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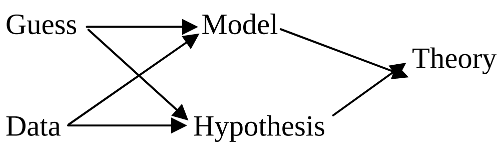
Chapter 1: Introduction to Chemistry

1.2 *See Section 1.1.*

Scientists: "Hypothesis" is a possible explanation for an event, even if it is an untested assumption. "Theory" is an explanation for a law of nature.
General public: "Theory" is an educated hunch or guess.

1.4 *See Section 1.1.*



1.6 *See Section 1.2.*

Intensive properties of air: temperature, pressure, specific volume, and density
Extensive properties of air: mass, volume, colorless, odorless

1.8 *See Section 1.2.*

The astronauts in space are still composed of matter. They still have the same mass as they do on earth but weight less because they are further from the earth's gravitational attraction.

1.10 *See Section 1.2*

Heterogeneous mixtures are typically easier to separate than homogeneous mixtures. These types of mixture can usually be separated using physical techniques (i.e. filtration, distillation, etc.). However, because homogeneous mixtures have the same consistency throughout, they are more difficult to separate.

1.12 *See Section 1.2.*

The light given by an electric bulb is an intensive property for a given wattage.

1.14 *See Section 1.2 and Figure 1.4.*

A sample of matter that cannot be separated into components by a physical process is called a substance. Compounds and elements are types of substances. Compounds are substances that can be decomposed into their constituent elements by chemical means whereas elements are substances that cannot be further decomposed by chemical means.

1.16 *See Section 1.3*

The term accuracy refers to how close a performed measurement is to the accepted value for that measurement. Precision refers to how close several measured values are to each other. A measurement that includes more significant figures indicates that the measurement was performed with an instrument calibrated in smaller increments allowing a more precise measurement to be made.

1.18 ***See Section 1.5.***

$$\text{km/hr} \xrightarrow{\text{Step 1}} \text{m/hr} \xrightarrow{\text{Step 2}} \text{m/min} \xrightarrow{\text{Step 3}} \text{m/s}$$

Step 1. Use km to m conversion factor; mutiply by m/km.
Step 2. Use hr to min conversion factor; multiply by hr/min, since hr is in the denominator.
Step 3. Use min to s conversion factor; multiply by min/s, since min is in the denominator.

1.20 ***See Section 1.4.***

No, all measured quantities have some uncertainty which depends on the measuring device and/or the person estimating the distance between units.

1.22 ***See Section 1.5.***

The length of a King's foot is easy to comprehend, but the size of a foot would vary from King to King.

1.24 ***See Section 1.1.***

meter (m): based on the distance that light travels in 1/299,792,458 of a second
kilogram (kg): based on an internationally accepted weight with a mass of 1 kg
second (s): based on the electronic transitions in Cs-133 isotope
ampere (A): based on the current required to produce 2×10^{-7} N of force between two wires that are placed 1 m apart
Kelvin (K): based on the triple point of water (1 K = 1/273.16 the thermodynamic temperature of water
mole (mol): the amount of a substance which contains as many particles as there are atoms in 0.012 kilograms of the isotope C-12
candela (cd): based on the luminous intensity of an object that emits monochromatic radiation of a frequency of 540×10^{12} Hz and that has a radiant intensity of 1/683 watt

1.26 ***See Section 1.2.***

(a) extensive, physical (b) intensive, chemical (c) extensive, physical (d) intensive, physical
(e) extensive, chemical

1.28 ***See Section 1.2.***

(a) physical (b) chemical (c) physical (d) chemical

1.30 ***See Section 1.2.***

(a) chemical (b) physical (c) chemical (d) physical

1.32 ***See Section 1.2.***

(a) chemical (b) chemical (c) physical (d) chemical

1.34 ***See Section 1.2.***

Rarely found as a free element (**Chemical**); Found combined with oxygen (**Chemical**); Can be obtained by reacting ore with carbon (**Chemical**); Silvery colored metal (**Physical**); Conducts heat and electricity (**Physical**); Hardness and mechanical strength (**Physical**); Steel does not corrode (**Chemical**)

