Delta Science Education

Billy Li

HKDSE Physics

Core 1: Heat and Gases

Chapter 1: Temperature, Heat and Internal Energy

Part 1

直接 Whatsapp Billy sir: 9341 0473

1. Temperature

(1) Meaning of Temperature

- Temperature is the measurement of the **degree of hotness** or the **average molecular kinetic energy** of a substance.

(2) Fixed points

- Fixed points always occur at a certain temperature and are reproducible in the laboratory.
- Fixed points are used to mark temperature scales on a thermometer.
- **Upper fixed point:**

- **[ ] point of [ ] water (steam point) at normal atmospheric pressure**

- **Lower fixed point:**

- **[ ] point of [ ] ice (ice point) at normal atmospheric pressure**

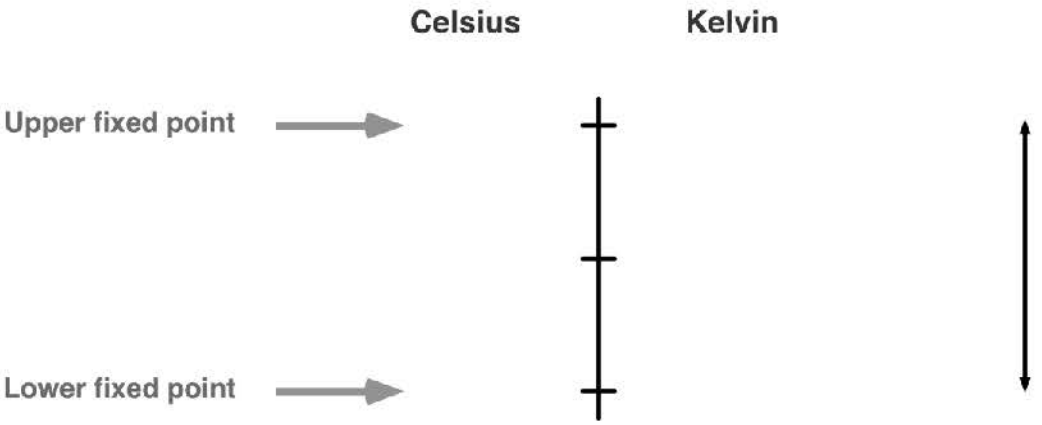
(3) Temperature scales

- Celsius scale θ:

  Steam point of water = **Ice point of water =**

- Kelvin scale T:

  Steam point of water = **Ice point of water =**



- Temperature difference:

	degree Celsius (°C) (centigrade)	degree Fahrenheit (°F)	Kelvin scale (K)
Commonly used in	Most of the other countries and scientific purposes	English-speaking countries	Solely scientific purposes
Conversion to °C		$^\circ C = \frac{5}{9}(^\circ F - 32)$	$^\circ C = K - 273$

Examples that you must fully understand

1. A cup of water is initially at the room temperature of 25°C. It is heated until it boils.

   (a) What is the room temperature in Kelvin?

   (b) What is the rise of temperature of the water in Kelvin?

2. Thermometers

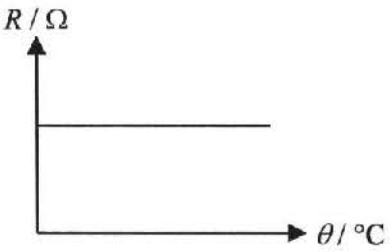
(1) Requirement of a thermometer

- The thermometer is a device that makes use of **some measurable** _____ which _____ according to the **degree of relative hotness or coldness**.
- Physical properties that can be used to measure temperature:
  - **Liquid volume**
  - **Gas volume or gas pressure**
  - **Resistance of metal**

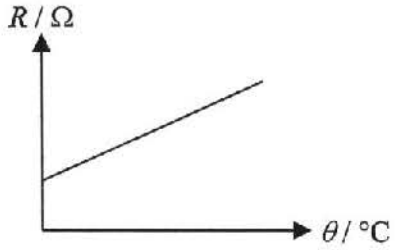
Examples that you must fully understand

2. The graphs below show how the electrical resistance R of three different circuit elements change with temperature. Which of the circuit elements can be used to measure temperature?

