Nuggets: Terms and Matter; Sig Figs; Temperature Conversion; Density; SI Units; Unit Conversions; Periodic Table

TERMS

Matter: has mass and volume; States of matter: solid, liquid, and gas

Substances: containing only one chemical substance, e.g., H$_2$O or NaCl, with a constant composition, e.g., H$_2$O; other texts may refer to this as a Pure Substance

Atom: the smallest chemical substance that has the properties of that element, e.g., He or Fe

Element: a substance that contains a single type of atom and cannot be decomposed into two or more substances; one of about 110 unique substances on the periodic table

Compound: a substance with two or more elements bonded together in fixed proportions, e.g., CO$_2$ or NO

Molecule: smallest discrete substance, e.g., O$_2$(g) or CH$_4$(g) that maintains the chemical characteristics of that species; electrically neutral; held together with covalent bonds;

Salts: held together with ionic bonds (salts = metal + nonmetal)

Chemical Change or Chemical Reaction: atoms are rearranged by making and/or breaking chemical bonds;
a chemical change is represented with starting materials (reactants) and new materials (products); e.g., going from C(s) to CO$_2$(g) as in C(s) + O$_2$(g) → CO$_2$(g)

Chemical Property: how a substance reacts chemically, e.g., C(s) can react with O$_2$(g) to form CO$_2$(g)

Physical Property: physical characteristic of a chemical such as its solubility, boiling point, melting point, density, etc.

Physical Change: a change in the state of matter; e.g., H$_2$O(s) to H$_2$O(l); s ↔ l ↔ g

SIGNIFICANT FIGURES (Appendix A)

- **Number < 1**: digits to the right of decimal are significant (e.g., 0.2560 = 4 sig figs); leading zeros are not significant, e.g., 0.0025 = 2 sig figs; trailing zeros are significant, e.g., 0.002500 = 4 sig figs

- **Number > 1**
  - *with decimal point*: all zeros right of the decimal point are significant, e.g., 547.00 = 5 sig figs; 240.0 = 4 sig figs
  - *without decimal point*: trailing zeros are not significant, e.g., 547 = 3 sig figs; 240 = 2 sig figs

- **Defined quantity**: Infinite sig figs, e.g., 100cm = 1m → infinite sig figs

- **Scientific notation**: All numbers of the significand or mantissa are significant, e.g., 2.304 × 10$^{-2}$ = 4 sig figs; 1.0400 × 10$^{-4}$ = 5 sig figs

**Precision** – measure of how close several measurements are to one another

**Accuracy** – how close a measured value is to the accepted value

TEMPERATURE CONVERSION

K = 273.15 + °C  (or °C = K – 273.15)
Kinetic Molecular Theory: Matter consists of tiny particles in constant motion; **Solids**: particles packed in a close regular array, vibrate but do not move; is rigid and volume is fixed; **Liquids**: particles are randomly arranged, touch and move past one another; **Gases**: has no fixed shape or volume; fill the container they’re in; can be compressed; particles move quite rapidly.

Phases of Matter (solid, liquid, gas):

DENSITY $\frac{\text{mass}}{\text{volume}}$ units: g/ml (liquids), g/cm$^3$ (solids), or g/L (gases)

$V = lwh$ (rectangular solid); $V = s^3$ (cube); $V = \frac{4}{3}\pi r^3$ (sphere with $r$ = radius)

SI UNITS (memorize)

<table>
<thead>
<tr>
<th>Unit</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giga</td>
<td>G</td>
<td>$1 \times 10^9$</td>
</tr>
<tr>
<td>Mega</td>
<td>M</td>
<td>$1 \times 10^6$</td>
</tr>
<tr>
<td>Kilo</td>
<td>k</td>
<td>$1 \times 10^3$</td>
</tr>
<tr>
<td>Centi</td>
<td>c</td>
<td>$1 \times 10^{-2}$</td>
</tr>
<tr>
<td>Milli</td>
<td>m</td>
<td>$1 \times 10^{-3}$</td>
</tr>
<tr>
<td>Micro</td>
<td>µ</td>
<td>$1 \times 10^{-6}$</td>
</tr>
<tr>
<td>Nano</td>
<td>n</td>
<td>$1 \times 10^{-9}$</td>
</tr>
<tr>
<td>Pico</td>
<td>p</td>
<td>$1 \times 10^{-12}$</td>
</tr>
</tbody>
</table>

1 ml = 1 cm$^3$  
1 Ångstrom = 1 Å = 1 x 10$^{-10}$ m
**DIMENSIONAL ANALYSIS (UNIT CONVERSIONS)**

**Example 1: Convert 5cm into meters.** (Example 1 is a one-step conversion: going between the pivot line and another unit.)