1.36 ***See Section 1.2.***

Liquid at room temperature (**Physical**); Acrid smelling (**Chemical**); Reacts readily with most metals (**Chemical**); Evaporates easily (**Physical**); Obtained from sodium bromide (**Chemical**)

1.38 ***See Section 1.2.***

(a) compound (b) homogeneous mixture (c) homogeneous mixture (d) element

1.40 ***See Section 1.2.***

(a) element (b) homogeneous mixture (c) homogeneous mixture (d) heterogeneous mixture

1.42 ***See Section 1.2.***

Salt water should be classified as a solution; wood, champagne and cloudy tea are not because they are not uniform throughout.

1.44 ***See Section 1.3.***

(a) Both accurate and precise (b) Accurate (c) Neither (d) Precise

1.46 ***See Section 1.3.***

(a) 3 (b) 4 (c) 4 (d) 1 (e) 5

1.48 ***See Section 1.3.***

(a) 5 (b) 3 (c) 5 (d) 4

1.50 ***See Section 1.3.***

(a) 0.0821 kg (b) 1.01 m (c) 18.998 g (d) 19.00 g

1.52 ***See Section 1.3.***

(a) 39.50 ºC (b) 21.47 mL (c) 13.0 s

1.54 ***See Section 1.3.***

(a) 0.0821 kg (b) 1.01 m (c) 18.998 g (d) 19.00 g

1.56 ***See Section 1.3.***

(a) 21.9 (b) 2.0×10^3 (c) 0.58 (d) 8.0

1.58 ***See Section 1.3.***

(a) 80.0 (b) 0.7615 (c) 14.712 (d) 0.0286

1.60 ***See Section 1.4.***

$\times = \frac{2.05 \times 10^{-65}}{3.4 \times 10^{51}} + 1.9 \times 10^{-3} = 1.9 \times 10^{-3} \pm 1 \times 10^{-4}$ One decimal place in answer, since there is just one decimal place in the quantity 1.9×10^{-3}

1.62 ***See Table 1.5.***

(a) mass, kilogram (b) distance, meter (c) temperature, kelvin (d) time, second

1.64 ***See Section 1.4.***

$1\ g = 1 \times 10^{-6}\ Mg$
$1\ Mg = 1 \times 10^{6}\ g$

1.66 ***See Section 1.4.***

$1\ ns = 1 \times 10^{-6}\ ms$
$1\ ms = 1 \times 10^{6}\ ns$

1.68 ***See Section 1.4.***

1 g/L = ? lb/ft^3

$$\frac{1g}{1L} \times \frac{1lb}{453.6g} \times \frac{1l}{1000mL} \times \frac{1mL}{1cm^3} \times \left(\frac{2.54cm}{1in}\right)^3 \times \left(\frac{12in}{1ft}\right)^3 = \mathbf{0.0624 lb / ft^3}$$

1.70 ***See Section 1.4.***

Volume = area x height. Convert the area to units of mi^2 and the height to ft and calculate volume. Then convert from ft^3 to liters.

$$\text{area} = 3.02 \times 10^6\ mi^2 \times \left(\frac{5280\ ft}{1\ mi}\right)^2 = 8.42 \times 10^{13}\ ft^2$$

$$\text{height} = 2\ in \times \frac{1\ ft}{12\ in} = 0.167\ ft$$

$$\text{volume} = 8.42 \times 10^{13}\ ft^2 \times 0.167\ ft = 1.41 \times 10^{13}\ ft^3$$

$$1.41 \times 10^{13}\ \text{ft}^3\ \mathbf{x}\ \frac{28.316\ \text{L}}{1\ \text{ft}^3} = 3.97 \times 10^{14}\ \text{L}$$

1.72 ***See Section 1.4.***

(a) $? \text{ km} = 25.5 \text{ m x } \frac{1 \text{ km}}{1000 \text{ m}} = \mathbf{2.55 \text{ x } 10^{-2} \text{ km}}$

(b) $? \text{ m} = 36.3 \text{ km x } \frac{1000 \text{ m}}{1 \text{ km}} = \mathbf{3.63 \text{ x } 10^{4} \text{ m}}$

