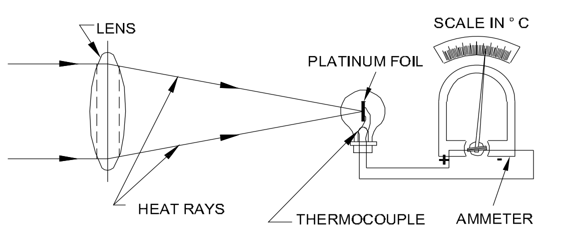


Pyrometer

Thermoelectric pyrometer is based on the principle that the soldering point between the wires of different metals, when heated a contact voltage is generated. The voltage depends upon the temperature difference between the hot measuring point and the cold end of the wire. Thermocouple elements are constructed of copper and Constant (up to 600°C) or of platinum and platinum-rhodium (up to 1600°C)

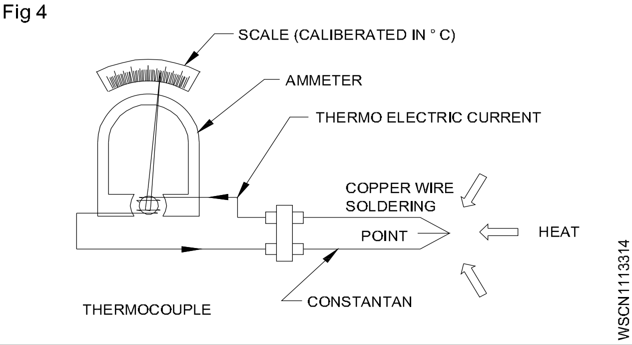
Radiation pyrometers are used to measure temperatures of red hot metals up to 3000°C. These concentrate thermal rays through an optical lens and focus them on to a thermo element. The scale of the ammeter is calibrated in degrees Celsius or Kelvin.

Fig 3



IN THE RADIATION PYROMETER, THERMAL RADIATION IS FOCUSED ON THE SOLDERING POINT OF A THERMOCOUPLE

Fig 4



Transmission of Heat

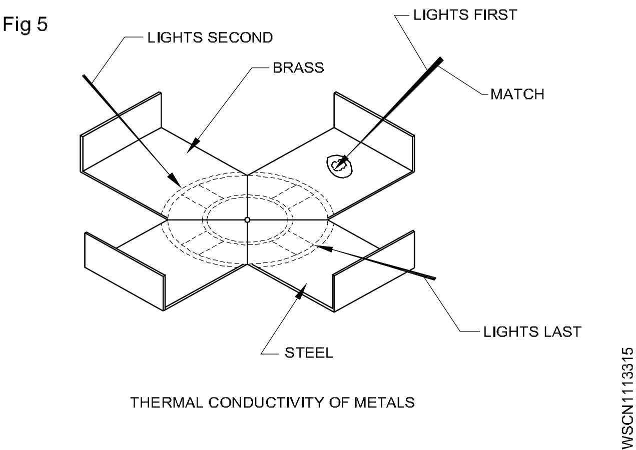
Heat is a form of energy and is capable of doing work. Heat flows from a hot body to a colder body or from a point of high temperature to a point of low temperature. The greater is the temperature difference the more rapidly will be the heat flow. Heat is transmitted in three ways.

- By Conduction
- By Convection
- By Radiation

Conduction

Conduction is the name given to the transmission of heat energy by contact. The heat source is in contact with the Conductor. (metal rod). The rod is in contact with a thermometer. Due to Conduction heat is transferred from the heated end to the free end. In general good electrical conductors are also good heat conductors and good electrical insulators are also good heat insulators. A good heat insulator does not necessarily withstand high temperature.

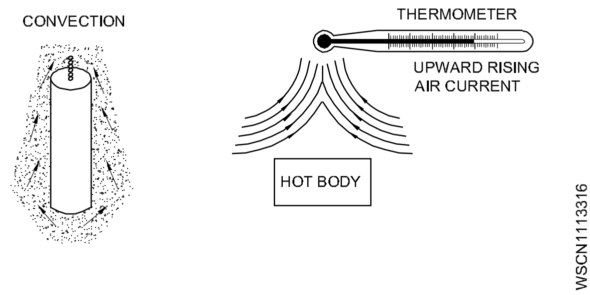
Fig 5



Convection

Convection is the name given to the transmission of heat energy by the up-ward flow. When heated, the fluid (liquid/gas) becomes less dense and because of its mobility, is displaced upwards, by a similar but colder and more dense fluid. e.g., The domestic hot water system, The cooling system in motor cars.

