1.4 The Nature of Energy

All objects in the universe are made of matter, but matter alone is not enough to describe the behavior of the world around us. The water in an alpine lake and a pot of boiling water are both made from the same substance, but your body will experience a very different sensation if you put your hand in each. The difference between the two is their energy content; boiling water has more energy than chilled water. To understand chemistry, we must also understand energy and the changes in energy that accompany chemical processes.

The primary means of generating energy for human endeavors is the combustion of fuels.

Fuels:

Coal - burned in power plants

Gasoline - burned in automobiles

Natural gas - heating

Heating oil – heating

.

Propane, charcoal, wood, candles, …

Hydrocarbon fuels like methane (CH_4) burn in the presence of oxygen to produce carbon dioxide and water. This process of **combustion releases energy.**

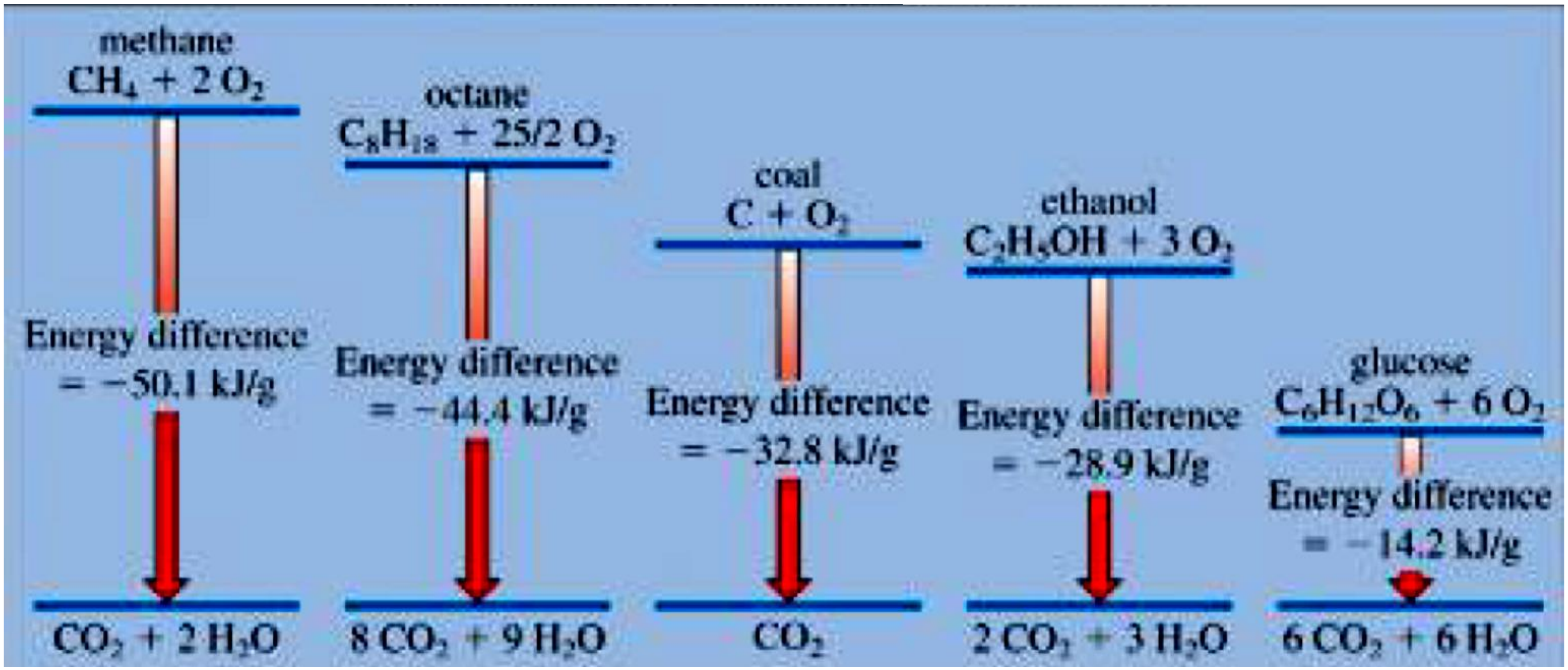
$$CH_4\,(g) + 2\,O_2\,(g) \longrightarrow CO_2\,(g) + 2H_2O\,(l) + \text{ENERGY}$$

<u>Are all fuels are not created equal</u>

<u>Biofuels</u>

Ethanol, Biodiesel, Garbage, Biogas

Renewable fuels derived from biological materials; plant matter. (grasses, trees crops and other biological material).