(c) $? \text{ g} = 487 \text{ kg x } \frac{1000 \text{ g}}{1 \text{ kg}} = \mathbf{4.87 \text{ x } 10^{5} \text{ g}}$

(d) $? \text{ mL} = 1.32 \text{ L x } \frac{1000 \text{ mL}}{1\text{L}} = \mathbf{1.32 \text{ x } 10^{3} \text{ mL}}$

(e) $? \text{ L} = 55.9 \text{ dL x } \frac{1 \text{ L}}{10 \text{ dL}} = \mathbf{5.59 \text{ L}}$

(f) $? \text{ cm}^3 = 6251 \text{ L x } \frac{1000 \text{ cm}^3}{1 \text{ L}} = \mathbf{6.251 \text{ x } 10^{6} \text{ cm}^3}$ (Note: 1 cm^3 = 1 mL)

1.74 ***See Section. 1.4.***

(a) 45 s = **4.5 x 10^4 ms** = **0.75 minutes**
(b) 550 nm = **5.5 x 10^{-5} cm** = **5.5 x 10^{-7} m**
(c) 4 ºC = **277.15 K** = **39.2 ºF**
(d) 2.00 L = **2000 cm^3** = **2.00 x 10^{-3} m^3** = **2.11qt**

1.76 ***See Sections 1.4, 1.5, and Table 1.9.***

$$? \text{ area in cm}^2 = (8.5 \text{ in} \times 11 \text{ in}) \left(\frac{2.54 \text{ cm}}{1 \text{ in}}\right)^2 = \mathbf{6.0 \times 10^2\ cm^2}$$

1.78 ***See Sections 1.4, 1.5, and Table 1.9.***

$$? \text{ speed limit in mi/hr} = \frac{100 \text{ km}}{\text{hr}} \times \frac{1 \text{ mi}}{1.609 \text{ km}} = \mathbf{62.2\ mi/hr}$$

$$? \text{ speed limit in m/s} = \frac{100 \text{ km}}{\text{hr}} \times \frac{10^3\text{m}}{\text{km}} \times \frac{1 \text{ hr}}{60 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ s}} = \mathbf{27.8\ m/s}$$

1.80 ***See Section.1.5***

$$? \text{ volume in fluid ounces} = 2.00 \text{ L} \times \frac{1 \text{ qt}}{0.946 \text{ L}} \times \frac{32 \text{ fl oz}}{1 \text{ qt}} = \mathbf{67.7\ fl.\ oz.}$$

1.82 ***See Section 1.5.***

$T_K = T_C + 273.15$ and $T_C = \left[\frac{1.0^{\circ}C}{1.8^{o}F}\right](T_F - 32^{o})$ yield $\mathbf{T_K = \left[\frac{1.0^{\circ}C}{1.8^{o}F}\right](T_F - 32^{o}F) + 273.15}$

1.84 ***See Section 1.5.***

(a) $T_F = T_c\left[\frac{1.8^{\circ}F}{1.0^{o}C}\right] + 32^{o}F = 80^{o}C\left[\frac{1.8^{\circ}F}{1.0^{o}C}\right] + 32^{o}F = 176^{o}F$

$T_K = T_c + 273.15 = 80 + 273.15 =$ **353 K**

(b) $T_C = (T_F - 32\ ^{o}F)\left[\frac{1.0\ ^{\circ}C}{1.8\ ^{\circ}F}\right] = (350\ ^{o}F - 32\ ^{o}F)\left[\frac{1.0\ ^{\circ}C}{1.8\ ^{\circ}F}\right] =$ **177 ºC**

1.86 ***See Section 1.5.***

Let $y = T_F = T_c$ in $T_F = T_c\left[\frac{1.8^{\circ}F}{1.0^{o}C}\right] + 32^{o}F$ giving $y = y\left(\frac{1.8}{1.0}\right) + 32$.