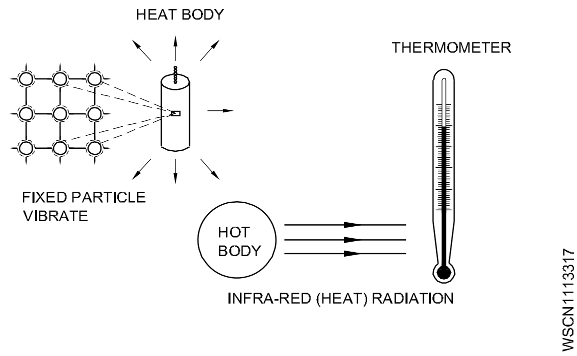
Fig 6



Radiation

Heat is radiated or transmitted from one object to the other in space without actually being in contact, by means of electro-magnetic waves. These waves are similar to light waves and radio waves. They can be refracted by lenses and reflected by mirrors. This radiation is called infrared. It requires no medium to carry the radiation. (e.g) The heat of the sun travels through the space.

Fig 7



Transmission of heat takes place in three ways Conduction, Convection and Radiation.

Expansion due to heat

When a solid, liquid or gaseous substance is heated, it expands and volume is increased. Similarly when it is cooled, it contracts (shrinks) and volume is decreased.

E.g : small gaps are left in between the lines of railway track to allow for expansion during summer. If this is not done, the rails would expand and bend there by causing derailment of trains.

Except a few substances, all solids, liquids and gases expand. For the same amount of heat given, the expansion of liquids is greater than solid and expansion of gas is more than liquid.

Volume of water is reducing while heating from 0^0C to 4^0C. After that volume is increasing. The data at 4^0C of water will be taken as reference point for any calculations relating with water.

Expansion of solids

A solid substance shows the following types of expansion when heated.

1 Linear expansion

2 Superficial expansion and

3 Cubical expansion

1 Linear expansion

When a solid is heated, its length increases. This is called linear expansion. It depends upon the material, original length and change in temperature.

Co-efficient of linear expansion

The co-efficient of linear expansion is the change in length per unit original length per degree rise in temperature. It is represented by α (Alpha).

Length of the solid at $t_1{}^0C = l_1$

Length of the solid at $t_2{}^0C = l_2$

Change in Temperature $= t_2 - t_1{}^0C$

Change in length $= l_2 - l_1$

$$\alpha = \frac{l_2 - l_1}{l_1 \times (t_2 - t_1)}$$

$$\alpha = \frac{l_2 - l_1}{l_1 t}[t_2 - t_1 = t]$$

$$\left.\begin{array}{l}\text{Co-efficient of}\\ \text{linear expansion}\end{array}\right\} = \frac{\text{Change in length}}{\text{Original length x change in temperature}}$$

Increased length $l_2 - l_1 = \alpha l_1 t$

Final length $l_2 = l_1(1 + \alpha t)$

2. Superficial expansion

When a solid is heated, its area increases is called superficial expansion.

Co-efficient of superficial expansion

The increase in area per unit original area per degree rise in temperature is called co-efficient of superficial expansion. It is represented by β (Beta).

Co-efficient of superficial

Expansion = 2 x linear expansion

$\beta = 2\alpha$

3. Cubical expansion

When a solid is heated, its volume increases is called cubical expansion.

Co-efficient of cubical expansion

The increase in volume per unit original volume per degree rise in temperature. It is represented by γ (Gama).

Co-efficient of cubical expansion

= 3 x linear expansion

$\gamma = 3\alpha$

Examples

Find the co-efficient of linear expansion. If an 8 metre long metal rod is heated from 30°C to 80°C. So that it may produce an elongation of 0.84 mm.

Initial length (l) = 8m

Increased length = 0.84 mm

Increased temperature(t) = 80 - 30 = 50°C

$$\left.\begin{array}{l}\text{Co-efficient of linear}\\ \text{expansion}(\alpha)\end{array}\right\} = \frac{\text{Increased length}}{\text{Initial length} \times \text{Increased temp}}$$

$$= \frac{0.84}{8000 \times 50}$$

$$= \frac{0.84}{400000}$$

$= 2.1 \times 10^{-6}\ /^0C$

If iron bridge is 100 metre long at 0°C. What will be the length of bridge if the temperature is 40°C and the co-efficient of linear expansion is 12 x 10^{-6} per degree.

Initial length of iron bridge = 100 m

Increased temperature = 40 - 0 = 40°C

$$\left.\begin{array}{l}\text{Co-efficient of linear}\\ \text{expansion}(\alpha)\end{array}\right\} = \frac{\text{Increased length}}{\text{Initial length} \times \text{Increased temp}}$$

$$12 \times 10^{-6} = \frac{\text{Increased length}}{100 \times 40}$$

$$\text{Increased length} = \frac{12}{1000000} \times 100 \times 40$$

= 0.048 m

Iron bridge at 40°C = 100 + 0.048 = 100.048 m

The length of a metal rod is 100 cm at 30°C and 100.14 cm at 100°C. Calculate the co-efficient of linear expansion and the rod length in 0°C.