<table>
<thead>
<tr>
<th>M</th>
<th>= 1 x 10^6</th>
</tr>
</thead>
<tbody>
<tr>
<td>k</td>
<td>= 1 x 10^3</td>
</tr>
</tbody>
</table>

\[ \text{m, l, g} \]

\[ c = 1 \times 10^{-2} \]

\[ m = 1 \times 10^{-3} \]

**Answer 1:** 1 step conversion: directly to pivot line

\[ \text{cm} \rightarrow \text{m} \]

\[ 5 \text{cm} \times \frac{1 \text{m}}{1 \times 10^2 \text{cm}} = 5 \times 10^{-2} \text{m} \]

**Setting up the conversion fractions correctly. Which conversion factor is correct?**

<table>
<thead>
<tr>
<th>( \frac{1 \text{m}}{1 \times 10^2 \text{cm}} )</th>
<th>( \frac{1 \text{m}}{1 \times 10^2 \text{cm}} )</th>
<th>( \frac{1 \times 10^3 \text{m}}{1 \text{cm}} )</th>
<th>( \frac{1 \times 10^{-2} \text{m}}{1 \text{cm}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{1 \text{m}}{1 \times 10^2 \text{cm}} )</td>
<td>( \frac{1 \text{m}}{1 \times 10^2 \text{cm}} )</td>
<td>( \frac{1 \times 10^3 \text{m}}{1 \text{cm}} )</td>
<td>( \frac{1 \times 10^{-2} \text{m}}{1 \text{cm}} )</td>
</tr>
</tbody>
</table>

The 1st one says:
A large number of small ones (cm) = 1 large one (m)
Correct!

The 2nd one says:
A fraction of a small one (cm) = 1 large one (m)
Incorrect!

The 3rd one says:
A large number of large ones (m) = 1 small one (cm)
Incorrect!

The 4th one says:
A fraction of the large one (m) = A fraction of the large one (m)
Correct!

**Example 2: Convert 5mm into nanometers.** (Example 2 is a two-step conversion: going between one unit and another where neither are on the pivot line. To do this, you must go through the pivot line since all the conversion factors convert units to the pivot line.)

<table>
<thead>
<tr>
<th>M</th>
<th>= 1 x 10^6</th>
</tr>
</thead>
<tbody>
<tr>
<td>k</td>
<td>= 1 x 10^3</td>
</tr>
</tbody>
</table>

\[ \text{m, l, g} \]

\[ c = 1 \times 10^{-2} \]

\[ m = 1 \times 10^{-3} \]

\[ \mu = 1 \times 10^{-6} \]

\[ n = 1 \times 10^{-9} \]

\[ p = 1 \times 10^{-12} \]

**Answer 2:** 2 step conversion: must go through the pivot line

\[ \text{mm} \rightarrow \text{m} \rightarrow \text{nm} \]

\[ 5 \text{mm} \times \frac{1 \text{m}}{1 \times 10^3 \text{mm}} \times \frac{1 \times 10^9 \text{nm}}{1 \mu \text{m}} = 5 \times 10^6 \text{nm} \]

**Example 3: Convert 5kg/mm^3 into mg/cm^3.** (Example 3 is a multi-step conversion and includes units raised to exponents. To do this, you must go through the pivot line and take care of the powers/exponents.)

**Answer 3:** multi-step conversion: must go through the pivot line and take care of the exponents

\[ \text{re-write as a "vertical" fraction:} 5 \text{kg/mm}^3 \rightarrow \frac{5 \text{kg}}{\text{mm}^3} \rightarrow \frac{5 \text{kg}}{\text{mm} \times \text{mm} \times \text{mm}} \] (expanded notation)

work on each unit conversion separately; doesn't matter which conversion is done first;
I'll work on the bottom conversion first (\( \text{mm}^3 \rightarrow \text{cm}^3 \))

\[ \text{mm}^3 \rightarrow \text{cm}^3 \] and then \( \text{kg} \rightarrow \text{g} \rightarrow \text{mg} \)

\[ \frac{5 \text{kg}}{\eta f \times \eta f \times \eta f} \times \frac{1 \times 10^3 \mu f}{\eta f} \times \frac{1 \times 10^3 \mu f}{\eta f} \times \frac{1 \text{g}}{1 \mu f} \times \frac{1 \times 10^9 \text{mg}}{1 \text{g}} \times \frac{1 \times 10^3 \text{mg}}{1 \text{g}} = \frac{5 \times 10^9 \text{mg}}{\text{cm}^3} \]