This yields y = 1.8y + 32, – 0.8y = 32, and y = 40. Hence, **–40ºF = –40ºC.**

1.88 ***See Section 1.5.***

$\text{Density} = \frac{\text{mass}}{\text{volume}}$ Rearranging this equation gives us: $\text{Volume} = \frac{\text{mass}}{\text{density}}$

$\text{Volume} = \frac{25.0\ \text{g ethyl acetate}}{0.9006\ \text{cm}^3} = \mathbf{27.8\ cm^3}$

1.90 ***See Section 1.5.***

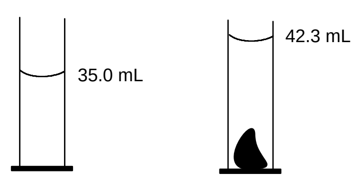
$\text{Volume of copper sphere} = 3.73 \times 10^3\ \text{g} \times \frac{1\ \text{cm}^3}{8.92\ \text{g}} = 420\ \text{cm}^3$

Hence, $r^3 = \frac{3\ V}{4\prod} = \frac{3 \times 420\ \text{cm}^3}{4 \times 3.1416} = 100\ \text{cm}^3$ and $r = (100\ \text{cm}^3)^{1/3} = \mathbf{4.64\ cm}$

1.92 ***See Section. 1.3***

Calculate the volume of the object from the change in the volume of the graduated cylinder, then calculate the density.

Volume of object = 42.3 mL – 35.0 mL = 7.3 mL



$$\text{density} = \frac{\text{mass (g)}}{\text{volume (mL)}} = \frac{11.33\text{ g}}{7.3\text{ mL}} = 1.6\text{ g/mL}$$

1.94 ***See Sections 1.4, 1.5.***

Since thickness = volume/area and volume = mass/density, thickness = mass/(area × density).

$$\text{? thickness in nm} = \frac{12\text{ oz}}{75\text{ ft}^2} \times \frac{1\text{ lb}}{16\text{ oz}} \times \frac{453.6\text{ g}}{1\text{ lb}} \times \left(\frac{1\text{ ft}}{12\text{ in}}\right)^2 \times \left(\frac{1\text{ in}}{2.54\text{ cm}}\right)^2$$

$$\times \frac{1\text{ cm}^3}{2.70\text{ g}} \times \frac{1\text{ m}}{10^2\text{ cm}} \times \frac{10^9\text{ nm}}{1\text{ m}} \mathbf{= 1.8 \times 10^{-4}\text{ nm}}$$

1.96 ***See Sections 1.4, 1.5.***

Calculate the volume of the object from the change in the volume of the graduated cylinder, then calculate the density.

Volume of object = 48.8 mL – 30.0 mL = 18.8 mL

$$\text{density} = \frac{\text{mass (g)}}{\text{volume (mL)}} = \frac{147.8\text{ g}}{18.8\text{ mL}} = \mathbf{7.86\text{ g/mL}}$$

1.98 ***See Section 1.5.***

(a) $$93{,}000{,}000\text{ mi} \times \frac{1.609\text{ km}}{\text{mi}} \times \frac{1000\text{ m}}{\text{km}} \times \frac{1\text{ s}}{3\times10^8\text{ m}} \times \frac{1\text{ min}}{60\text{ s}} \times \frac{1\text{ hr}}{60\text{ min}} \times \frac{1\text{ day}}{24\text{ hr}} \times \frac{1\text{ yr}}{365.25\text{ days}}$$

$$\mathbf{= 1.58203628 \times 10^{-5}\text{ light years}}$$

(b) $$\text{? minutes} = 93{,}000{,}000\text{ mi} \times \frac{1.609\text{ km}}{1\text{ mi}} \times \frac{10^3\text{ m}}{1\text{ km}} \times \frac{1\text{ s}}{3.00 \times 10^8\text{ m}} \times \frac{1\text{ min}}{60\text{ s}} = \mathbf{8.3\text{ min}}$$

1.100 ***See Sections 1.4, 1.5.***

$$\text{? mL A} = 9.9132\text{ g A} \times \frac{1\text{ mL A}}{0.98\text{ g A}} = 10\text{ mL A}$$

$$\text{? mL B} = 9.9132\text{ g B} \times \frac{1\text{ mL B}}{1.03\text{ g B}} = 9.62\text{ mL B}$$