Initial length at 30°C = 100 cm

Final length at 100°C = 100.14 cm

Increased length = 0.14 cm

Increased temperature = 100 - 30 = 70°C

$$\left.\begin{array}{l}\text{Co-efficient of linear}\\ \text{expansion}(\alpha)\end{array}\right\} = \frac{\text{Increased length}}{\text{Initial length} \times \text{Increased temp}}$$

$$= \frac{0.14}{100 \times 70}$$

$$= \frac{14}{100 \times 70 \times 100}$$

$$= \frac{2}{100000}$$

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

To find the length at 0^0C

$$l_1 = l_0 (1 + \alpha t)$$

$$100 = l_0 (1 + 2 \times 10^{-5} \times 30)$$

$$100 = l_0 (1 + 0.0006)$$

$$l_0 = \frac{100}{1 + 0.0006}$$

Length at 0°C = 99.94 m

Find the change in length of metallic rod 100 cm long, when its temperature is increased from 25^0C to 40^0C and the co-efficient of linear expansion is 10 x 10^{-6} /^{0}C.

Initial length = 100 cm

Increased temperature = 40 - 25 = 15^0C

Co-efficient of linear expansion (α) = 10 x 10^{-6}/^{0}C

$$\left.\begin{array}{l}\text{Co-efficient of linear}\\ \text{expansion}(\alpha)\end{array}\right\} = \frac{\text{Increased length}}{\text{Initial length} \times \text{Increased temp}}$$

$$10 \times 10^{-6} = \frac{\text{Increased length}}{100 \times 15}$$

Increased length = 10 x 10^{-6} x 100 x 15

$$= \frac{10 \times 100 \times 15}{1000000}$$

$$= \frac{15}{1000} = 0.015\text{cm}$$

Find out the temperature that the rod will extend by 0.54 mm in linear direction when a piece of metal rod is 2.5 metre long in 20^0 C and the co-efficient of linear expansion is 10.4 x 10^{-6} per degree centigrade.

Initial length = 2.5 m = 2500 mm

Increased length = 0.54 mm

Initial temperature = 20^0C

Co-efficient of linear expansion (α) = 10.4 x 10^{-6}

$$\left.\begin{array}{l}\text{Co-efficient of linear}\\ \text{expansion}(\alpha)\end{array}\right\} = \frac{\text{Increased length}}{\text{Initial length} \times \text{Increased temp}}$$

$$10.4 \times 10^{-6} = \frac{0.54}{2500 \times \text{Increased temp}}$$

$$\text{Increased temperature} = \frac{0.54}{2500 \times 10.4 \times 10^{-6}}$$

$$= \frac{0.54 \times 1000000}{2500 \times 10.4}$$

$$= \frac{5400}{260} = 20.77\ ^0\text{C}$$

Final temperature = 20 + 20.77

= 40.77^0C

Assignment

Co-efficient of linear expansion

1 Calculate the co-efficient of linear expansion of rod. If rod is found to be 100m long at 20^0C and 100.14m long at 100^0C.

2 Find the change in length if the co-efficient of linear expansion of rod is 0.00024/^{o}C and the temperature of a rod of 3.6m length is raised by 120^0C,

3 Find the change in length if the co-efficient of linear expansion of rod is 0.00024/^{0}C. If the temperature of a rod of 6m length is raised by 120^0C,

4 Find the increase in length 100 cm iron rod if the temperature raise from 40^0C to 90^0C. The co-efficient of linear expansion of the iron is 10x10^{-6}/^{0}C

5 If micrometer reading is standardised at 15^0C. What will be the true reading of the micrometer if the reading taken at 35^0C is 20.20 mm?

The co-efficient of linear expansion of material of micrometer is 11 x 10^{-6}/^{0}C.