**Simplified:**

\[ \frac{5 \text{kg}}{\eta f^3} \times \left( \frac{1 \times 10^3 \mu f}{\eta f^2} \right)^3 \times \frac{1 \text{g}}{1 \times 10^2 \text{cm}} \times \frac{1 \times 10^9 \text{mg}}{1 \text{g}} \times \frac{1 \times 10^3 \text{mg}}{1 \text{g}} = \frac{5 \times 10^9 \text{mg}}{\text{cm}^3} \]

Note how the \( \text{mm}^3 \) required three \( \text{mm} \rightarrow \text{m} \) conversions that can be written separately or by raising one conversion to the 3rd power.

**Common error:**

\[ \frac{5 \text{kg}}{\eta f^3} \times \left( \frac{1 \times 10^3 \mu f}{\eta f^2} \right)^3 \times \frac{1 \text{g}}{1 \times 10^2 \text{cm}} \times \frac{1 \times 10^9 \text{mg}}{1 \text{g}} \times \frac{1 \times 10^3 \text{mg}}{1 \text{g}} = \frac{5 \times 10^7 \text{mg}}{\text{cm}^3} \] **Wrong answer!**

**Common error** is to place the power of 3 for the \( 1 \times 10^3 \mu \text{m}/1 \text{mm} \) conversion inside the parentheses and only on the units instead of outside the parentheses which then also raises the numbers to the power of 3 as well.
Law of Conservation of Mass: Mass is neither created nor destroyed

PERIODIC TABLE:

Family or Groups (best to memorize) = columns: alkali metals (Group IA), alkaline earth metals (Group IIA), halogens (Group VIIA), noble gases (Group VIII A); other groups on the Periodic Table: transition metals; actinides; lanthanides

Period = row;
Three types of elements: metals, non-metals, metalloids

Diatomic Elements: F2, Cl2, Br2, I2, N2, O2, H2 (best to memorize)

Phases of elements:
- Liquid elements: Br(1), Hg(l) (best to memorize)
- Gas elements: noble gases: He(g), Ne(g), Ar(g), Kr(g), Rn(g); F2(g), Cl2(g), H2(g), N2(g), O2(g);
- Solid elements: All other elements that are not liquids or gases are solids

1. Classify each of the following as a physical property or a chemical property.
   a. Density   b. Melting temperature   c. Substance that decomposes into two elements upon heating
   d. A substance that does not react with sulfur

2. Classify each of the following as a physical or chemical change.
   a. Rusting of iron   b. Burning gasoline   c. Water evaporating from a lake

3. How many sig figs are in the following numbers/calculations?
   a. 124.02   b. 0.00045   c. 120,000,000   d. 10   e. 1.00045   f. 1.20 x 10^-5

4. I. Write the chemical symbols for the elements:
   a. potassium   b. cobalt   c. manganese   d. iron   e. phosphorous
   II. Write the chemical names for the following symbols:

5. Do the following unit conversions.
   a. 50.0 ng is equivalent to ________________ mg.
   b. 1.75 mm is equivalent to ________________ pm.
   c. A density of 50.0 g/cm^3 is equivalent to ________________ kg/m^3.
   d. How many feet are there in 2960 cm? (2.54 cm = 1.00 inch)
   e. The speed of light is 3.00 x 10^8 m/s. What is this speed in mi/hr? (2.54 cm = 1.00 inch; 5280 feet = 1.00 mile)

6. If a runner ran a 50.6 mile race in 8.00 hours and 23.0 minutes, how long would it take them to run a marathon (26.2 miles) in hours and minutes at the same average speed they ran the longer race?

