

Measurement of temperature:

Thermometric property: A physical property that varies with temperature is called as the thermometric property.

The thermometric property can be used to measure the temperature of objects.

Example:

- The thermal expansion of a liquid in "The liquid in glass thermometer" is the thermometric property
 - The voltage difference between the hot and the cold junctions is the thermometric property of thermocouple thermometers.
 - Bending of a bimetallic strip
 - Expansion/ volume or pressure of a gas
 - Colour of a hot surface
 - Colour change of certain chemicals.
-

Fixed points:

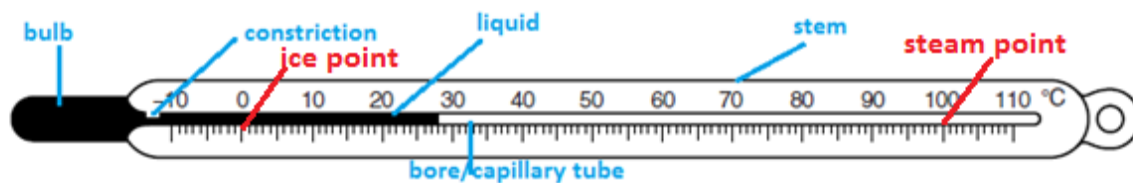
The Celsius scale of a thermometer denoted by $^{\circ}\text{C}$ is defined by two fixed points; namely:

- The ice point (the lower fixed point)= 0°C = temperature of pure melting ice or the freezing point of pure water
- Steam point (the upper fixed point)= 100°C = temperature of pure boiling water.
at standard atmospheric pressure.

While calibrating a thermometer , the space between the lower and upper fixed points is divided into 100 equal divisions and each division is equal to 1°C .

Liquid in glass thermometers:

Structure and action of the liquid in glass thermometer:



Construction:

- It consists of a thin glass bulb joined to a capillary tube with a narrow bore which is sealed at the other end. The glass bulb is thin to allow rapid heat transfer.
- The wall of the stem is thick to reduce the chance of breaking and to magnify the thread.
- The length of the stem affects the range as there is space for the liquid to expand.
- The capillary tube in which the liquid expands is narrow to increase the sensitivity of the thermometer. Thus diameter of a capillary affects the sensitivity of a thermometer.
- If the diameter of the capillary is not uniform, then the thermometer will be non-linear, meaning the liquid will not expand uniformly for every degree rise in temperature.
- The liquid used is usually mercury or coloured alcohol.
- The space between the end of the liquid thread and the end of the tube is filled with vacuum.
- The type of liquid used depends upon the temperatures to be measured. alcohol has a low freezing point than mercury so is used to measure lower temperatures.
- When the bulb is immersed in an object whose temperature needs to be measured, the liquid in the bulb expands and rises up in the capillary tube.
- The temperature is measured in degree Celsius or Kelvin.

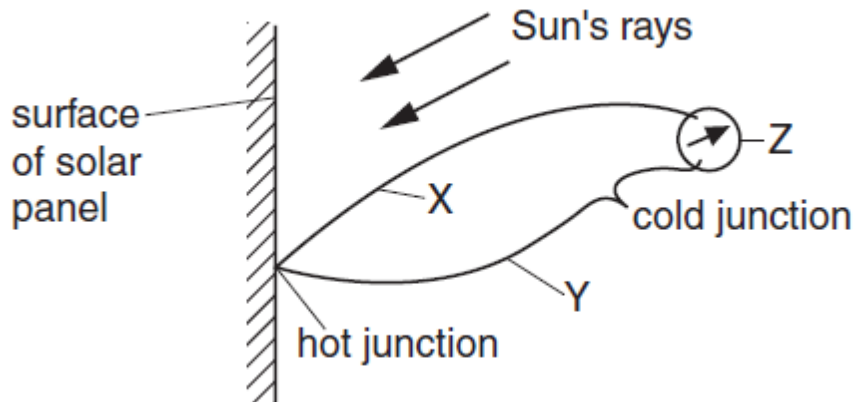
Working:

- When the bulb becomes warmer, the liquid in it expands more than the available volume in the bulb, so some of the liquid rises into the capillary tube.
 - The thread of the liquid in the capillary tube increases in length.
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Alcohol is suitable to be used in thermometers due to the following reasons:

- It expands uniformly
- It expands more than glass.(It has high expansivity)
- It has reasonably low specific heat capacity
- It has lower freezing point as compared to mercury.