Think and Explain

Why would people want to drink hydrogen water?

So-called "hydrogen water"—water into which hydrogen gas is dissolved—is increasingly popular…

How much Hydrogen can dissolve in Water?

Gas	Composition of Gas in Atmosphere (%)	Concentration Normally in Water	
		(mmol/L)	(mg/L)
Nitrogen (N_2)	78.08	0.48	13.34
Oxygen (O_2)	20.95	0.27	8.71
*Carbon Dioxide (CO_2)	3.97×10^{-2}	1.35×10^{-9}	5.94×10^{-8}
Neon (Ne)	1.82×10^{-3}	8.18×10^{-3}	0.17
Helium (He)	5.24×10^{-4}	1.94×10^{-6}	7.76×10^{-6}
Hydrogen (H_2)	5.50×10^{-5}	4.29×10^{-7}	8.65×10^{-7}

Solubility of Gases---Henry's Law

舉世第一列氫動力火車 9/17/2018在德國上路投入營運

Hydrogen-Powered Public Transport Become a Reality

Hydrogen fuel-cell vehicles (Hydrail) have the potential to be one of the best alternatives to electric and hybrid cars. These cars produce no air pollution, they can travel further between re-fuelling, and they have shorter charging times.

Hydrogen storage: 25 kg ~ 40 kg
travel range: 300-400 km

Alternatives to Electric

There are pilot projects that are using hydrogen-powered buses as part of the public transport system. These projects are rooted in a couple of cities, including Winnipeg (Canada), Cleveland (USA), and London (UK).

In 2014, five European bus manufacturers signed a letter of understanding, expressing the ambition to have between **five hundred and thousand fuel cell buses running on hydrogen in operation in European public transport by 2020**. WaterstofNet has also initiated projects in line with the ambition to have public bus transport creating zero emissions in the near future

There is also a very interesting project in India, which aims to replace the traditional auto rickshaws with vehicles that are powered by hydrogen. This project is part of India's Hydrogen Highway initiative, and it has set a target to have one million hydrogen fuel-cell vehicles on Indian roads by 2020. The project is part of a wider effort to reduce air pollution caused by motor vehicles, which is a huge issue in India.

More on Energy will be discussed

1.5 Units of Measurement

The units most often used for scientific measurement are those of the **metric system**

SI Units:

1960: All scientific units use **S**ystème **I**nternational d'Unités (**SI Units**).

***There are seven** base units, what are they?*

TABLE 1.3 SI Base Units

Physical Quantity	Name of Unit	Abbreviation
Length	Meter	m
Mass	Kilogram	kg
Temperature	Kelvin	K
Time	Second	s or sec
Amount of substance	Mole	mol
Electric current	Ampere	A or amp
Luminous intensity	Candela	cd

Unit Conversion

SI base unit of *length* = meter (1 m = 1.0936 yards).
SI base unit of mass (not weight) = kilogram (1 kg = 2.2 pounds)

Prefixes

are used to indicate smaller (or larger) units obtained by taking decimal fractions (or multiples) of the base units.

What is the name of the unit that equals
(a) 10^{-9} gram,
(b) 10^{-6} second
(c) 10^{-3} meter?

TABLE 1.4 Prefixes Used in the Metric System and with SI Units

Prefix	Abbreviation	Meaning	Example	
Peta	P	10^{15}	1 petawatt (PW)	$= 1 \times 10^{15}$ watts[a]
Tera	T	10^{12}	1 terawatt (TW)	$= 1 \times 10^{12}$ watts
Giga	G	10^{9}	1 gigawatt (GW)	$= 1 \times 10^{9}$ watts
Mega	M	10^{6}	1 megawatt (MW)	$= 1 \times 10^{6}$ watts
Kilo	k	10^{3}	1 kilowatt (kW)	$= 1 \times 10^{3}$ watts
Deci	d	10^{-1}	1 deciwatt (dW)	$= 1 \times 10^{-1}$ watt
Centi	c	10^{-2}	1 centiwatt (cW)	$= 1 \times 10^{-2}$ watt
Milli	m	10^{-3}	1 milliwatt (mW)	$= 1 \times 10^{-3}$ watt
Micro	μ[b]	10^{-6}	1 microwatt (μW)	$= 1 \times 10^{-6}$ watt
Nano	n	10^{-9}	1 nanowatt (nW)	$= 1 \times 10^{-9}$ watt
Pico	p	10^{-12}	1 picowatt (pW)	$= 1 \times 10^{-12}$ watt
Femto	f	10^{-15}	1 femtowatt (fW)	$= 1 \times 10^{-15}$ watt
Atto	a	10^{-18}	1 attowatt (aW)	$= 1 \times 10^{-18}$ watt
Zepto	z	10^{-21}	1 zeptowatt (zW)	$= 1 \times 10^{-21}$ watt