Mixing of heat

Fig 1

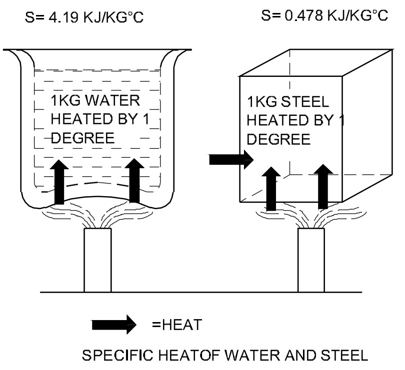


Fig 2

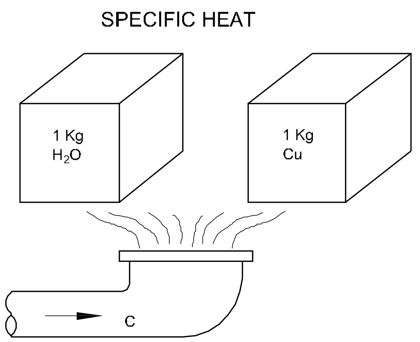


Fig 3

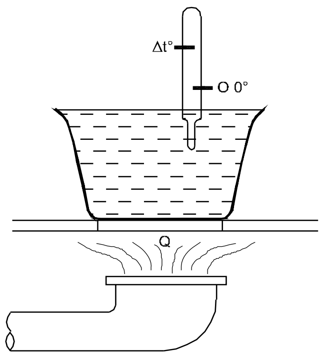
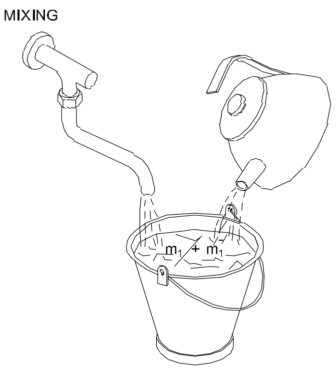


Fig 4



m_1 - Mass of first substance

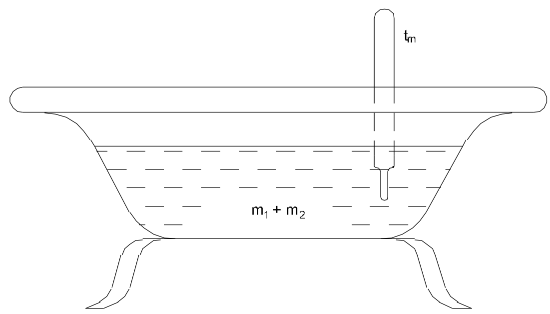
s_1 - specific heat of first substance

m_2 - mass of 2nd substance

s_2 - specific heat of 2nd substance

t_m - temperature of mixture

Fig 5



m - mass

Q - Quantity of heat

$\delta t/\Delta t$ - temperature difference

t_m - temperature of the mixture.

Unit of amount of heat

The derived unit for the amount of heat in S.I. unit is 1 joule (j).

Specific heat

It is also expressed as the amount of heat required to raise the temperature of unit mass of a substance through 1°C. In S.I. unit in order to heat a mass of 1 kg of water through 1°C,

the amount of heat needed or the

mechanical equivalent of heat = 4186 joules

= 4.2 kj/kg°C.

Quantity of heat needed for a substance to rise the temperature

The amount of heat needed for heating 1 kg of the substance through 1°C is equal to the specific heat of the substance 's'. For heating a mass of 'm' kg of the substance to attain a temperature difference of t,

the quantity of heat needed = $m \times s \times \Delta t$

Therefore Q = $m \times s \times \Delta t$.

Mixing

When there is an exchange of temperatures, there is an exchange in the amount of heat. When hotter bodies involve with colder substances, heat transference takes place from hotter substances to the colder substances until the mixture or both the substances acquire the same temperature.

Heat lost by the bodies at higher temperature

= Heat gained by the bodies at lower temperature and hence the total amount of heat of the component substances

= amount of heat in the mixture.

Heat loss by hot substance = Heat gained by colder substance
S of the component amounts of heat = amount of heat in the mixture
$m_1 \times s_1 \times t_1 + m_2 \times s_2 \times t_2 = (m_1s_1 + m_2s_2)tm$.

Example

A bath tub contains 40 litres of water at 15°C and 80 litres of water at 60°C is poured to it. What is the temperature of the mixture.

$$m_1 \times s_1 \times t_1 + m_2 \times s_2 \times t_2 = (m_1s_1 + m_2s_2)tm.$$

$$\therefore 40\text{ kg} \times \frac{4.2\text{ kj}}{\text{kg}°\text{C}} \times 15°\text{C} + 80\text{ kg} \times \frac{4.2\text{ kg}}{\text{kg}°\text{C}} \times 60°\text{C}$$

$$= \left(40\text{kg} \times \frac{4.2\text{kj}}{\text{kg}^0\text{C}} \times 15 + 80\text{kg} \times \frac{4.2\text{kj}}{\text{kg}^0\text{C}} \times 60\right) t_m$$

$$t_m = \frac{22680}{120 \times 4.2}{}^0\text{C} = 45^0\text{C}$$

Examples

A container contains 25 kg of water. Initial temperature of container and water is 25^0C. Calculate the heat required to heat the water to the boiling temperature of water. Assume water equivalent of container = 1 kg.

Mass of the water (m)	= 25 Kg.
Initial temperature of water and container	= 25^0C
Final temperature of water and container	= 100^0C
Increased temperature (t)	= 100 - 25
	= 75^0C
Water equivalent (m s)	= 1 Kg.
Required amount of heat to container	= m s t
	= 25 x 1 x 75
	= 1875 K.cal.
Required amount of heat to container	= m s t
	= 1 x 75
	= 75 K.cal.
Total required amount of heat	= 1875 + 75
	=1950 K.cal.

