

# Temperature and thermometers



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Temperature and Thermometers The Temperature of an object is a measure of the hotness or coldness of that object. An alternative way to think of temperature is to say that “ the temperature of an object is a number – on some manmade scale – that indicates the hotness of the object”. ‘ Hotness’ in turn is a measure of the kinetic energy of the molecules of the material.

Note: You must use the term ‘ hotness’. \* The SI unit of temperature is the Kelvin (K)\* Relationship between degrees Celsius and Kelvin\*: Thermometric Properties A Thermometric Property is any physical property that changes measurably with temperature.

Note: You must use the term ‘ measurably’. Examples of thermometric properties: •Length of a column of liquid, e. g. mercury and alcohol thermometers, •Electrical resistance (see chapter 23), •Colour (colour ‘ strips’ are sometimes used by nurses and placed against a person’s forehead), •Emf of a thermocouple (emf is a fancy word word for ‘ voltage’), •Volume of gas at constant pressure, •Pressure of a gas at constant volume.

Disagreement between thermometers Two different types of thermometer will give slightly different readings at the same temperature. This means we need to agree on one particular thermometer to have as a standard.

Practical Thermometers •Clinical thermometer •Oven thermometer •Temperature gauge in a car Clinical thermometer; Two Main Features: Short range because temperature of the human body doesn’t vary much either side of normal body temperature (37. 60 C). A kink to prevent the liquid falling back down when the thermometer is removed from the mouth and held vertically. Experiment: Using a thermometric property to measure temperature\* 1. Note the value of the thermometric property in melting ice

(00 C) and also in boiling water (1000 C). . Plot these two points on a graph and draw a straight line joining them. 3. For an unknown temperature, note the thermometric property and use the graph to calculate the corresponding temperature. Mandatory Experiment: To plot a calibration curve for a thermometer using a mercury thermometer as a standard. Leaving Cert Physics Syllabus Content Depth of Treatment Activities STS Concept of temperature Measure of hotness or coldness of a body. The S. I. unit of temperature is the Kelvin. Celsius scale is the practical scale of temperature.

$$T / ^\circ\text{C} = T / \text{K} - 273.15$$

Thermometric Properties A physical property that changes measurably with temperature. Demonstration of some thermometric properties:

- length of liquid column, e. g. length of mercury column
- emf of thermocouple
- Pressure of a gas at constant volume
- Volume of a gas at constant pressure
- Resistance
- colour

Thermometers Thermometers measure temperature. Two thermometers do not necessarily give the same reading at the same temperature. The need for standard thermometers – use any commercial laboratory thermometer as a school standard. Graduate two thermometers at ice and steam points.

Compare values obtained for an unknown temperature, using a straight-line graph between the reference points. Practical thermometers, e. g.

- clinical thermometer
- oven thermometers
- boiler thermometer
- temperature gauge in a car.

Extra Credit \* You must use the term ‘ hotness’ So why can’t we say that “ the temperature of an object is a measure of how hot or cold an object is”? ‘ Hot’ is a vague term. Does it refer specifically to temperature, or to the amount of heat in the object? After all, a litre of water at 1000 Celsius has

twice as much heat as half a litre of water at 1000 Celsius. Hotness' is the physicists way of overcoming this potential confusion. \*The SI unit of temperature is the Kelvin (K) SI stands for ' Standard Internationale' (French). Basically it's a system of units (incorporating the metric system) which connects up all the main physical quantities, and which has been agreed by all scientists (but not Engineers, funnily enough). For more info on this see <http://www.npl.co.uk/reference/> And before you ask, no I don't know why we have degrees Celsius, degrees Fahrenheit, but just plain old Kelvins. Relationship between Degrees Celsius and Kelvins What's significant about 273. 15? Well, temperature is really a measure how quickly atoms or molecules in an object are moving or vibrating; the colder the temperature the more sluggish the molecules move. Now, taking this to the extreme, scientists have calculated that these atoms would cease moving if the temperature dropped as low as -273. 15. This is therefore the coldest temperature obtainable anywhere in the universe. A Scottish scientist called William Thompson worked this out and decided that if -273. 5 0Celsius is the lowest possible temperature then wouldn't it make sense to have a new temperature with this as the starting point? It would mean that there would be no negative temperatures. And so it came to be. For this (and much, much more) Thompson was knighted and took the honorary title of Kelvin. The temperature scale is called the Kelvin scale in his honour, and the unit of temperature on this scale, as we have seen, is called the Kelvin. This lowest temperature 00 Kelvin (or -273. 15 C) is called ' Absolute Zero'.