7. A cube of metal has a side length of 2.0 cm and a mass of 40.0 grams. What is its density in g/cm^3?

8. An irregular shaped piece of metal has a density of 3.76g/cm^3 and when placed in a graduated cylinder containing water, the water rises from 31.25ml to 32.58ml. What is the mass of the metal in grams? (recall 1ml = 1cm^3)

9. A rectangular sample titanium foil has a top surface area of 13.9m^2 and has a mass of 681.6g. The density of titanium is 4.506 g/cm^3. Calculate the thickness of the titanium foil in cm.

10. If second rectangular sample of titanium in the form of a cube has a mass of 25.7mg (D_Ti = 4.506 g/cm^3) what is the side length of the cube in cm?
11. If a third sample of titanium is in the form of a sphere and has a mass of 245.1$\mu$g $(D_{Ti} = 4.506 \text{ g/cm}^3)$ what is the radius of the sphere in cm? Recall volume of a sphere $= \frac{4}{3}\pi r^3$

12. The following data was obtained when the volume of a solution of sodium chloride was measured:

- 25.774 ml
- 25.756 ml
- 25.744 ml
- 25.802 ml

Average: 25.769 ml

The actual volume of the solution was 11.660 ml. The above data can best be described as:

a. Accurate and precise  

b. Accurate and imprecise  

c. Inaccurate but precise  

d. Inaccurate and imprecise  

e. The terms accurate and precise do not apply in the above situation.

(For more practice with SI unit conversions or more practice with element names and symbols: See the last pages of this handout.)

ANSWERS

1. a. physical property  
   b. physical property  
   c. chemical property  
   d. chemical property

2. a. chemical change  
   b. chemical change  
   c. physical change

3. a. 5  
   b. 2  
   c. 2  
   d. 1  
   e. 6  
   f. 3

4. I. a. K  
   b. Co  
   c. Mn  
   d. Fe  
   e. P  
   II. a. chromium  
   b. calcium  
   c. krypton  
   d. sulfur  
   e. silicon  
   f. vanadium  
   g. manganese  
   h. sodium

5. a. $5.00 \times 10^{-5} \text{mg}$  
   b. $1.75 \times 10^9 \text{pm}$  
   c. $5.00 \times 10^4 \text{kg/m}^3$  
   d. 97.1 ft

6. 4.00 hours and 20.5 minutes  
   (8.00 hr x (60 min/1 hr) = 480 min + 23 min = 503 min total;  
   (503 min/50.6 mi) x (26.2 mi) = 260.45 min to run a marathon;  
   260.45 min x (1 hr/60 min) = 4.3408 hr;  
   4 hours and 0.3408 hr;  
   0.3408 hr x (60 min/1 hr) = 20.45 min;  
   4.00 hr and 20.5 min)

7. $5.00 \text{g/cm}^3$  
   a. $\text{D} = \frac{\text{m}}{\text{V}}$  
   b. $V = (2.0 \text{cm})^3 = 8.0 \text{cm}^3$  
   c. $D = \frac{40.0 \text{g}}{8.0 \text{cm}^3} = \frac{5.00 \text{g}}{\text{cm}^3}$
8. $5.00g \quad D = m/V; m = D(V) = \left( \frac{3.76g}{cm^3} \right) \left( \frac{lcm^3}{1ml} \right) (32.58ml - 31.25ml) = 5.00g$

9. $0.00109cm \quad \{D = \frac{mass}{vol}; \quad vol = \text{length x width x thickness}; \quad \text{rearrange equation: thickness} = \frac{mass}{\text{length x width x } D}; \quad \text{area} = \text{length x width}; \quad \text{thickness} = \frac{mass}{\text{area x } D}; \quad \text{convert units:} \quad 13.9m^2 \times (100cm/1m)^2 = 139,000cm^2; \quad \text{thickness} = \frac{681.6g}{139,000cm^2 \times \frac{4.506g}{cm^3}} = 0.001088cm \}$

10. $0.179cm \quad \{D = \frac{mass}{vol}; \quad \text{volume (cube)} = \text{side}^3; \quad D = \frac{mass}{\text{side}^3}; \quad \text{rearrange equation:} \quad \text{side}^3 = \frac{mass}{D}; \quad \text{convert units:} \quad 25.7mg \times (1g/1000mg) = 0.0257g; \quad \text{side} = \left( \frac{0.0257g}{4.506g/cm^3} \right)^{1/3} = 0.1787cm \}$

