Temperature Conversions

There are numerous different temperature scales that are commonly used, and one consistent source of confusion is how to convert between them. Do I add 32 or subtract? Or is it 273.15? And then multiply by 5/9? Or 9/5? Or do I multiply first?
If you rely on formulas, it's confusing. Let's try to think about where the formulas come from and build from there…

Temperature as Energy

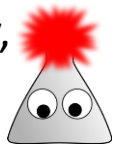
What *is* temperature? One pretty simple interpretation is that temperature is a way for us to measure the kinetic energy of the atoms, ions, or molecules that make up a substance. As things get hotter, the atoms, ions, or molecules move more whether than means simply vibrating faster in the solid phase or flying apart to become a gas.
Let's pick a specific substance…

Water

Water is the most important substance to life as we know it, so let's look at its properties.

Property	Degrees Celsius	Degrees Fahrenheit
Boiling Point (at sea level)	100°C	212°F
Melting Point	0°C	32°F

Again, temperature is just a way to measure energy, we know that "0°C" and "32°F" represent the same energy state. Similarly, "100°C" and "212°F" are the same state.



Water continued…

In the Celsius scale, the difference in temperature between the freezing point of water and the boiling point of water is:
100°C - 0°C = 100°C difference

In the Fahrenheit scale, the difference in temperature between the freezing point of water and the boiling point of water is:
212°F - 32°F = 180°F difference

Celsius and Fahrenheit

Another way to say that is:

100°C and 180°F represent the same difference in energy states!

By the way, 100/180 = 5/9 and 180/100 = 9/5
This is the origin of the 5/9 or 9/5 factor that appears in formulas.

A specific problem

Let's look at a specific problem. Convert 73°F to Celsius.

If we use the freezing point of water as a reference, we can say that 73°F is 41°F *above the freezing point* of water.
{We got that by subtracting "32"…}

A specific problem

Now if we use the relationship on the previous slide:

$$(41^{\circ}\cancel{F})\left(\frac{100^{\circ}C}{180^{\circ}\cancel{F}}\right) = 23^{\circ}\text{C}$$

But remember, that's 23°C *above the freezing point of water*. Since the freezing point of water is 0°C, 23°C above 0°C is…

23°C

A specific problem… try again…

Let's look at that problem again. Convert 73°F to Celsius.

If we use the *boiling point of water* as a reference this time, we can say that 73°F is 139°F *below the boiling point* of water.
{We got that by subtracting from "212"…}

A specific problem… try again…

Now if we use the relationship from a previous slide:

$$(139\cancel{^\circ F})\left(\frac{100^\circ C}{180\cancel{^\circ F}}\right) = 77°\text{C}$$

But remember, that's 77°C *below the boiling point of water*. Since the freezing point of water is 100°C, 77°C below 0°C is…

23°C!

(*Good thing we got the same answer!*)

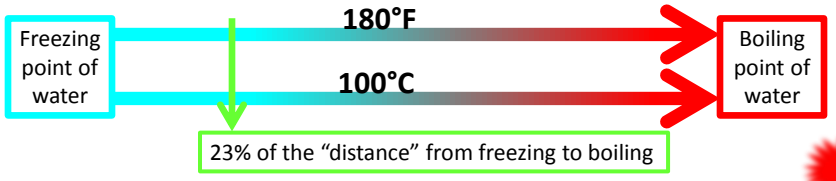
A specific problem… and again…

Let's look at that problem one more time. Convert 73°F to Celsius.

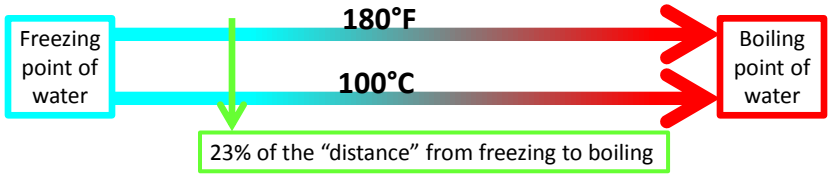
If we use the freezing point of water as a reference, we can say that 73°F is 41°F *above the freezing point* of water.
{We got that by subtracting "32"…}

A specific problem… and again…

If going all the way from the freezing point of water to the boiling point of water represents 180°F, then 41°F *above the freezing point* of water is (41/180)*100%=23% of the way from freezing to boiling.



A specific problem… and again…



If the whole "distance" from freezing to boiling is represented by 100°C, then 23% of the way from freezing to boiling in the Celsius scale is (100°C * 0.228) = 23°C above the freezing point of water. Since the freezing point of water is 0°C, 23°C above 0°C is…

23°C!

A specific problem #2

Let's try another one going the other direction. Convert 84°C to Fahrenheit.

If we use the freezing point of water as a reference in this case, we can say that 84°C is 84°C *above the freezing point* of water.
{No subtracting "32" this time…}

A specific problem #2

Now if we use the relationship from a previous slide:

$$(84\,\cancel{^\circ C})\left(\frac{180\,^\circ F}{100\,\cancel{^\circ C}}\right) = 151\,^\circ\text{F}$$

Notice we flipped the fraction because now we want °C to cancel.

But remember, that's 151°F *above the freezing point of water*. Since the freezing point of water is 32°F, 151°F above 32°F is…

183°F

Test Time!!

Do you think you have this all figured out?

You have travelled to an alien world millions of lightyears from Earth. One of the inhabitants of this alien world (who fortunately happens to speak English…) tells you that water freezes at -374°Zv (that's "degrees Zeevaloo") and boils at 625°Zv. If the temperature on the day you visit is 39°Zv, what is the temperature in °F?

Good thing your space suit has a cooling system!