Thermocouple thermometers:



- They are electrical thermometers containing 2 junctions at different temperatures.
- One junction is always maintained at a known temperature and the other junction is used as a temperature probe.
- A voltage develops because the two junctions are at different temperatures.
- The voltmeter needs to be calibrated to read the temperature either in degree Celsius or Kelvin.
- Readings of the meter change with temperature.

Advantages of using thermocouple thermometers:

- The size of the thermocouple junction is very small. It has small heat capacity. It has a low mass and hence the temperature junction reaches the temperature of the object quickly and so it is used to measure rapidly changing temperatures.

- They can be used to measure much higher temperatures than the liquid in glass thermometers.

Comparison between liquid in glass and thermocouple thermometers.

Type of thermometer	Thermometric property	Uses
Liquid in glass thermometer	Thermal expansion of the liquid	Temperatures in homes, hospitals, greenhouses .
Thermocouple	Voltage between two different metals in contact	Food heated in oven, data logging, remote locations. to measure high temperatures, to measure rapidly changing temperature

Factors that affect the choice of thermometers

- **The range of temperatures:** For example if a temperature between -10°C and 50°C is being measured, then coloured alcohol must be used .This is because it visible, has even expansion, alcohol has low specific heat capacity and alcohol does not stick to the glass.
- **Sensitivity:** It is the change in the length of the liquid column per degree rise in temperature
- **Linearity:** It means that the change in the length of the liquid column is the same for all degrees.

The factors affecting the accuracy of a thermometer:

- Sensitivity
- Linearity

Suppose while comparing two thermometers, it is stated that a thermometer X has **large range**, **good linearity** and **high sensitivity**. then it implies that:

Large range: It covers greater range of temperatures

Good linearity: Liquid in X expands uniformly with temperature rise.

High sensitivity: For the same temperature rise, the liquid X expands more.

How to improve the range and sensitivity of liquid in glass thermometers?

> Greater Range:

Make the capillary tube longer

Use a liquid with lower expansivity

> Higher Sensitivity:

Make the capillary tube thinner or finer.

Use a bigger bulb

Use a liquid with higher expansivity

APPLICATION BASED QUESTIONS:

MCQ:

16 A thermometer has a scale which starts at -10°C and ends at 110°C .



What is the value of the lower fixed point and of the upper fixed point of the scale?

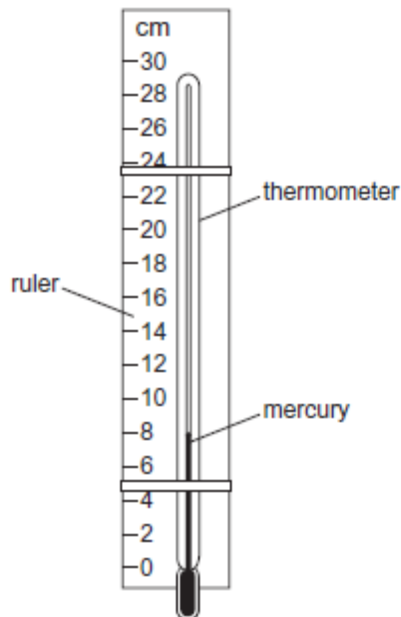
	lower fixed point / $^{\circ}\text{C}$	upper fixed point / $^{\circ}\text{C}$
A	-10	100
B	-10	110
C	0	100
D	0	110

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16 A mercury thermometer with no scale is taped to a ruler as shown.

When the thermometer is placed in steam, the mercury level rises to 22.0 cm.

When the thermometer is placed in pure melting ice, the mercury level falls to 2.0 cm.



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Which temperature is shown by the mercury level in the diagram?

- A 6°C B 8°C C 30°C D 40°C

16 A mercury-in-glass thermometer is to be used to measure temperatures from 0 °C to 100 °C.

Why is mercury suitable?

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- A Mercury expands when heated.
B Mercury has a boiling point below 100 °C.
C Mercury has a melting point above 0 °C.
D Mercury is a poor conductor.
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APPLICATION BASED QUESTIONS-EXTENDED THEORY

4 A technician has been asked to design a liquid-in-glass thermometer, using alcohol as the liquid.

M/J/10-P33

(a) (i) State what is meant by the *sensitivity* of the thermometer.

.....
..... [1]

(ii) State one design feature the technician could use in order to ensure a very sensitive thermometer.