11. $0.02350cm \quad \{D = \frac{mass}{vol}; \quad \text{volume (sphere)} = \frac{4}{3}\pi r^3; \quad D = \frac{mass}{\left( \frac{4}{3}\pi r^3 \right)}; \quad \text{rearrange equation:} \quad r^3 = \frac{mass}{\left( \frac{4}{3}\pi \right)D}; \quad r = \left( \frac{mass}{\left( \frac{4}{3}\pi \right)D} \right)^{1/3}; \quad \text{convert units:} \quad 245.1\mu g \times (1g/1.0 \times 10^6\mu g) = 0.0002451g; \quad r = \left( \frac{0.0002451g}{\left( \frac{4}{3}\pi \right)4.506g/cm^3} \right)^{1/3}; \quad r = \left( \frac{0.0002451g}{18.875g/cm^3} \right)^{1/3} = 0.02350cm \}$

12. c. \quad \{\text{accurate means the value measured is very close to the true value: 25.679 is not close to 11.660; \text{precise means the measured values are all clustered to one another: all the values are very close to one another; hence, they are precise but not accurate} }\}$
1. Convert the value on the left into the units specified. These require two steps to convert the units.
(Note: \(1 \times 10^{10} \text{Å} = 1 \text{m}; \text{Å} = \text{Angstrom}; \text{Å} \) is not a SI unit but is commonly used in chemistry.)

   a. 5.0nm to Mm
   b. 12.7kg to pg
   c. \(3.5 \times 10^2\)mL to \(\mu\)L
   d. 6.500cg to ng
   e. 62Gm to mm
   f. 89.5pg to cg
   g. 25.5mm to km
   h. 55nm to Å
   i. 0.055kL to GL
   j. 125pL to mL
   k. 5.0mg to Mg
   l. 7.55cL to mL
   m. 12.5Gg to pg
   n. 18\(\mu\)g to ng
   o. 95.5km to \(\mu\)m
   p. 5.55pL to nL
   q. 134pm to Mm
   r. 43.5cg to Gg

2. Convert the value on the left into the units specified. These require multiple steps to convert the units.
   a. 25g/cm\(^3\) to kg/\(\mu\)m\(^3\)
   b. 55kg/ml to ng/cm\(^3\) \((1\text{ml} = 1\text{cm}^3)\)
   c. 5.0mg/mm\(^3\) to kg/km\(^3\)
   d. 45m/s\(^2\) to cm/hr\(^2\)
   e. 23cm\(^3\)/hr to L/min \((1\text{ml} = 1\text{cm}^3)\)
   f. 15ft/s to mm/hr \((1\text{in} = 2.54\text{cm})\)
   g. 23mi\(^2\) to cm\(^2\) \((\text{mi} = \text{mile}; 1\text{mi} = 5280\text{ft}; 1\text{in} = 2.54\text{cm})\)
3. Write the elemental symbol for each element name. Listed below are the *first 36 elements* from the Periodic Table and *a handful of other common elements* (e.g., the rest of the noble gases, halogens, alkali metals, and alkaline earth metals, and a few other common elements).