(1)



(2)



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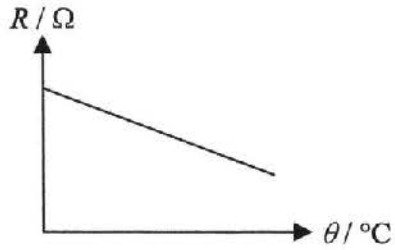
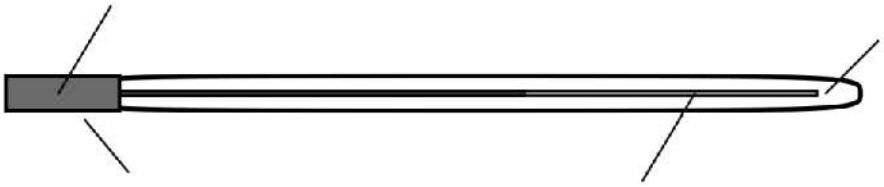


(2) A liquid-in-glass thermometer

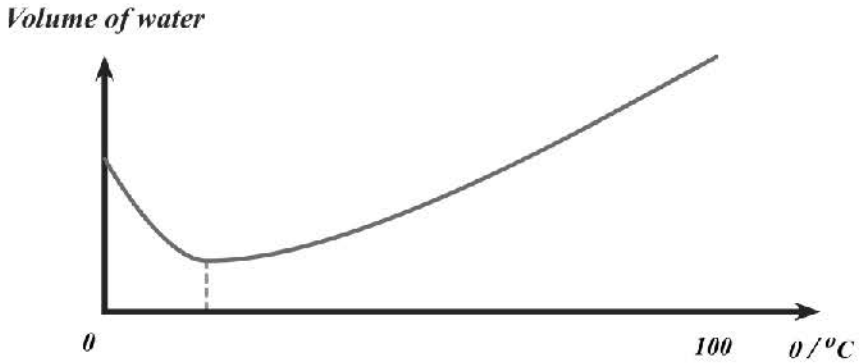
- The liquid-in-glass thermometer makes use of the **uniform** [ ] **of liquid** at different temperatures.
- Structure of a liquid-in-glass thermometer:



- Two liquids in common use are:
  -
  -
- **Mercury-in-glass thermometer:**
  - Mercury remains in liquid state from -39°C to 357°C. Thus, it is **suitable for measuring** [ ] **temperature but not suitable for measuring** [ ] **temperature**.
  - Mercury is a **good** [ ]. It thus gives [ ] to changes in temperature.
  - Mercury is **opaque** and can easily be seen.
  - Mercury does not **wet glass**.
- **Alcohol-in-glass thermometer:**
  - Alcohol remains as liquid from -115°C to 78°C, thus it is **suitable for measuring** [ ] **temperature but not suitable for measuring** [ ] **temperature**.
  - Alcohol is **transparent**. It has to be **dyed** in order to be seen.
  - Alcohol is **cheaper** than mercury.

Mercury-in-glass thermometer	Alcohol-in-glass thermometer
Can measure **high** temperature (up to 357 °C)	Can measure **low** temperature (down to – 115 °C)
Quick response to temperature changes	**Slow response** to temperature changes
Mercury is **poisonous**	Alcohol is **non-poisonous**

- **<u>Water is not used in a liquid-in-glass thermometer:</u>**
  - Water remains as liquid from 0°C to 100°C.
  - Water **does not expand uniformly.** It has an abnormal expansion from 0°C to 4°C.



