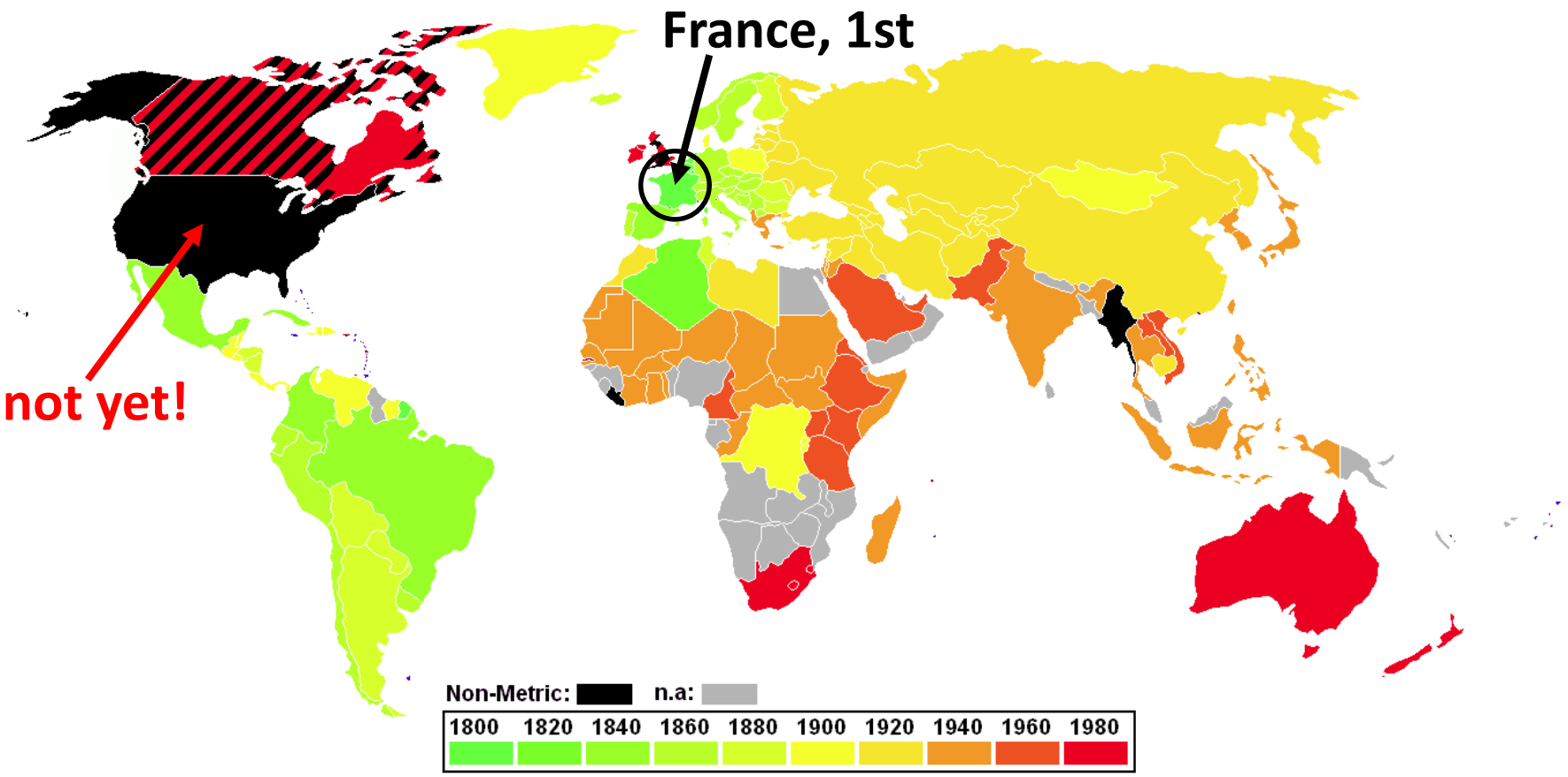
Metrication of the World



Currently USA is the only country (and perhaps also Myanmar and Liberia) **that has not fully adopted the Metric System as its official system of measurement…as a result, Metric System is used in *Science*, but not *Manufacturing*!**

Loss of NASA orbiter

NASA's Mars Climate Orbiter
lost on September 23, 1999.
Cost: $125 million.

For a key spacecraft operation, Lockheed Martin engineering team used Imperial units of measurement while the NASA's team used more conventional Metric system…

The spacecraft insertion trajectory came too close to the planet; the Orbiter disintegrated upon entering the upper Martian atmosphere.