<table>
<thead>
<tr>
<th>Element</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. sodium</td>
<td>Na</td>
</tr>
<tr>
<td>b. iron</td>
<td>Fe</td>
</tr>
<tr>
<td>c. helium</td>
<td>He</td>
</tr>
<tr>
<td>d. chlorine</td>
<td>Cl</td>
</tr>
<tr>
<td>e. nitrogen</td>
<td>N</td>
</tr>
<tr>
<td>f. lead</td>
<td>Pb</td>
</tr>
<tr>
<td>g. aluminum</td>
<td>Al</td>
</tr>
<tr>
<td>h. bromine</td>
<td>Br</td>
</tr>
<tr>
<td>i. calcium</td>
<td>Ca</td>
</tr>
<tr>
<td>j. hydrogen</td>
<td>H</td>
</tr>
<tr>
<td>k. fluorine</td>
<td>F</td>
</tr>
<tr>
<td>l. argon</td>
<td>Ar</td>
</tr>
<tr>
<td>m. radon</td>
<td>Rn</td>
</tr>
<tr>
<td>n. sulfur</td>
<td>S</td>
</tr>
<tr>
<td>o. gallium</td>
<td>Ga</td>
</tr>
<tr>
<td>p. lithium</td>
<td>Li</td>
</tr>
<tr>
<td>q. manganese</td>
<td>Mn</td>
</tr>
<tr>
<td>r. titanium</td>
<td>Ti</td>
</tr>
<tr>
<td>s. iodine</td>
<td>I</td>
</tr>
<tr>
<td>t. oxygen</td>
<td>O</td>
</tr>
<tr>
<td>u. carbon</td>
<td>C</td>
</tr>
<tr>
<td>v. boron</td>
<td>B</td>
</tr>
<tr>
<td>w. silicon</td>
<td>Si</td>
</tr>
<tr>
<td>x. beryllium</td>
<td>Be</td>
</tr>
<tr>
<td>y. neon</td>
<td>Ne</td>
</tr>
<tr>
<td>z. magnesium</td>
<td>Mg</td>
</tr>
<tr>
<td>aa. gold</td>
<td>Au</td>
</tr>
<tr>
<td>bb. copper</td>
<td>Cu</td>
</tr>
<tr>
<td>cc. mercury</td>
<td>Hg</td>
</tr>
<tr>
<td>dd. silver</td>
<td>Ag</td>
</tr>
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<td>ee. potassium</td>
<td>K</td>
</tr>
<tr>
<td>ff. chromium</td>
<td>Cr</td>
</tr>
<tr>
<td>gg. scandium</td>
<td>Sc</td>
</tr>
<tr>
<td>hh. nickel</td>
<td>Ni</td>
</tr>
<tr>
<td>ii. phosphorous</td>
<td>P</td>
</tr>
<tr>
<td>kk. platinum</td>
<td>Pt</td>
</tr>
<tr>
<td>ll. arsenic</td>
<td>As</td>
</tr>
<tr>
<td>mm. krypton</td>
<td>Kr</td>
</tr>
<tr>
<td>nn. selenium</td>
<td>Se</td>
</tr>
<tr>
<td>oo. cesium</td>
<td>Cs</td>
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<tr>
<td>pp. strontium</td>
<td>Sr</td>
</tr>
<tr>
<td>qq. barium</td>
<td>Ba</td>
</tr>
<tr>
<td>rr. rubidium</td>
<td>Rb</td>
</tr>
<tr>
<td>ss. cobalt</td>
<td>Co</td>
</tr>
<tr>
<td>tt. zinc</td>
<td>Zn</td>
</tr>
<tr>
<td>uu. xenon</td>
<td>Xe</td>
</tr>
<tr>
<td>vv. vanadium</td>
<td>V</td>
</tr>
</tbody>
</table>
4. Write the element name for each chemical symbol.

a. He: ______________
b. Li: ______________
c. Co: ______________
d. Ga: ______________
e. Fe: ______________
f. Au: ______________
g. Na: ______________
h. K: ______________
i. P: ______________
j. Si: ______________
k. B: ______________
l. Ne: ______________
m. Rn: ______________
n. Ca: ______________
o. Ag: ______________
p. Pt: ______________
q. Ti: ______________
r. Sc: ______________
s. N: ______________
t. F: ______________
u. Be: ______________
v. H: ______________
w. Sr: ______________
x. Ar: ______________
y. Cl: ______________
z. O: ______________
aa. I: ______________
bb. V: ______________
cc. Ge: ______________
dd. S: ______________
ee. Br: ______________
ff. Xe: ______________
gg. Mn: ______________
hh. Ni: ______________
ii. Mg: ______________
jj. Kr: ______________
kk. Rb: ______________
ll. Ba: ______________
mm. Cs: ______________
nn. Pb: ______________
oo. As: ______________
pp. Cu: ______________
qq. Zn: ______________
rr. Hg: ______________
ss. Se: ______________
tt. C: ______________
uu. Al: ______________
vv. Cr: ______________
Extra Practice #1 – SI Units and Element Names and Symbols

ANSWERS

1. a. $5.0 \times 10^{-15}\text{Mm}$  \{ $5.0\text{nm}\left(\frac{1\text{m}}{1 \times 10^9\text{nm}}\right)\left(\frac{1\text{Mm}}{1 \times 10^6\text{m}}\right) = 5.0 \times 10^{-15}\text{Mm}$ \}

b. $1.27 \times 10^{16}\text{pg}$  \{ $12.7\text{kg}\left(\frac{1000\text{g}}{1\text{kg}}\right)\left(\frac{1 \times 10^{12}\text{pg}}{1\text{g}}\right) = 1.27 \times 10^{16}\text{pg}$ \}