- When the temperature of an object is to be measured, only the [ ] is used to detect the temperature.
- A good design of thermometer should **respond quickly** to the change of temperature. Designs that can make the thermometer respond quicker to change in temperature includes:
  - using **mercury** instead of **alcohol** as mercury is a [ ];
  - using a [ ] as the heat capacity of the liquid is **less;** and
  - using a [ ] as the **conduction of heat will be faster**
- To design a thermometer **more sensitive** to the change in temperature, we should:
  - using a [ ] as the overall **expansion of the liquid is greater;** and
  - using a [ ] as the **increase in the height** after expansion is greater
- However, if the **length of the thermometer** [ ], the **more sensitive** the thermometer is, the [ ] **the measurable range** of the thermometer.

Greater range

More sensitive

Examples that you must fully understand

3. Which of the following is / are the advantages of using mercury to measure temperature?

(1) Mercury expands uniformly.

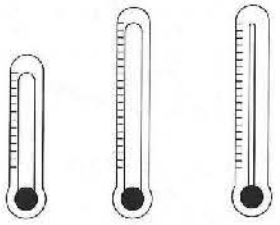
(2) Mercury can be used in Arctic area where the temperature is very low.

(3) Mercury is transparent.

(4) Mercury is poisonous.

(5) Mercury gives a slow response to change in temperature of the environment.

4. Which of the following can increase the sensitivity of a liquid-in-glass thermometer?



(1) Increase the size of the bulb.

(2) Increase the length of the glass tube.

(3) Reduce the thickness of the bore of the glass tube.

(4) Use a tube having a narrower bore.

(5) Use a liquid which conducts heat faster.

5. Which of the following can make the thermometer response more quickly to temperature change?

(1) Increase the size of the bulb.

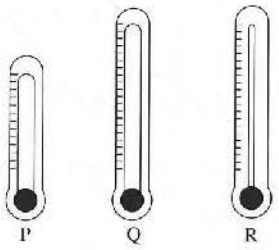
(2) Reduce the thickness of the wall of the bulb.

(3) Use mercury instead of alcohol as the liquid for the thermometer.

(4) Use a tube having a narrower bore.

6. Three thermometers P, Q, R contain mercury. The sizes of bore of P and Q are the same while they are larger than that of R. The lengths of stem of Q and R are the same while they are longer than that of P.

At $0^{\circ}C$ all mercury goes back to their bulbs. All thermometers can measure temperature above $100^{\circ}C$.



(a) Arrange the sensitivity of P, Q and R in ascending order.

(b) Which of the following statements about P, Q and R is / are correct?

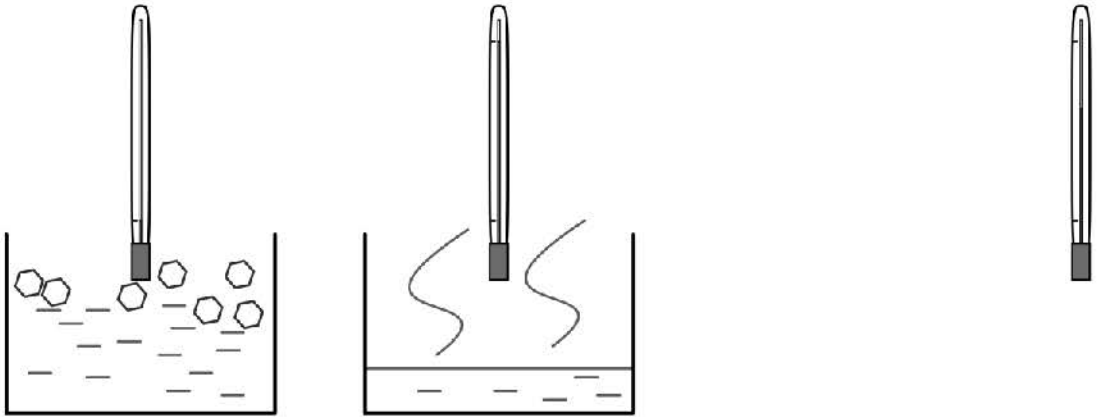
(1) Q measures the larges range of temperature.

