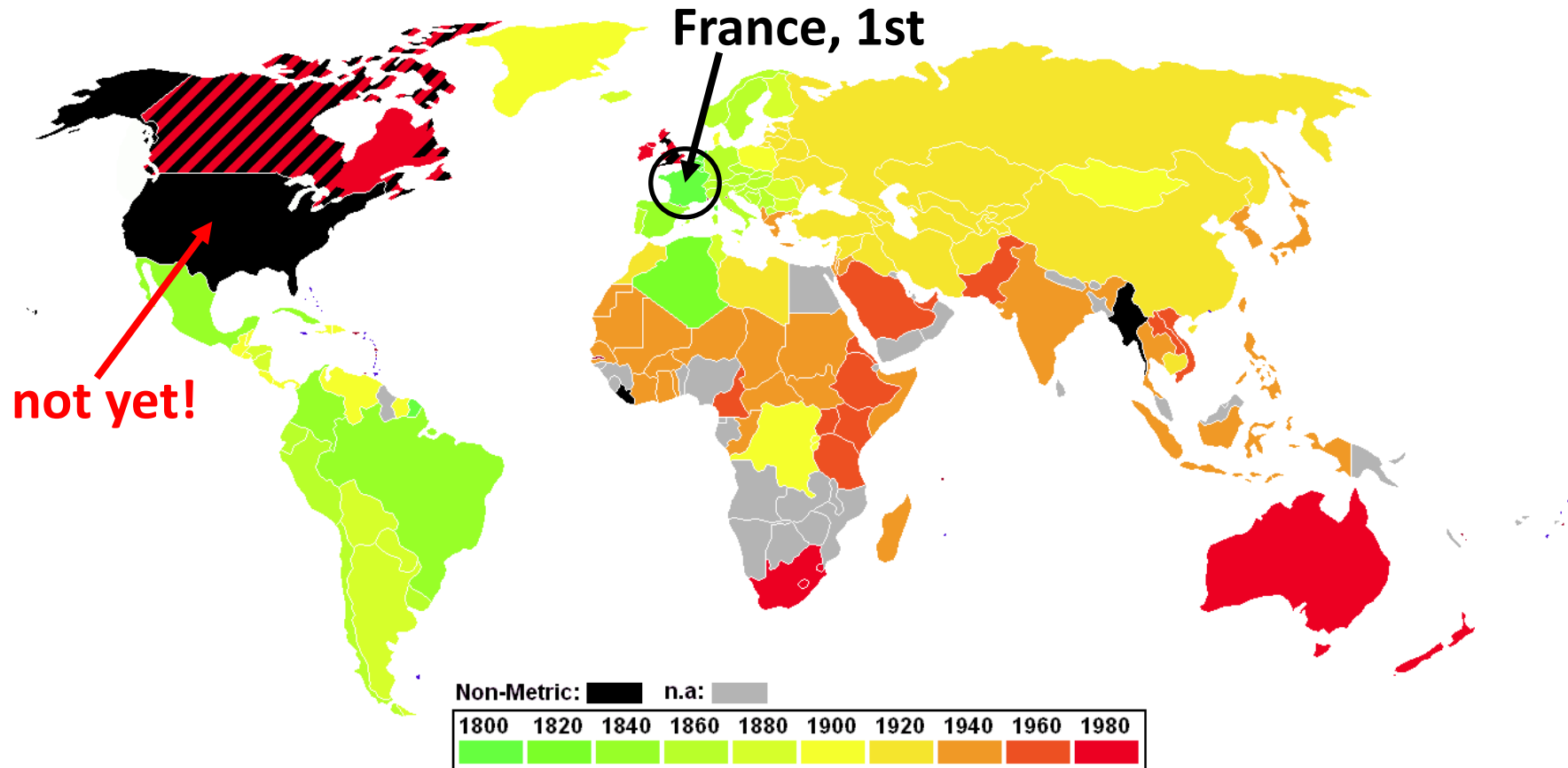


Metrication of the World



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

- 1 in = 2.54 cm
- 3.28 ft = 1 m
- 1 mi = 1.61 km

Units of Weight

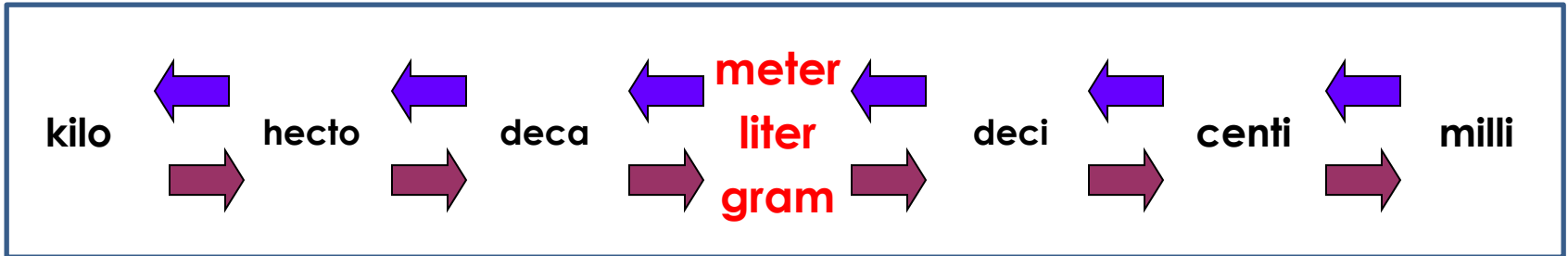
- 1 oz = 28.35 g
- 1 lb = 454 g
- 2.2 lb = 1 kg

Units of Capacity

- 1.06 qt = 1 L
- 1 gal = 3.79 L

- 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**.