300 gram of water at 25°C is mixed with 200 gram of water at 85^0C. Find out the final temperature of the mixture assuming that no heat escapes.

i)	Weight of water	= 300 gram
	Initial temperature	= 25^0C
	Final temperature	= Assume 'X'
	Temperature gained	= x - 25^0C
ii)	Mass of water	= 200 gram
	Initial temperature	= 85^0C
	Temperature lost	= 85^0C - x
	Heat gained by 300 gram water	= m s t
		= 300 x 1 x (x - 25)
		= 300 x -7500 cal.
	Heat lost by 200 gram water	= m s t
		= 200 x 1 x (85 - x)
		= 17000 - 200 x cal.
	Heat gained	= Heat lost
	300 x -7500	= 17000 - 200 x
	300 x + 200 x	= 17000 + 7500
	500 x	= 24500

$$x = \frac{24500}{500} = 49°\text{C}$$

Final temperature = 49^0C

20gm of common salt at 91^0C immersed in 250 gram of turpentine oil at 13^0C. The final temperature is found to be 16^0C. If the specific heat of turpentine oil is 0.428. Calculate the specific heat of common salt.

Mass of the salt(m)	= 20 gram
Initial temperature(t)	= 91^0C
Mass of the turpentine(m)	= 250 gram
Initial temperature(t)	= 13^0C
Specific heat of turpentine(s)	= 0.428
Final temperature of mixture	= 16^0C
Heat gained by turpentine(Q)	= m s t
	= 250 x 0.428 x (16-13)
	= 250 x 0.428 x 3
	= 321 calories.
Heat lost by salt (Q)	= m s t
	= 20 x s x (91-16)
	= 20 x s x 75
	= 1500 s calories
Heat lost	= Heat gained
1500 s	= 321

$$s = \frac{321}{1500}$$

Specific heat of salt = 0.214

If copper calorimeter contains 80 gram of water at 20⁰C. The water equivalent of calorimeter is 20 gm. What will be be resultant temperature of the mixture, when 100 gm of water at 40⁰C is added to the mixture?

Mass of the water in calorimeter = 80 gram

Temperature = 20^0C

Final temperature of the mixture = Assume 'x'

Temperature raised in water = x - 20

Specific heat of calorimeter(ms) = 20 gram

Mass of water added = 100 gram

Temperature = 40^0C

Temperature lost = 40 - x

Heat gained

Heat gained by water in calorimeter = m s t

= 80 x 1 x (x - 20)

= 80 x (-1600)

Heat gained by calorimeter = m s t

= 20 x (x - 20)

= 20 x (-400)

Heat lost

Heat lost by added water = m s t

= 100 x 1 x (40 - x)

= 4000 - 100x

Heat gained = Heat lost

80x (-1600) + 20x (-400) = 4000 - 100x

100x -2000 = 4000 - 100x

100x+100x = 4000 + 2000

200x = 6000

$$x = \frac{6000}{200}$$

= 30

Final temperature = 30^0C

Find the amount of heat required to boil 15 gram of ice at -8⁰C. Latent heat of ice = 336 joule/gm. Latent heat of steam = 2268 J/gm. Relative specific heat of ice = 0.5

Heat of ice cube

-8^0C to 0^0C Ice Q = mct kJ

= m x s x 4.2 x t kJ

= 0.015 x 0.5 x 4.2 x 8 kJ

= 0.252 kJ

0^0C Ice to 0^0C water = m x h s f kJ

= 0.015 x 336 kJ

= 5.04 kJ

0^0C water to 100^0C water = m c t kJ

= 0.015 x 4.2 x 100 kJ

= 6.3 kJ

100^0C water to 100^0C steam Q= m x h_{sfg} kJ

= 0.015 x 2268 kJ

= 34.02 kJ

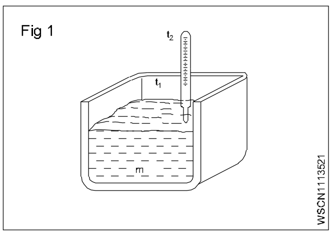
Total amount of heat Q = 0.252 + 5.04 + 6.3 + 34.02 kJ

Answer = 45.612 kJ

Assignment

Mixing of Heat

1.



m = 120 litres

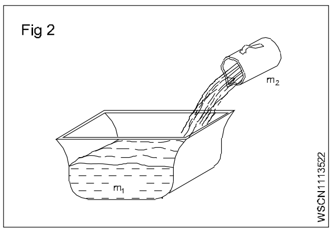
t_1 = 20°C

t_2 = 85°C

s = 4.2

Q = ______ kj

2.



m_1 =80 litres of water

m_2 =40 litres of water

t_1 = 10°C

t_2 = 70°C

t_m = ______ °C

3.