Conversion of Units

- **For the same quantity measured, we can convert units using an equivalence statement which shows the relationship between the units (this relationship is called a *conversion factor*).**

Imperial-Metric equivalence statements:

Units of Length	Units of Weight	Units of Capacity
➢ 1 in = 2.54 cm	➢ 1 oz = 28.35 g	➢ 1.06 qt = 1 L
➢ 3.28 ft = 1 m	➢ 1 lb = 454 g	➢ 1 gal = 3.79 L
➢ 1 mi = 1.61 km	➢ 2.2 lb = 1 kg	

- **Units that measure *physical quantities* (like the examples above) always have a common zero.**
- **Within the Metric System itself, by design, conversion factors are always a power of 10.**

Conversions within Metric System

Prefix	Symbol	Factor x Base Unit	
tera	T	1000000000000	10^{12}
giga	G	1000000000	10^{9}
mega	M	1000000	10^{6}
kilo	k	1000	10^{3}
hecto	h	100	10^{2}
deca	da	10	10^{1}
(none)	(none)	1	10^{0}
deci	d	0.1	10^{-1}
centi	c	0.01	10^{-2}
milli	m	0.001	10^{-3}
micro	µ	0.000001	10^{-6}
nano	n	0.000000001	10^{-9}
pico	p	0.000000000001	10^{-12}

Dimensional Analysis

- **<u>Dimensional Analysis</u>** (also called *Factor-Label Method* or the *Unit Factor Method*) **is a problem-solving method that uses the fact that any number or expression can be <u>multiplied by 1</u> *(Magic One)* without changing its value.**
- **To help with conversion of units, Magic One is built using the equivalence statement:**

Equivalence Statement(s)		Magic One(s)	
1 in = 2.54 cm	⟹	$\frac{1\text{ in}}{2.54\text{ cm}} = 1$	$\frac{2.54\text{ cm}}{1\text{ in}} = 1$
2.2 lb = 1 kg	⟹	$\frac{2.2\text{ lb}}{1\text{ kg}} = 1$	$\frac{1\text{ kg}}{2.2\text{ lb}} = 1$

Example: Convert 130 lbs to kg

- **Step 1. Write the *original* measurement as a *unit fraction*:**

$$130 \text{ lbs} / 1$$

- **Step 2. Using the equivalence statement, build a *magic one* (building rule - the *numerator unit* is the unit you *want*, the *denominator unit* is the *original* unit you want to *eliminate*):**

$$2.2 \text{ lb} = 1 \text{ kg} \quad \Longrightarrow \quad \frac{1 \text{ kg}}{2.2 \text{ lb}} = 1$$

- **Step 3: multiply your unit fraction by your magic one and write your answer in the new units:**

$$\frac{130 \cancel{\text{lbs}}}{1} \cdot \boxed{\frac{1 \text{ kg}}{2.2 \cancel{\text{lbs}}}} = \frac{130 \text{ kg}}{2.2} = 59.1 \text{ kg}$$

Example: The fuel tank of a plane can hold 876 liters of gas. How many gallons would it be?

Equivalency: 1 gallon = 3.8 liters

$$\frac{876\ \cancel{L}}{1} \cdot \boxed{\frac{1\ gal}{3.8\ \cancel{L}}} = \frac{876\ gal}{3.8} = \mathbf{230.5\ gal}$$

Gimli Glider

July 23, 1983: Air Canada Flight 143 (Boeing 767-233 jet), ran out of fuel at an altitude of 41,000 feet (12 km), about halfway through its flight from Montreal to Edmonton.

The crew were able to glide the aircraft safely to an emergency landing at Gimli Industrial Park Airport. None of the 61 passengers were seriously hurt.

Investigation: fuel loading was miscalculated due to a misunderstanding of the recently adopted metric system which replaced the imperial system.

Exercise: As a practical joke, for the Candid Camera show, a gas station listed their price as **$1.79/L**. People gassing up thought they were getting a great deal, but then were outraged when their total owed came up. **WHY?**

What should we do?