- If you **convert into larger units** (*towards the left in the diagram*), move the decimal point to the **left**.
400000 millimeters = 4.00000 kilometers = 4 kilometers
- If you **convert into smaller units** (*toward the right in the diagram*), move the decimal point to the **right**.
7 kilograms = 7.000000 kilograms = 7000000 milligrams

Dimensional Analysis



- **Dimensional Analysis** (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 multiplied by 1 (*Magic One*) without changing its value.**
- To help with conversion of units, Magic One is built using the equivalence statement:

Equivalence Statement(s)

$$1 \text{ in} = 2.54 \text{ cm}$$

$$2.2 \text{ lb} = 1 \text{ kg}$$



$$\frac{1 \text{ in}}{2.54 \text{ cm}} = 1$$

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

Magic One(s)

$$\frac{2.54 \text{ cm}}{1 \text{ in}} = 1$$

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

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*:

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

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

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

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”

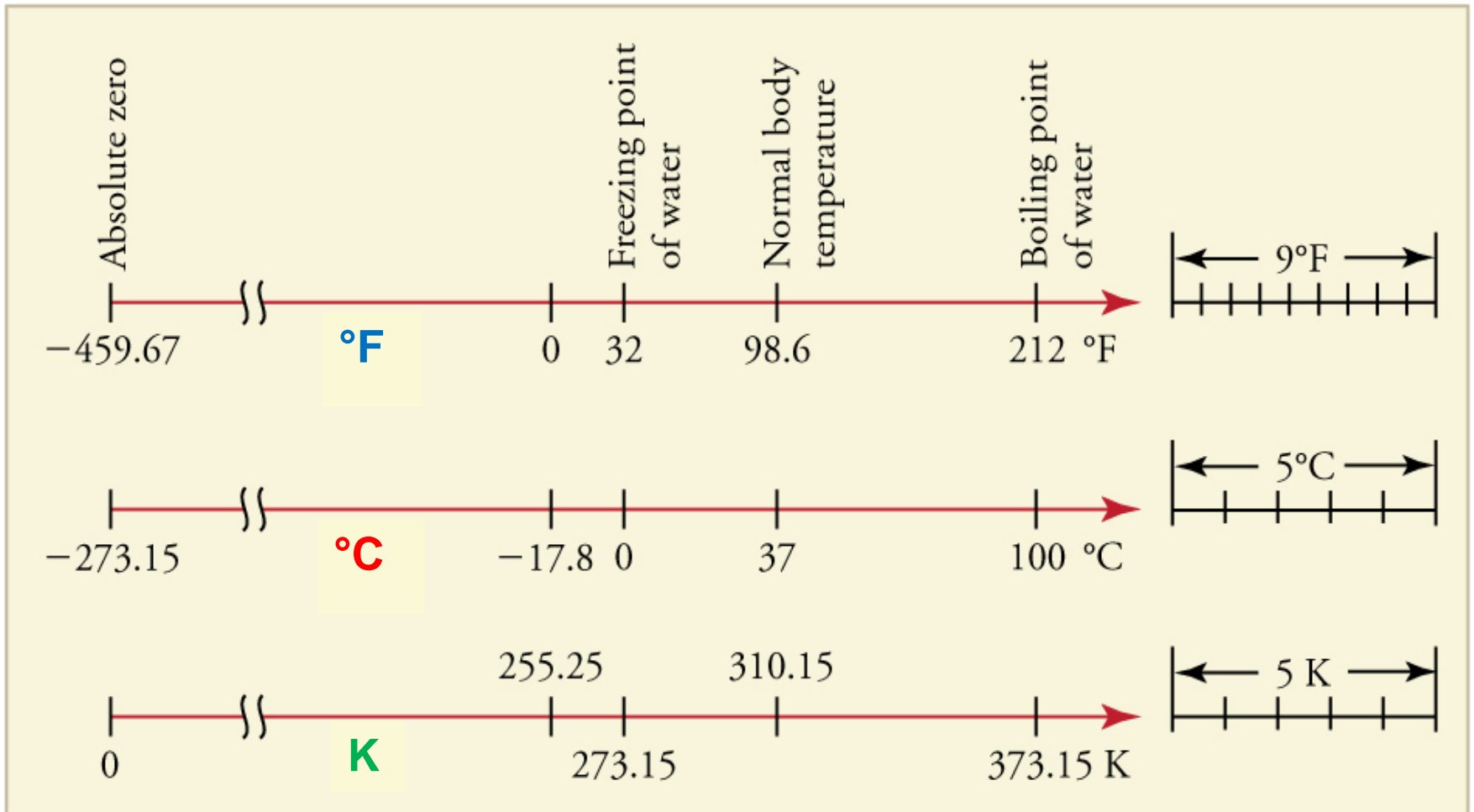
Equivalency: 1 gal = 3.79 L

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

“The deal” was
actually **\$6.78/gal!**



Temperature Scales



Note: according to the latest research, normal human body temperature 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 different “0” points, 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)

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