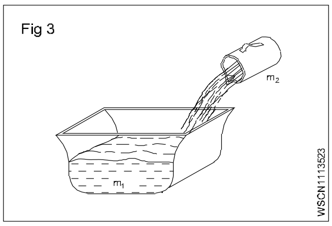


Fig 3

m_1 = 25 litres of water
t_1 = 12°C
t_2 = 70°C
t_m = 33.75°C
m_2 = ______ litres

4.

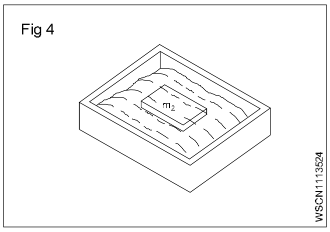


Fig 4

m_1 = 100 kg of water
t_1 = 12°C
m_2 = 50 kg of steel
t_2 = 600°C

$S_1 = 4.2 \frac{kj}{Kg°C}$

$S_2 = 0.46 \frac{kj}{Kg°C}$

Rise in temperature =_____°C of water

5.

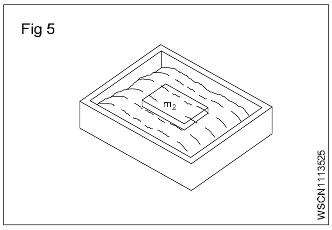


Fig 5

m_1 = 250 litres of water
m_2 = 150 kg of steel
t_1 = 15°C
t_m = 70°C
t_2 = ______ °C

6.

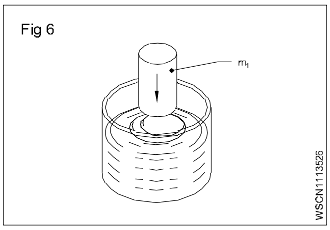


Fig 6

t_1 = ______ °C

m_1 = 20 litres of machine oil
m_2 = 30 kg of steel
t_2 = 160°C
t_m = 60°C

density of oil

$= 0.91 \frac{gr}{cm^3}$

7.

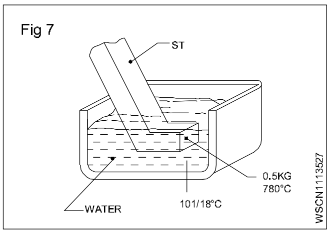


Fig 7

m_1 = 10 litres

$S_1 = 4.2 \frac{kj}{Kg°C}$

$S_2 = 0.46 \frac{kj}{Kg°C}$

m_2 = 0.5 kg
t_1 = 18°C
t_2 = 780°C
Rise in temperature =___°C of water

8.

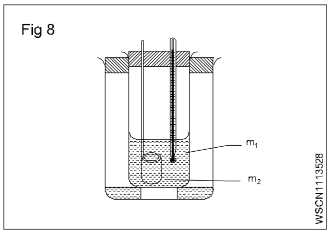


Fig 8

m_1 = 60 gms of water
m = 70 gms of calorimeter
m_2 = 80 gms of metal
t_1 = 20^0C
t_2 = 95^0 C
t_m = 25^0C
s = 0.2
s_1 = 1
s_2 =_____

9.

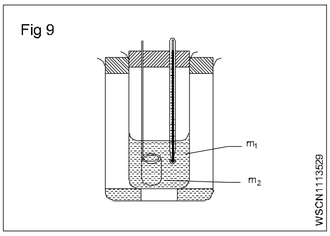


Fig 9

m_1 = 250 gms of oil
t_1 = 15^oC
m_2 = 150 gms of brass
t_2 = 90^0C
t_m = 25°C
s_2 = 0.09 water equivalent of = 3 gms calorimeter
s_1 = ______ gms

Heat loss and heat gain

1 Calculate the amount of heat required to raise the temperatureof 85.5 g. of sand from 20^0C to 35^0C. Specific heat of sand = 0.1

2 How much quantity of heat will be rejected in one hour, if the rate of flow of water is 11 kg/min and the raise of temperature of water is 12^0C.

3 Find out its specific heat. If we require 510 calories to raise the temperature of 170/ gm of material 50^0C to 80^0C.

4 Calculate the specific heat of metal piece. If 500gm metal piece at 300^0C is dropped in 5 kg of water. Its temperature raises from 30^0C to 75^0C (There is no heat loss).

5 Find out the final temperature of mixture, assuming that no heat escapes. If 300gm of water at 25^0C is mixed with 200gm of water at 85^0C.

6 What will be the resultant temperature of the mixture, when 100gm of water at 40^0C is added to the mixture. If copper calorimeter contains 80 gm of water at 20^0C. The water equivalent of calorimeter is 20 gm.

Insulating materials: Heat will flow from high temperature to low temperature. Heat flow by radiation, conduction and convection method through the wall, door, ceiling and glass door to the refrigerated space.