To obtain range of volumes based on uncertainties ± 1 in last digit of the densities,

$$\text{? mL A max} = 9.9132\text{ g A} \times \frac{1\text{ mL A}}{0.97\text{ g A}} = 10\text{ mL A}$$

$$\text{? mL A min} = 9.9132\text{ g A} \times \frac{1\text{ mL A}}{0.99\text{ g A}} = 10\text{ mL A}$$

$$? \text{ mL B max} = 9.9132 \text{ g B} \times \frac{1 \text{ mL A}}{1.02 \text{ g B}} = 9.72 \text{ mL B}$$

$$? \text{ mL B min} = 9.9132 \text{ g B} \times \frac{1 \text{ mL B}}{1.04 \text{ g B}} = 9.53 \text{ mL B}$$

The uncertainty in the density of A does not contribute to an uncertainty in the calculated volume of A having a mass of 9.9132 g because the result of the volume calculation is limited to just two significant figures. However, the uncertainty in the density of B causes the result of the calculated volume to be 9.62±0.10 mL, since the density of B was known to three significant figures.

1.102 ***See Section 1.5.***

$$T_c \text{ for } 80.0^{\circ}\text{F} = \left(\frac{1.0^{\circ}\text{ C}}{1.8^{\circ}\text{ F}}\right)(80.0^{\circ}\text{F} - 32^{\circ}\text{F}) = 26.7^{\circ}\text{C}$$

$$T_c \text{ for } 215.0^{\circ}\text{F} = \left(\frac{1.0^{\circ}\text{ C}}{1.8^{\circ}\text{ F}}\right)(215.0^{\circ}\text{F} - 32^{\circ}\text{F}) = 101.7^{\circ}\text{C}$$

$$\text{Thus, rate of change in }^{\circ}\text{C per second} = \frac{(101.7^{\circ}\text{ C} - 26.7^{\circ}\text{ C})}{1 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ s}} = \mathbf{1.25^{\circ}C/s}$$

1.104 ***See Section 1.2.***

Maybe something like "similar substances may have very similar physical properties and chemical reactivity that may appear identical within the accuracy and precision of our measuring devices. However, upon careful analysis, 2 different substances must have some measurable differences in their properties.

1.106 ***See Section. 1.4.***

(a) $? \text{ height in mm} = (9.2 \times 10^{12}) \times (0.166 \text{ mm}) = 1.53 \times 10^{12} \text{ mm}$

$$? \text{ height in km} = 1.53 \times 10^{12} \times \frac{1 \text{ km}}{1 \times 10^{6} \text{ mm}} = \mathbf{1.5 \times 10^{6} \text{ km}}$$

(b) $? \text{ mass in g} = (9.2 \times 10^{12}) \times (1.01 \text{ g}) = \mathbf{9.3 \times 10^{12} \text{ g}}$

Chapter 2: Atoms, Molecules, and Ions

2.2 ***See Section 2.1.***

(a) Dalton's fourth postulate explains the Law of Conservation of Mass.
(b) Dalton's third postulate explains the Law of Constant Composition.

2.4 ***See Section 2.2.***

The masses of protons and neutrons are approximately equal and approximately 1836 times greater than the mass of an electron. The protons and electrons have equal but opposite charges, and neutrons have no charge.
On a relative scale, we say the masses of protons and neutrons are each one and the electron has a mass of zero.
Similarly, on a relative scale, we say the charge on a proton is +1 and the charge on an electron is −1.

2.6 ***See Section 2.2.***

To explain the deflection of alpha particles, Rutherford proposed that the positive charge and nearly all of the mass of atom are in the central core, with the electrons at a relatively large distance from this core.

2.8 ***See Section 2.2.***

The protons and neutrons are located in a central core that is called the nucleus. The electrons surround the nucleus and occupy most of the volume occupied by atoms.

2.10 ***See Section 2.3.***

(a) Atomic number is the number of protons in the nucleus of an atom.
(b) Mass number is the total number of protons and neutrons in an atom. Hence, the number of neutrons is equal to the mass number minus the atomic number.
(c) The chemical symbol of an element does not tell us directly the number of particles of any kind in atoms of that element. However, the chemical symbol is always accompanied by the atomic number of the element in the periodic table, and the atomic number is the number of protons in the nucleus of an atom.