Now it turns out that the temperature of outer space is not actually Absolute Zero but is about 3 degrees above it. This fact (found accidentally by a

couple of scientists working for IBM in the 60's) is one of the major pieces of evidence for The Big Bang. \*Temperature in degrees Celsius = Temperature in Kelvin - 273. 15 Note however that a temperature change of one degree Celsius corresponds to a temperature change of one Kelvin. In other words if enough heat is provided to increase an objects temperature by say, 10 degrees Celsius, then it's temperature will also have risen by 10 Kelvin.

In Fahrenheit however, its temperature may increase by 6. 243 degrees (and yes I just made up that number, but the point is, there is no one-to-one relationship between Kelvin and Fahrenheit). See the note on the last page on the origins of Celsius and Fahrenheit. \*Two different types of thermometer will give slightly different readings at the same temperature. This is because different thermometric properties do not change proportionally with the same change in degree of hotness. I have italicised the line above because it is the expected answer to the question ' why do we need a standard thermometer? This is a common exam question but is also a tricky concept to get hold of. Basically it means that thermometric properties do not change exactly proportionally with changes in heat energy. Some may come close, but none are perfect. For what it's worth, scientists use what is called the ' Constant volume-gas thermometer' as the standard. It's a bit too bulky and cumbersome for school purposes however. \*Using a thermometric property to measure temperature Strictly speaking a straight line is only valid if we assume that the thermometric property does change linearly with temperature.

We know that it doesn't, but in practice the difference is so small that we can ignore it. Origins of the Celsius and Fahrenheit scales Everybody knows 0

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degrees on the Celsius scale is the freezing point of water and 100 degrees is the boiling point. On the Fahrenheit scale, however, freezing is 32 degrees and boiling 212. How on earth were these numbers arrived at? Do 0 and 100 degrees Fahrenheit mean anything? Researchers have gone to their graves trying to figure out what old man Fahrenheit was up to.

Here's the story as well as I can piece it together: Daniel Gabriel Fahrenheit (1686-1736) was a German instrument maker who invented the first practical mercury thermometer. Casting about for a suitable scale for his device, he visited the Danish astronomer Ole Romer, who had devised a system of his own. As it turned out, it was a case of the blind leading the blind. Romer had decided that the boiling point of water should be 60 degrees. This at least had the strength of numerological tradition behind it (60 minutes in an hour, right? ).

But zero was totally arbitrary, the main consideration apparently being that it should be colder than it ever got in Denmark. (Romer didn't like using negative numbers in his weather logbook. ) In addition to the boiling point of water, the landmarks on Romer's scale were the freezing point of water, 7? degrees, and body temperature, 22 ? degrees. D. G. , simple soul that he was, thought this cockeyed system was the soul of elegance. He made one useful change: to get rid of the fractions, he multiplied Romer's degrees by 4, giving him 30 for the freezing point and 90 for body temperature.

Then, for reasons nobody has ever been able to fathom, he multiplied all the numbers by 16/15, making 32 freezing and 96 body temperature. Boiling point for the time being he ignored altogether. By and by Fahrenheit got

ready to present his scale to London's Royal Society, the scientific big leagues of the day. It dawned on him that it was going to look a little strange having the zero on his scale just sort of hanging off the end, so to speak. So he cooked up the explanation that zero was the temperature of a mix of ice, water, and ammonium chloride.

At some point Fahrenheit figured out that the boiling point of water came in at 212 degrees. Over time this replaced body temp as the upper landmark on his scale. Meanwhile, as more precise measurements were made, body temperature had to be adjusted to 98.6 degrees. In short, 100 means nothing at all on the Fahrenheit scale, 96 used to mean something but doesn't anymore, and 0 is colder than it ever gets in Denmark. Brilliant. Lest we get too down on Fahrenheit, though, consider Anders Celsius, who devised the centigrade scale (0 to 100). Everybody agrees Celsius's scale makes more sense than Fahrenheit's.

Trouble is, the original Celsius scale had 100 for freezing, 0 for boiling. In other words, it was upside-down. (The numbers were reversed after Celsius's death. ) These thermometer guys, what gets into them? Must be too much mercury exposure. OK, you're saying, very interesting. But what I REALLY need is a temperature trivia question that will make me the life of the party. I have just the thing. At what temperature are the Fahrenheit and Celsius readings the same? People will look at you with newfound respect when you reveal the astonishing answer: minus 40.