[a]The watt (W) is the SI unit of power, which is the rate at which energy is either generated or consumed. The SI unit of energy is the joule (J); $1\ J = 1\ kg \cdot m^2/s^2$ and $1\ W = 1\ J/s$.

[b]Greek letter mu, pronounced "mew."

Derived SI Units

formed by multiplication or division of one of the seven base units

Volume

- Units of *volume* = (units of length)^3 = m^3.
- This unit is unrealistically large, so we use more reasonable units:
  - cm^3 (also known as mL (*milliliters*) or cc (*cubic centimeters*))
  - dm^3 (also known as *liters*, L).
- Note: the liter is <u>not</u> an SI unit.

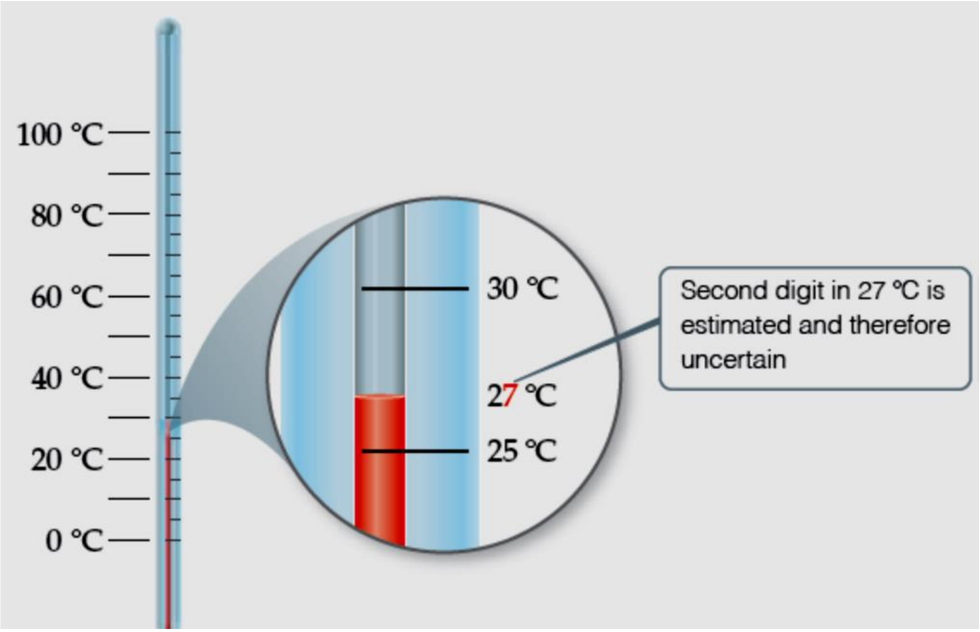
Density defined as mass divided by volume.

- Units: g/cm^3 or g/mL (for solids and liquids);
  g/L (often used for gases).

TABLE 1.5 Densities of Selected Substances at 25 °C

Substance	Density (g/cm^3)
Air	0.001
Balsa wood	0.16
Ethanol	0.79
Water	1.00
Ethylene glycol	1.09
Table sugar	1.59
Table salt	2.16
Iron	7.9
Gold	19.32

1.6 Uncertainty in Measurement



Which of the following numbers in your personal life are exact numbers?

(a) Your cell phone number (b) your weight (c) your IQ

(d) the distance you walked yesterday

There are 1000 cm^3 in 1 liter. Does this make the liter an exact volume?

Precision vs. Accuracy

- **Precision** is a measure of how closely individual measurements agree with one another.
- **Accuracy** refers to how closely individual measurements agree with the correct, or “true,” value.
- Experimentally, we often take several measurements and determine a standard deviation.

Figure 1.24 Precision and accuracy.

Precision refers to ________.