(2) All three mercury-in-glass thermometers cannot record temperatures below 0°C.

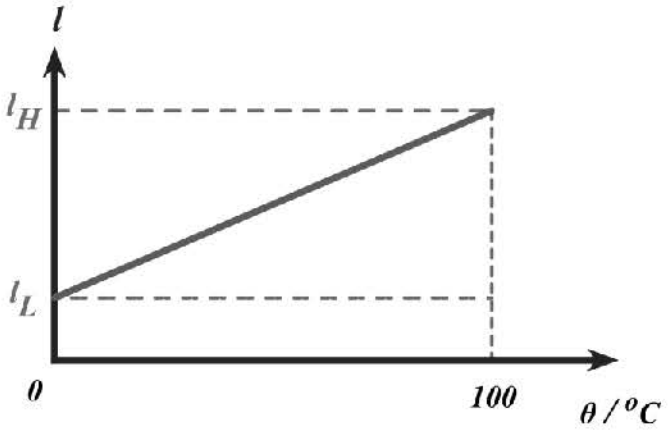
(3) At 100°C, mercury in all three thermometers reaches the same level.

(3) Calibration of a thermometer

- Calibration of a thermometer is to **mark the proper scales** onto the thermometer.
- **Procedure of calibration of a mercury-in-glass thermometer:**
  - Put the thermometer into a cup of [ ], mark the length of the mercury thread l_L as [ ].
  - Put the thermometer in the steam above a cup of [ ], mark the length of the mercury thread l_H as [ ].
  - **Assume the expansion is** [ ], divide the length between l_L and l_H into [ ] **equal divisions**, each division is [ ].



- Calibration graph:



- Equation relating the temperature θ with the length l in a liquid-in-glass thermometer:

Examples that you must fully understand

7. The length of the mercury thread in a mercury-in-glass thermometer is 4 cm at ice point and 20 cm at steam point.

(a) What is the temperature when the length of the mercury thread is 14 cm?

(b) What would be the length of the mercury thread at the room temperature of 20°C?

(c) What is the temperature when the length of the mercury thread is 2 cm?

(d) What is the length of the mercury thread in 1°C interval?

8. Regarding the thermometer below,

(a) Find the length of the liquid when the temperature is now:

50 °C	−28 °C	750 °C

(b) Find the temperature of the thermometer when the length of the liquid is now:

75 cm	2 cm	150 cm

(c) Can such a thermometer measure temperature of -78°C?

☐. At this temperature, all of the liquid will go ☐ to the ☐.

Examples that you must fully understand

9. The distance between the readings of the two fixed points of a mercury thermometer is 20 cm. If the reading of T is 7.4 cm above the reading of 0°C, find T.

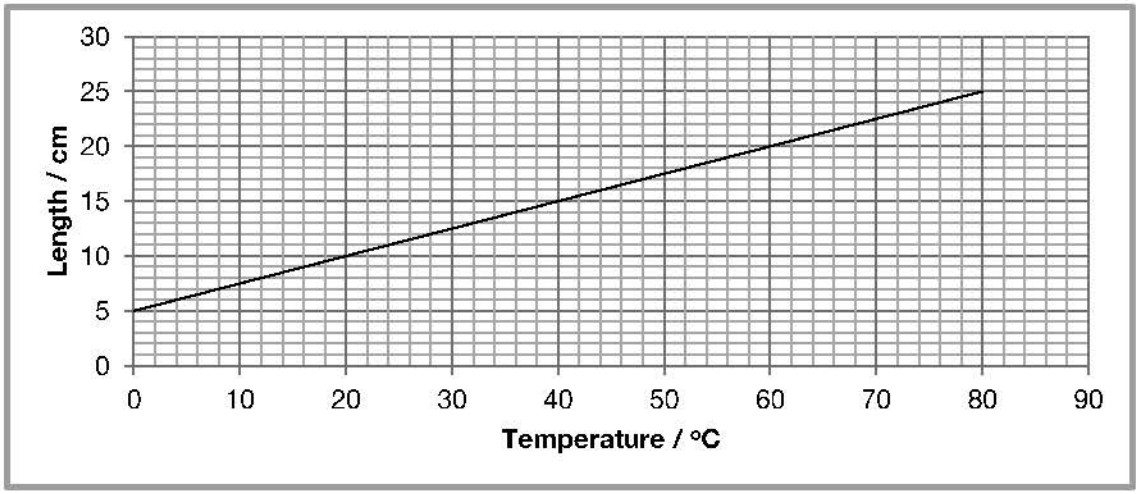
10. A faulty thermometer with a uniform bore reads –3°C in melting ice and 102°C in boiling water.