2.12 ***See Section 2.5.***

4 P represents 4 atoms of phosphorus, whereas P_4 represents a molecule composed of 4 atoms of phosphorus.

2.14 ***See Section 2.5 and Figure 2.11.***

Each molecule of methane, CH_4, is composed of one carbon atom and four hydrogen atoms.

2.16 ***See Sections 2.5, 2.6.***

Carbon monoxide, CO, exists as molecules composed of one carbon atom and one oxygen atom each.
Cesium bromide, CsBr, exists as Cs^+ ions and Br^- ions present in a one-to-one ratio.

2.18 *See Section 2.8.*

In naming acids corresponding to anions, if the name of the anion ends in *ate*, the *ate* ending is changed to *ic* and the word *acid* is added. If the name of the anion ends in *ite*, the *ite* ending is changed to *ous* and the word *acid* is added.

2.20 *See Section 2.8.*

A Roman numeral in parentheses represnets the positive charge on transition metal ions. The correct name for $CrCl_3$ is chromium(III) chloride.

2.22 *See Section 2.7.*

Ionic compounds are generally hard crystalline solids which do not conduct electricity and have high melting points. However, ionic compounds do conduct electricity when melted or when dissolved in water.

Molecular compounds consisting of small molecules generally exist as low-melting solids, liquids or gases at room temperature and generally do not conduct electricity.

2.24 *See Section 2.7.*

The chemist should conclude the solid is an ionic compound because ionic compounds exist as crystalline solids having high melting points and conduct electricity when dissolved in water.

2.26 *See Section 2.9.*

In a molten (liquid) ionic compound, the ions present are free to move about and can carry an electrical current. Molten molecular compounds are poor conductors of electricity because they would contain very little (if any) charged particles.

2.28 *See Section 2.5.*

Many responses are equally valid here. Below are a few common examples. These lists are not comprehensive; many other answers are also right. The periodic table on the inside cover of your text is color coded to indicate metals, non-metals and metalloids.

(a) Common metallic elements: iron, Fe; gold, Au; lead, Pb; copper, Cu; aluminum, Al
(b) Common non-metallic elements: carbon, C; hydrogen, H; oxygen, O; nitrogen, N
(c) Metalloids: boron, B; silicon, Si; germanium, Ge; arsenic, As; antimony, Sb; tellurium, Te
(d) Elements that are diatomic molecules: nitrogen, N_2; oxygen, O_2; hydrogen, H_2; fluorine, F_2; chlorine, Cl_2; bromine, Br_2; iodine, I_2

2.30 *See Section 2.3.*

(a) ${}^{59}_{28}Ni$ (b) ${}^{184}_{74}W$

2.32 *See Section 2.3.*

(a) $^{11}_{5}B$ (b) $^{55}_{25}Mn$ (c) $^{28}_{14}Si$

2.34 *See Section 2.3 and Examples 2.1, 2.2, 2.3.*

(a) $^{32}_{16}S$: 16 protons, 16 neutrons, 16 electrons

(b) $^{24}_{12}Mg$: 12 protons, 12 neutrons, 12 electrons

(c) $^{37}_{17}Cl$: 17 protons, 20 neutrons, 17 electrons

2.36 *See Section 2.3.*

Since the charge of the ion is –2, the number of electrons in this ion is two more than the number of protons.

$e^- = p + 2$

It is given in the problem that the number of neutrons is 20 more than the number of electrons. Therefore, there are 22 more neutrons than protons.

$n = e^- + 20 = (p + 2) + 20 = p + 22$

It is also given that the ion has a mass number of 126. Therefore, the sum of the protons and neutrons is equal to 126.

$p + n = 126$

Since n = p + 22, this information can be used to solve for the number of protons.

$p + (p + 22) = 126$

$2p = 104$

p = 52, therefore the element must be tellerium, Te.

n = p + 22 = 52 + 22 = 74, therefore there must be 74 neutrons in this ion.

$e^- = p + 2 = 52 + 2 = 54$, therefore there must be 54 electrons.

The symbol for this ion is therefore $^{126}_{52}Te^{2-}$

2.38 *See Section 2.3 and Example 2.2.*

(a) $^{9}_{4}Be^{2+}$ (b) $^{72}_{32}Ge^{2+}$ (c) $^{79}_{35}Br^{-}$