The material which restricts such heat flow is called insulating materials

Properties of insulating materials

- It has low conductivity
- Resistance to fire
- Less moisture absorption
- Good rigidity
- Odourless
- Vapour permeability
- Light in weight

Selection of insulating material: The following factors are the prime importance in the selection of a proper insulating material.

- **Low thermal conductivity**: Thermal conductance value of a material is a measure of its effectiveness to allow the flow of heat through it by conduction, obviously an insulating material should have a very low thermal conductivity.
- Resistance to fire.
- Mechanical strength
- Low moisture absorption capacity
- Easy to lay
- Cost
- Easy of handling
- Low cost

Types of insulating materials

Glass wool, PUF, Cork sheet, Thermocole, Insulating foil, fiber glass.

Types of insulating materials: Basic types of insulating materials are inorganic fibrous or cellular materials. Example, glass wool, slag wool ceramic products, asbestos, etc. Organic fibrous materials, cork, cotton, rubber foam, saw dust, rice husk, polystyrene, polyurethane, phenotherm, etc. The type and form available as the applications of various insulations as follows.

Glass wool: Available as semi-rigid, resin bonded slabs/sheets of different densities -higher density gives strength and lower conductivity but allows vapour transmission. Available with foil or other coverings.

Cork: Compressed and moulded into a rigid block, light but strong, can be cut easily with a saw, resists water but allows relatively high rate of water vapour transmission.

Expanded polystyrene(Thermocole): it is available as a rigid board, beads, moulded into shape for pipe/curved surface, can be cut easily with a saw, light weight allows relatively low vapour transmission.

Polyurethane: available as a rigid board, flexible board, liquid can be sprayed on surfaces and allowed to foam, can be used for in site applications.

Wood shaving/Saw dust: It needs good supporting compartment, can easily settle down. Fairly high conductivity absorbs moisture/water.

Phenotherm: Available slabs with different facings, and as performed pipe sections, can be easily cut with a saw.

Insulting materials and properties/specifications:

There are many insulating materials used in refrigeration and air conditioning field. For our water tank only few of them were in use.

Now-a-days the following insulating materials were in broad use.

- Thermocole
- Glasswool/Tar felt
- Puf
- Fiberglass

Thermocole: It is one of the insulting materials in normal use. It is available in low and high density. This is available in various thicknesses ranging 0.25" to 5".

Thermocole is available in various shapes (moulded) of necessity.

Thermocole allows (Characteristically) low transmission of vapour, thereby heat entry through is cut short. This may vary with its low/high density.

It can be cut very easily even with knife to a required shape. Thermocole withstands cool/heat for a longer time.

The 'K' factor of an insulation material follows (thermocole).

Thermocole -0.20 btu/hr Ft2 deg.f°/inch

Fibreglass: Also one of the insulating materials used for is manufactured from inorganic materials (sand, dolomite, limestone). Glass fibre insulation does not shrink due to temperature variation.

This insulation materials used for higher temperatures also upto 450°C (842°F).

Fibreglass products does not absorb moisture from the ambient air.

Glass wool: Normally glass wool material is heavily thin weighted object in layers, soft (touching). It comes off in various sizes (thickness from 0.5" to 2.5". it comes in white, yellow colours mixed up with broken glass pieces.

Handling glass wool is hazardous and harmful (if it is breathed). Always it is advisable to handle glass wool with gloves and goggles (eye) while working on it. It also comes off in various densities.

Glass wools are of two types of uses. One type of glass wool used for low temperature refrigeration/air conditioning purpose. The other type is used for boiler materials (heat prevention) purposes.

The 'K' factor of insulation material:

Glasswool: 0.230-.27 Btu/Hr ft2 deg. F°/inch.

Puf: The other mode of insulating materials used in water cooler at the evaporator tank's external body.

For this kind of insulation two chemicals used namely isocyanide-R11., Both available in liquid form in bottles (for lesser capacities) and cans (for higher capacities).

Both the liquids (chemicals) should always kept cool. When both of them added in a container and stirred in few minutes it becomes foamy (initially with thin and becomes thicker and becomes hard (sticks with the unit).

We should be careful that there is no air gap in the tank covered. It foams out with high density and uneven finish at the outer level.

Puf (materials) insulations are widely used by our manufacturer's for their products as it keeps the temperature for a longer period.

The main disadvantage of the insulation is as soon as the chemicals are mixed and stirred it should be poured over the evaporator coil (or) outside the evaporator tank within the shortest period. If the time exceeds the solution starts framing at the container itself and becomes useless.

The evaporator tank should be covered well with wooden/ steel boards with required gaps for insulation tightened all the corners well giving small gaps to pour the solution.

Method of laying duct insulation: when there is no chance of moisture condensation on the duct, glass wool can be used. Since it is economical and fire resistant. However if moisture condensation can occur greater care should be exercised in case of glass wool. First a uniform coat of bitumen is applied to the duct surface and the wool is stuck to the bitumen. The insulation is then covered with a polythene sheet which acts as a vapour barrier. The surface can be plastered after spreading chicken wire mesh as reinforcement.