c. $3.5 \times 10^5\mu\text{L}$  \{ $3.5 \times 10^2\text{mL}\left(\frac{1\text{L}}{1000\text{mL}}\right)\left(\frac{1 \times 10^6\mu\text{L}}{1\text{L}}\right) = 3.5 \times 10^5\mu\text{L}$ \}

d. $6.500 \times 10^7\text{ng}$  \{ $6.500\text{cg}\left(\frac{1\text{g}}{100\text{cg}}\right)\left(1 \times 10^9\text{ng}\right) = 6.500 \times 10^7\text{ng}$ \}

e. $6.2 \times 10^{13}\text{mm}$  \{ $62\text{Gm}\left(\frac{1 \times 10^9\text{m}}{1\text{Gm}}\right)\left(\frac{1000\text{mm}}{1\text{m}}\right) = 6.2 \times 10^{13}\text{mm}$ \}

f. $8.95 \times 10^{-9}\text{cg}$  \{ $89.5\text{pg}\left(\frac{1\text{g}}{10^1\text{pg}}\right)\left(\frac{100\text{cg}}{1\text{g}}\right) = 8.95 \times 10^{-9}\text{cg}$ \}

g. $2.55 \times 10^{-5}\text{km}$  \{ $25.5\text{mm}\left(\frac{1\text{m}}{1000\text{mm}}\right)\left(\frac{1\text{km}}{1\text{m}}\right) = 2.55 \times 10^{-5}\text{km}$ \}

h. $550\text{Å}$  \{ $55\text{nm}\left(\frac{1\text{m}}{1 \times 10^9\text{nm}}\right)\left(\frac{1\text{Å}}{1\text{m}}\right) = 550\text{Å}$ \}

i. $5.5 \times 10^{-8}\text{GL}$  \{ $0.055\text{kL}\left(\frac{1000\text{L}}{1\text{kL}}\right)\left(\frac{1\text{GL}}{1 \times 10^9\text{L}}\right) = 5.5 \times 10^{-8}\text{GL}$ \}

j. $1.25 \times 10^{-7}\text{mL}$  \{ $125\text{pL}\left(\frac{1\text{L}}{1 \times 10^{12}\text{pL}}\right)\left(\frac{1000\text{mL}}{1\text{L}}\right) = 1.25 \times 10^{-7}\text{mL}$ \}

k. $5.0 \times 10^{-9}\text{Mg}$  \{ $5.0\text{mg}\left(\frac{1\text{g}}{1000\text{mg}}\right)\left(\frac{1\text{Mg}}{1 \times 10^6\text{g}}\right) = 5.0 \times 10^{-9}\text{Mg}$ \}

l. $75.5\text{mL}$  \{ $7.55\text{cL}\left(\frac{1\text{L}}{100\text{cL}}\right)\left(\frac{1000\text{mL}}{1\text{L}}\right) = 75.5\text{mL}$ \}

m. $1.25 \times 10^{22}\text{pg}$  \{ $12.5\text{Gg}\left(\frac{1 \times 10^9\text{g}}{1\text{Gg}}\right)\left(\frac{1 \times 10^{12}\text{pg}}{1\text{g}}\right) = 1.25 \times 10^{22}\text{pg}$ \}

n. $1.8 \times 10^4\text{ng}$  \{ $18\text{µg}\left(\frac{1\text{g}}{1 \times 10^6\text{µg}}\right)\left(\frac{1 \times 10^9\text{ng}}{1\text{g}}\right) = 1.8 \times 10^4\text{ng}$ \}

o. $9.55 \times 10^{10}\text{µm}$  \{ $95.5\text{km}\left(\frac{1000\text{m}}{1\text{km}}\right)\left(\frac{1 \times 10^6\text{µm}}{1\text{m}}\right) = 9.55 \times 10^{10}\text{µm}$ \}

p. $5.55 \times 10^{-3}\text{nL}$  \{ $55.5\text{pL}\left(\frac{1\text{L}}{1 \times 10^{12}\text{pL}}\right)\left(\frac{1 \times 10^9\text{nL}}{1\text{L}}\right) = 5.55 \times 10^{-3}\text{nL}$ \}

q. $1.34 \times 10^{-16}\text{Mm}$  \{ $134\text{pm}\left(\frac{1\text{m}}{1 \times 10^{12}\text{pm}}\right)\left(\frac{1\text{Mm}}{1 \times 10^6\text{m}}\right) = 1.34 \times 10^{-16}\text{Mm}$ \}