.....
..... [1]

(b) (i) State what is meant by the *range* of the thermometer.

.....
..... [1]

(ii) State one design feature that would ensure that the thermometer measured the desired range of temperatures.

.....
..... [1]

(c) (i) State what is meant by *linearity*, as it applies to the thermometer.

.....
..... [1]

(ii) State one design feature that would ensure linearity in the technician's thermometer.

.....
..... [1]

[Total: 6]

5 (a) Equal volumes of a gas held at constant pressure, a liquid and a solid undergo the same temperature rise.

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(i) State which of the three, solid, liquid or gas,

1. expands the most,
2. expands the least.

(ii) Explain why the pressure of the gas must be kept constant for this comparison.

.....
[2]

(b) Fig. 5.1 shows an alcohol thermometer.

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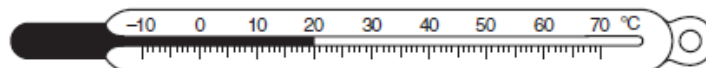


Fig. 5.1

(i) State two properties of alcohol which make it suitable for use in a thermometer.

1.

2.
[2]

(ii) State two changes to the design of this thermometer which would make it more sensitive.

1.

2.
[2]

(c) Explain why it is an advantage for the glass surrounding the alcohol in the bulb of the thermometer to be very thin.

.....
[1]

5 (a) State two examples of physical properties that vary with temperature and that may be used for the measurement of temperature.

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O/N/15-p33

1.

2.

[2]

(b) When first manufactured, a liquid-in-glass thermometer has no scale markings.

(i) Describe the procedure needed to determine

1. the position on the thermometer of the lower fixed point,

.....
.....
.....

2. the position on the thermometer of the upper fixed point.

.....
.....
.....

[3]

(ii) Explain why

1. the graduations marked on the thermometer between the fixed points are spaced equally,

.....
.....[1]

2. the expansion of the glass of the thermometer is ignored.

.....
.....[1]

[Total: 7]

- 7 Three wires and a meter are used to construct a thermocouple for measuring the surface temperature of a pipe carrying hot liquid, as shown in Fig. 7.1.

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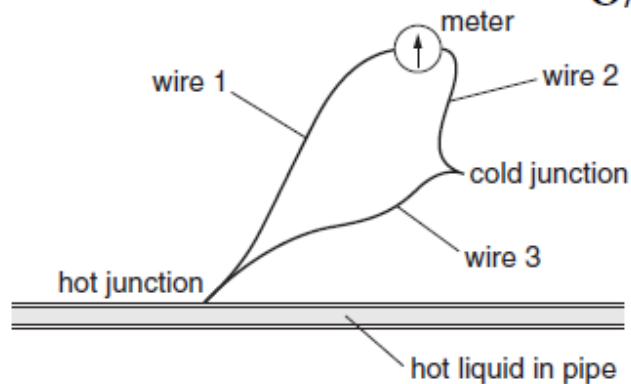


Fig. 7.1

- (a) Copper wire and constantan wire are used in the construction of the thermocouple.

State which metal might be used for

wire 1

wire 2

wire 3

[1]

- (b) State what type of meter is used.

..... [1]

- (c) State one particular advantage of thermocouples for measuring temperature.

..... [1]

[Total: 3]



5 Fig. 5.1 shows a thermocouple set up to measure the temperature at a point on a solar panel.

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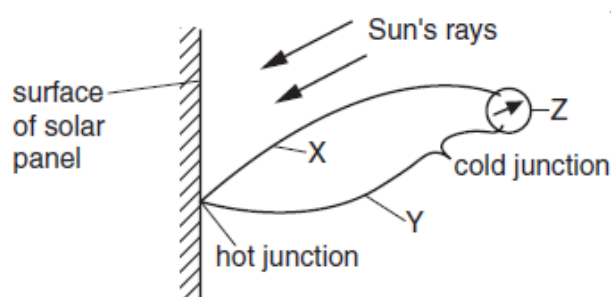


Fig. 5.1

(a) X is a copper wire.

(i) Suggest a material for Y.

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(ii) Name the component Z.

.....

[2]

(b) Explain how a thermocouple is used to measure temperature.

.....

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.....[3]

(c) Experiment shows that the temperature of the surface depends upon the type of surface used.

Describe the nature of the surface that will cause the temperature to rise most.

.....

.....[1]