Expanded polystyrene can be laid easily as it is rigid. Bitumen is applied on the duct and the insulation is stuck joints are also sealed with bitumen. No separate vapour barrier is needed other than a coat of bitumen. The insulation can be finished with cement and plaster or metal cladding.

Purpose of false ceiling: The conditioned air arrives through the ducts at the supply air diffusers and enters the conditioned space. Most diffusers are attached to the false ceiling and a variety of diffusers are available for different air spreading needs. The return air grills will be fixed to the false ceiling. The false ceiling prevents mixing of conditioned air and return air.

Return air usually flow into the plenum or return air box through grill placed in the false ceiling. Since substantial amount of energy goes into the air in the first place. It is a practice to recycle the air. The air is therefore brought back to the air conditioning. Plant room it is common to route the return air through the gap between the false ceiling and the main ceiling. A space referred to as a plenum, the false ceiling is also known as a return air duct.

Concept of pressure - Units of pressure, atmospheric pressure, absolute pressure, gauge pressure and gauges used for measuring pressure

Exercise 1.6.32

Concept of pressure

Continuous physics force exerted on or against an object by something in contact with it.

Definition

Pressure is an expression of force exerted on a surface per unit area, i.e., the force applied is perpendicular to the surface of object per unit area.

As the amount of gas increases assuming the volume of chamber and the temperature remain constant the pressure increases.

Unit: Standard unit and also the S.I. unit of pressure is Pascal (Pa) and Metric unit of pressure is Bar.

1 Pascal is defined as a force of one newton per square metre

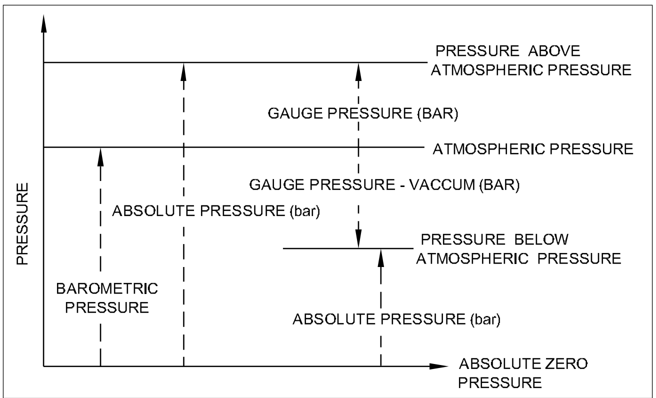
i.e., 1 Pascal = 1 N/m^2

1 Bar = 10^5 N/m^2

Pressure units in different systems

British unit FPS	Pounds per square inch	lb/in^2
Metric units CGS	Gram per square centimetre	g/cm^2
MKS	Kilogram per square metre	kg/m^2
International	Newtons per square metre circuits SI	N/m^2

Types of Pressure



1 Absolute pressure

2 Atmosphere pressure

3 Gauge pressure

Measuring Instruments

I Manometers

- a Simple manometer
  - i Piezometer
  - ii 'U' tube manometer
  - iii single column manometer
- b Differential manometer
  - i 'U' tube differantial manometer
  - ii Inverted 'U' tube manometer

II Mechanical Gauges

- a Diaphragm pressure gauge
- b Bourdon's tube pressure gauge
- c Dead weight pressure gauge
- d Bellows pressure gauge

Example

A liquid gives force of 100 N over an area of 2m^2. What is the pressure?

Force = 100 N

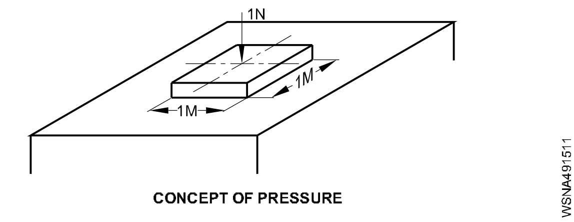
Area = 2 m^2

Pressure = ?

$$P = \frac{F}{A} = \frac{100}{2}$$

$= 50\ N/m^2$

Fig 1



CONCEPT OF PRESSURE

Unit of pressure N/m^2, 1 N/m^2 = 1 pascal.

This unit is too small (Pressure of a fly on a area of 1 cm^2). Hence ‘bar’ is introduced as the unit of pressure. 1 bar = 10^5 pascal.

$$10^5\ P_a = 10^5\ \frac{N}{m^2} = 10\ \frac{N}{cm^2} = 1\ bar$$

1 bar = 1000 mbar. [SI unit of Pressure is Pascal (Pa) and Metric unit of Pressure is bar]

Properties of Pressure

1 The pressure in a liquid increases with increase in depth.