(a) What does the thermometer read when it is immersed in a liquid with a real temperature of 75°C?

(b) What is the real temperature when the reading of the thermometer is 20°C?

(c) At what temperature is the thermometer reading equal to the true reading?

11. The length of the mercury thread of a thermometer is plotted against temperature in the following graph.

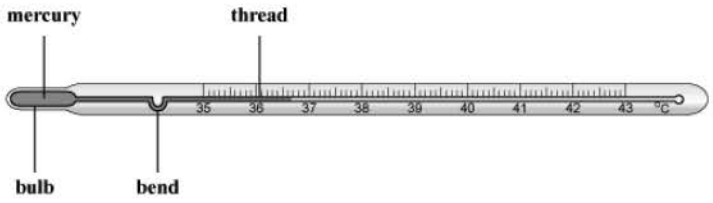


(a) Write an equation relating the length to the temperature.

(b) What is the temperature when the length of the mercury thread is 16 cm?

(c) What will be the length of the mercury thread if the temperature is -10°C?

(4) Clinical thermometer



- It is a specially designed [ ]-in-glass thermometer used to measure body temperature.
- It is [ ] **and** has a **small temperature range**: from 34°C to 42°C
- When the thermometer is just taken out from the human body, the temperature drops. A [ ] is used **to prevent the mercury thread from falling**.
- Mercury is used since it is a **good conductor** and **responds quickly** to any change in temperature.

Examples that you must fully understand

12. A clinical thermometer is designed to measure body temperature around 37°C. What are the advantages of the following design features?

(i) It has only a small temperature range from 34°C to 42°C.
So that the thermometer can be designed to be more [ ].

(ii) It has a very narrow bore.
It enables the thermometer to be more [ ].

(iii) It has a thin glass wall at the bulb.
It enables the thermometer to [ ] to changes in temperature.

(iv) It has a constriction in the bore.
It prevents the liquid from [ ] to the [ ] when the thermometer is [ ] from the human body.

13. Explain the followings about a clinical thermometer:

(i) liquid mercury is used rather than water;
The volume of water is not [ ] with temperature. The [ ] [ ] upon [ ] is much smaller for water. Mercury is a better [ ] of heat than water.

(ii) the glass wall is very thin; and
Thermometers with thin glass wall can give a [ ] to temperature change.

(iii) we should not sterilize the thermometer using boiling water
It is because the [ ] of clinical thermometer is much [ ] than boiling point. The thermometer will [ ] if it reaches the boiling point of water. Also, it takes long time to let the reading [ ] back the [ ].