A) how close a measured number is to other measured numbers

B) how close a measured number is to the true value

C) how close a measured number is to the calculated value

D) how close a measured number is to zero

E) how close a measured number is to infinity

Accuracy refers to ________.

A) how close a measured number is to zero

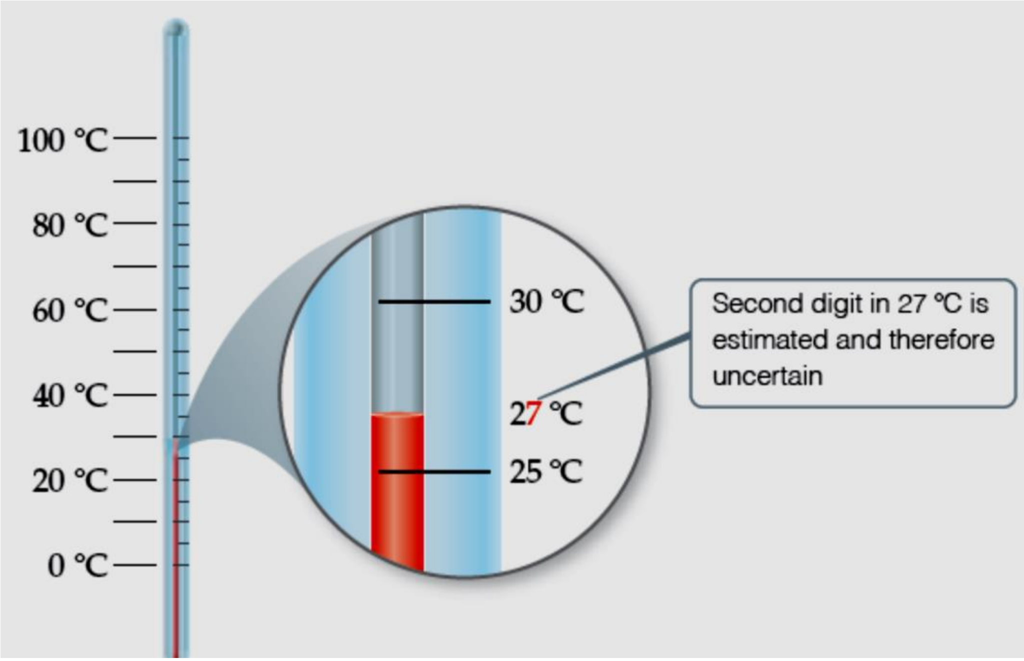
B) how close a measured number is to the calculated value

C) how close a measured number is to other measured numbers

D) how close a measured number is to the true value

E) how close a measured number is to infinity

Uncertainty and Significant Figures



- All digits of a measured quantity, including the uncertain ones, are called **significant figures**.
- When rounding calculated numbers, we pay attention to significant figures so we **do not overstate the accuracy** of our answers.

Significant Figures

1. All nonzero digits are significant.
2. Zeroes between nonzero digits are significant.
3. Zeroes at the beginning of a number are never significant.
4. Zeroes at the end of a number are significant if it contains a decimal point.

- When a number ends with zeros but contains no decimal point it is normally assumed that the zeros are not significant.

But all the zeros to the right of the decimal point are significant

1.03×10^4 g	(three significant figures)
1.030×10^4 g	(four significant figures)
1.0300×10^4 g	(five significant figures)

Which of the following has the same number of significant figures as the number 1.00310?

(A) 1×10^6 (B) 199.791 (C) 8.66 (D) 5.119 (E) 11.762

The number with the most significant zeros is

A) 0.00002510

B) 0.02500001

C) 250000001

D) 2.501 × 10-7

E) 2.5100000

In which one of the following numbers are <u>all</u> of the zeros significant?

A) 100.090090

B) 0.143290

C) 0.0010

D) 0.0001

E) 0.1

Significant Figures in Calculations

- The least certain measurement limits the number of significant figures in the answer.
- When addition or subtraction is performed, answers are rounded to the least significant **decimal place***.*
- When multiplication or division is performed, answers are rounded to the same number of digits as the measurement with the ***fewest* number of significant figures**.
- Know the number of appropriate digits throughout, but round off at the end only!

Round the number 3456.5 to two significant figures.
A) 3400.0
B) 3400
C) 3000
D) 3500
E) 3000.0

How many significant figures should be retained in the result of the following calculation?

$$12.00000 \times 0.9893 + 13.00335 \times 0.0107$$