Let's carefully examine:

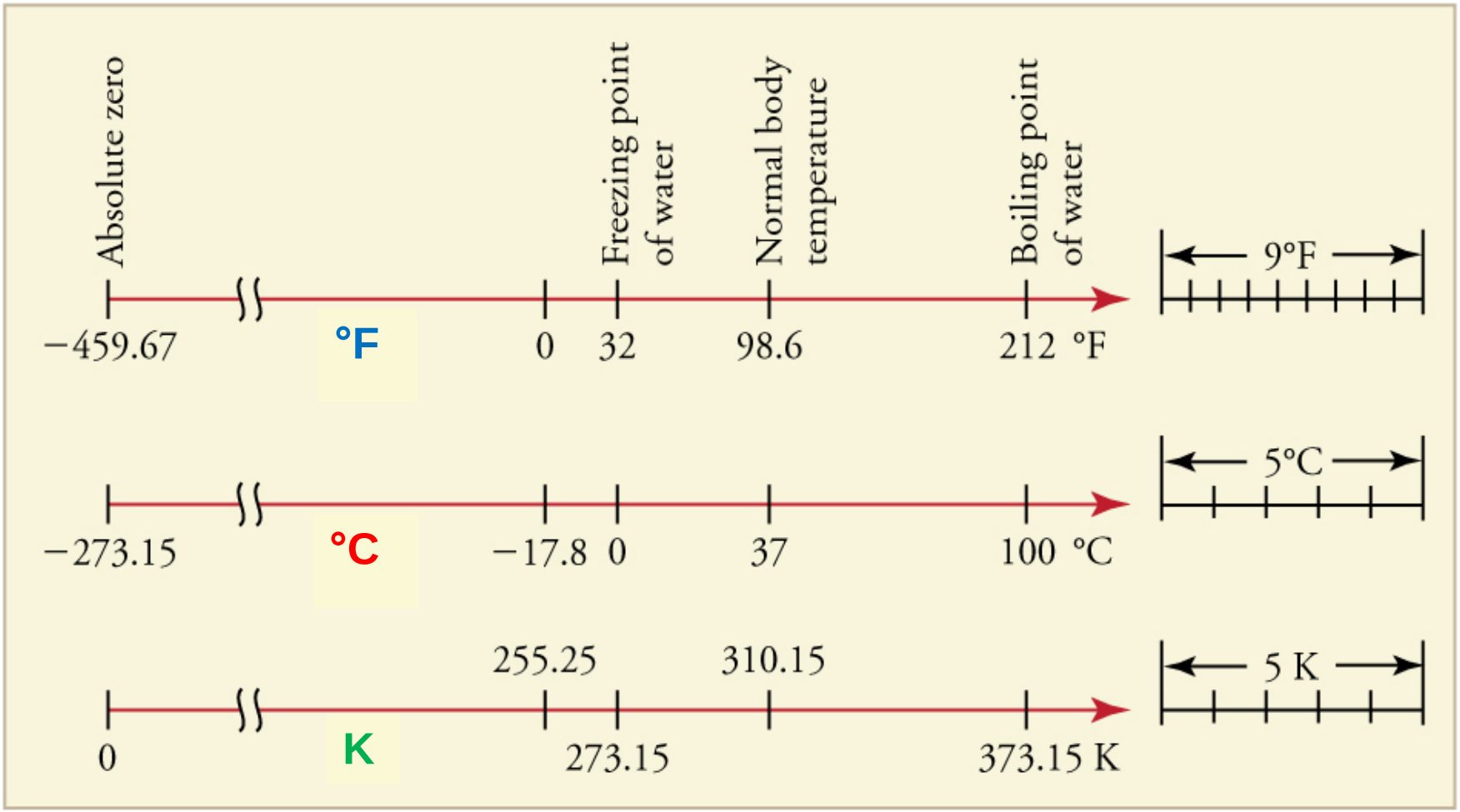
"Listed their price as $1.79/L"

Equivalency: 1 gal = 3.79 L

$$\frac{\$1.79}{1\,\cancel{L}} \cdot \boxed{\frac{3.79\,\cancel{L}}{1\,\text{gal}}} = \frac{\$6.78}{1\,\text{gal}}$$

"The deal" was actually **$6.78/gal**!

Temperature Scales



Note: according to the latest research, <u>normal human body temperature</u> is 36.8 °C ±0.7 °C, or 98.2 °F ±1.3 °F.

Conversion of Temperature

When converting temperature between different scales, we need to pay attention to the fact that they all have <u>different "0" points</u>, therefore not only a *multiplication factor* is needed but also a *shift*.

Kelvin

$$K = {}^{\circ}C + 273.15$$

Fahrenheit

$${}^{\circ}F = {}^{\circ}C \cdot 1.8 + 32 = {}^{\circ}C \cdot \frac{9}{5} + 32$$

Celsius (Centigrade)

$${}^{\circ}C = ({}^{\circ}F - 32)/1.8 = ({}^{\circ}F - 32) \cdot \frac{5}{9}$$