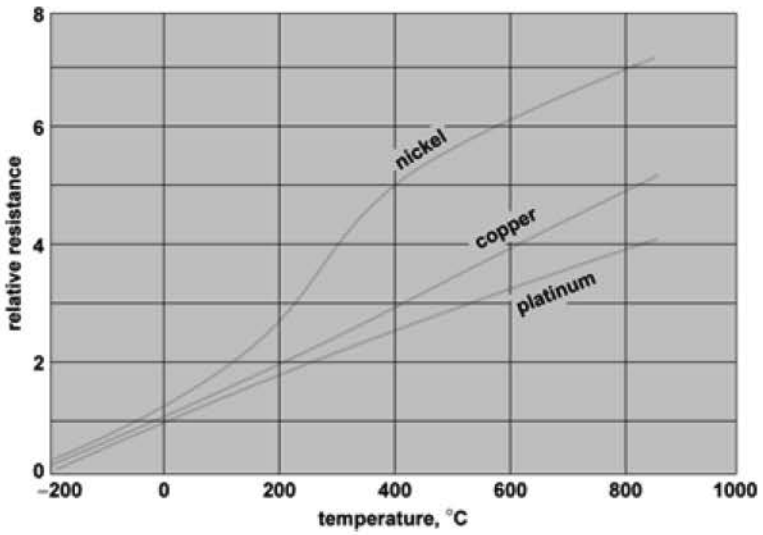
(5) Other types of thermometers

I. Thermistor thermometer

- **Resistance** of the thermistor [ ] when **temperature increases**. Therefore, a [ ] **current** can be obtained.
- Measuring the current can thus know the temperature.
- It is usually used in an automation circuit.

II. Resistance thermometer

- **Resistance** of metal wire [ ] when **temperature increases**. Therefore, a [ ] **current** can be obtained.
- Measuring the current can thus know the temperature.
- It can measure temperatures of over a thousand degrees Celsius and can be used in industry to measure the temperatures of ovens and furnaces.



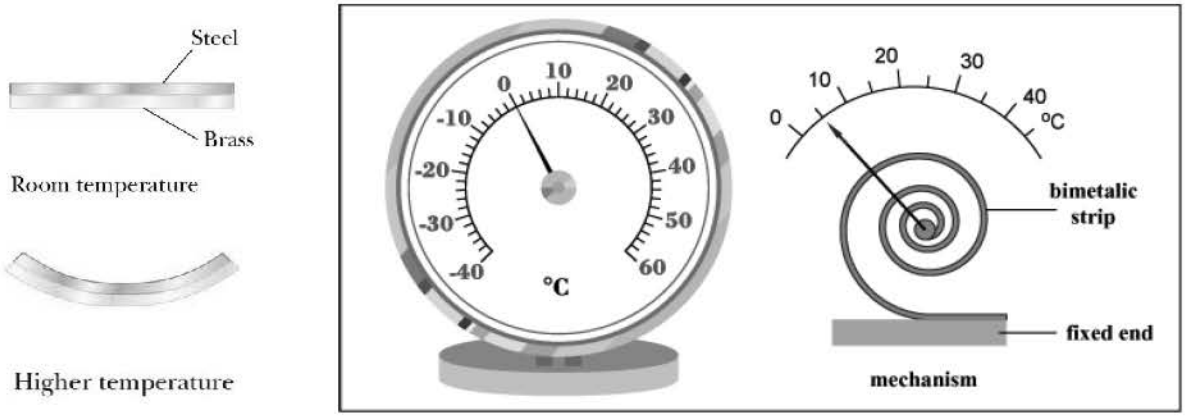
- **Thermistor Thermometer:**
- **Resistance Thermometer:**

III. Infra-red thermometer

- If an object is at a temperature **higher than** [ ], it **emits** [ ] **radiation**.
- The **higher the temperature**, the [ ] **the infra-red radiation** an object emits.
- Measuring the amount of infra-red can thus know the temperature.
- It is usually used in measuring **body temperature**.

IV. Rotary thermometer

- This thermometer makes use of a **bimetallic strip** that consists of two strips of different metal joined together surface to surface.
- The strip bends as one metal expands more than the other under temperature change. As **temperature increases**, the **coiled bimetallic strip bends more to rotate a pointer** around on a scale.
- **Brass** and **iron** are usually used to make the bimetallic strip in a rotary thermometer.
- Rotary thermometer is usually [ ] **in response**.



V. Liquid crystal thermometer

- A liquid crystal thermometer is a type of thermometer that contains [ ] liquid crystals in a plastic strip that change [ ] to indicate different temperatures.