r. $4.35 \times 10^{-10}\text{Gg}$  \{ $43.5\text{cg}\left(\frac{1\text{g}}{100\text{cg}}\right)\left(\frac{1\text{Gg}}{1 \times 10^9\text{g}}\right) = 4.35 \times 10^{-10}\text{Gg}$ \}
2. a. \(2.5 \times 10^{-14} \text{ kg/\(\mu\text{m}^3\)}\) \(= \frac{25 \text{ g}}{\text{cm}^3} \left(\frac{1 \text{ kg}}{1000 \text{ g}}\right) \left(\frac{100 \text{ cm}}{1 \text{ m}}\right)^3 \left(\frac{1 \text{ m}}{1 \times 10^6 \text{ \(\mu\text{m}\)}}\right)^3 \)

b. \(5.5 \times 10^{13} \text{ ng/cm}^3\) \(= \frac{55 \text{ kg}}{\text{ml} \text{ lcm}^3} \left(\frac{1 \text{ mg}}{1000 \text{ g}}\right) \left(\frac{1 \text{ x} 10^9 \text{ ng}}{1 \text{ g}}\right) \)

c. \(5.0 \times 10^{12} \text{ kg/km}^3\) \(= \frac{5.0 \text{ mg}}{\text{mm} \text{ lmm}^3} \left(\frac{1 \text{ g}}{1000 \text{ mg}}\right) \left(\frac{1 \text{ kg}}{1 \text{ g}}\right) \left(\frac{1000 \text{ mm}}{1 \text{ km}}\right)^3 \left(\frac{1000 \text{ m}}{1 \text{ km}}\right)^3 \)

d. \(5.8 \times 10^{10} \text{ cm/hr}^2\) \(= \frac{45 \text{ m}}{\text{s} \text{ lms}^2} \left(\frac{60 \text{ s}}{1 \text{ min}}\right) \left(\frac{60 \text{ min}}{1 \text{ hr}}\right) \left(\frac{100 \text{ cm}}{1 \text{ m}}\right) \)

e. \(3.8 \times 10^{-4} \text{ L/min}\) \(= \frac{23 \text{ cm}^3}{\text{hr} \text{lhrs}^3} \left(\frac{1 \text{ hr}}{60 \text{ min}}\right) \left(\frac{1 \text{ ml}}{1 \text{lcm}^3}\right) \left(\frac{1 \text{ L}}{1000 \text{ ml}}\right) \)

f. \(1.6 \times 10^7 \text{ mm/hr}\) \(= \frac{15 \text{ ft}}{\text{s} \text{lfs}^2} \left(\frac{60 \text{ s}}{1 \text{ min}}\right) \left(\frac{60 \text{ min}}{1 \text{ hr}}\right) \left(\frac{12 \text{ in}}{1 \text{ ft}}\right) \left(\frac{2.54 \text{ cm}}{1 \text{ in}}\right) \left(\frac{1 \text{ m}}{100 \text{ cm}}\right) \left(\frac{1000 \text{ mm}}{1 \text{ m}}\right) \)

g. \(6.0 \times 10^{11} \text{ cm}^2\) \(= \frac{23 \text{ mi}^2}{\text{lmi} \text{ lmi}^2} \left(\frac{5280 \text{ ft}}{1 \text{ mi}}\right) \left(\frac{12 \text{ in}}{1 \text{ ft}}\right) \left(\frac{2.54 \text{ cm}}{1 \text{ in}}\right)^2 \)


4. a. helium  b. lithium  c. cobalt  d. gallium  e. iron  f. gold  g. sodium  h. potassium  i. phosphorous  j. silicon  k. boron  l. neon  m. radon  n. calcium  o. silver  p. platinum  q. titanium  r. scandium  s. nitrogen  t. fluorine  u. beryllium  v. hydrogen  w. strontium  x. argon  y. chlorine  z. oxygen  aa. iodine  bb. vanadium  cc. germanium  dd. sulfur  ee. bromine  ff. xenon  gg. manganese  hh. nickel  ii. magnesium  jj. krypton  kk. rubidium  ll. barium  mm. cesium  nn. lead  oo. arsenic  pp. copper  qq. zinc  rr. mercury  ss. selenium  tt. carbon  uu. aluminum  vv. chromium