WARNING! The unit conversion method is used ***EXTENSIVELY*** in Chemistry 11, [illegible] *and love it!*

KEY

# YOULearn #2 - UNIT CONVERSIONS

- *SI Units we commonly use in Chemistry*:

| Type of measurement | Base unit | Unit symbol |
|---|---|---|
| mass | gram | g |
| length | metre | m |
| volume | litre | L |
| pressure | Pascal | Pa |
| temperature | Kelvin | K |
| time | second | S |
| amount of matter | mole | mol |

- *SI prefixes we will use regularly*:

| Prefix | Symbol | As a power |
|---|---|---|
| mega | M | $10^6$ |
| kilo | k | $10^3$ |
| hecto | h | $10^2$ |
| deka | da | 10 |
| | | 1 |
| deci | d | $10^{-1}$ |
| centi | c | $10^{-2}$ |
| milli | m | $10^{-3}$ |
| micro | μ | $10^{-6}$ |
| nano | n | $10^{-9}$ |

## A. Calculations Using Unit Conversions

- You ***must***follow the same method shown below.
- We can convert from one unit to another by using relationships that are equivalent to each other then arranged as a ratio. The ratio is called the **conversion factor.**
- For example, with time we know the following relationships:

| Relationship | Conversion Factor |
|---|---|
| 1 min = 60 s | $\frac{1\min}{60s}$ and $\frac{60s}{1\min}$ |
| 1 hour = 60 min | $\frac{1hour}{60\min}$ and $\frac{60\min}{1hour}$ |
| 24 hours = 1 day | $\frac{1day}{24hours}$ and $\frac{24hours}{1day}$ |

*Note that the values in the ratios are equal to each other (i.e. 1min = 60 s). Therefore, the ratio really has a value equal to 1. Multiplying any factor by the conversion factor is equivalent o multiplying by 1 and will not change the value of the expression.*

WARNING! The unit conversion method is used ***EXTENSIVELY*** in Chemistry 11, ***learn it and love it!***

The general formula for solving problems using the conversion factor method:

**Unknown Amount = (initial amount given in the problem) x (conversion factor)**

**Examples:**

1. How many seconds are there in 49 minutes?

$$49\ \cancel{min} \times \frac{60\ sec}{1\ \cancel{min}} = 2940\ sec \quad \boxed{2900 sec} \text{ or } \boxed{2.9\times10^{3} sec}$$

2. How many hours are there in 448 minutes?

$$448\ \cancel{min} \times \frac{1\ hr}{60\ \cancel{min}} = 7.4666\ hr \quad \boxed{7.47\ hr}$$

3. How many minutes are there in 44 days? (2 steps)

$$44\ days \times \frac{???\ min}{day}$$

$$44\ \cancel{days} \times \frac{24\ \cancel{hr}}{1\ \cancel{day}} \times \frac{60\ min}{1\ \cancel{hr}} = 63360\ min \quad \boxed{63000\ min}$$

4. How many seconds are there in 3 days? (3 steps)

$$3\ \cancel{days} \times \frac{24\ \cancel{hr}}{1\ \cancel{days}} \times \frac{60\ \cancel{min}}{1\ \cancel{hr}} \times \frac{60\ sec}{1\ \cancel{min}} = 259200\ sec \quad \boxed{300\ 000\ sec}$$

Note:

- **All the units cancel each other except the desired unit** (s). (show this in your work!)
- The expression " 3 days" is multiplied by three conversion factors that are all equivalent to "1". The final answer changed because the "expression" has a different unit, but the actual **value** is still the same.

5. If the density of sea water is 1.2 g/mL, calculate the mass of 45mL of sea water.

$$45\ \cancel{mL} \times \frac{1.2\ g}{1\ \cancel{mL}} = 54\ g \quad \boxed{54\ g}$$

6. If a car is moving at 50km/h, calculate how far (in metres) the car moves in 5 seconds.

$$5\ sec \times \frac{1\ min}{60\ sec} \times \frac{1\ hr}{60\ min} \times \frac{50\ km}{hr} \times \frac{1(10^{3})\ m}{1\ km} =$$

$$= 69.44\ m$$

$$= 70\ m \text{ or } 7\times10^{1}\ m$$

ALWAYS INCLUDE THE UNITS FOR ALL THE CALCULATIONS WE DO IN CHEMISTRY. **DO NOT BE TEMPTED TO EXCLUDE THEM!**

WARNING! The unit conversion method is used ***EXTENSIVELY*** in Chemistry 11, ***learn it and love it!***

**More Examples:**(Hint: always put the ***unit convertor*** 2nd!)

a) How many minutes are there in 1 week?

$$1\text{ week} \times \frac{7\text{ day}}{1\text{ week}} \times \frac{24\text{ hr}}{1\text{ day}} \times \frac{60\text{ min}}{1\text{ hr}} = \boxed{10080\text{ min}}$$

"∞" sig figs as it is a perfect number!

b) How many centimeters are in 21.5km?

$$21.5\text{ km} \times \frac{1(10^{3})\text{ m}}{1\text{ km}} \times \frac{1\text{ cm}}{1(10^{-2})\text{ m}} = \boxed{2150000\text{ cm}}$$

c) If you have 45 dozen eggs, how many eggs do you have?

$$\underbrace{45}_{\text{"}\infty\text{" sig figs}}\text{ dozen eggs} \times \frac{12\text{ eggs}}{1\text{ dozen eggs}} = \boxed{\underbrace{540.}_{\text{"}\infty\text{" sig figs}}\text{ eggs}}$$

d) If a car can move 50km/h, how far can the car go in 3.5 hours?

$$3.5\text{ hr} \times \frac{50\text{ km}}{1\text{ hr}} = 175\text{ km} \quad \boxed{200\text{ km}}$$

e) One molecule of phosphorus has 4 atoms. How many molecules are there in 448 atoms of phosphorus?

$$448\text{ atoms } P_4 \times \frac{1\text{ molecule } P_4}{4\text{ atoms } P} = 112\text{ molecules } P_4$$

f) If one mole of carbon has a mass of 12.0g, what is the mass of 4.7 moles of carbon?

$$4.7\text{ mole} \times \frac{12.0\text{ g}}{1\text{ mole}} = 56.4\text{ g} \quad \boxed{56\text{ g}}$$

g) The density of aluminum is 2.7g/mL. What is the volume of 7.4 g of aluminum?

$$7.4\text{ g Al} \times \frac{1\text{ mL}}{2.7\text{ g}} = 2.7407\text{ mL Al} \quad \boxed{2.7\text{ mL Al}}$$

h) If a car averages 60km/h, how long will it take to cover 57km?

$$57\text{ km} \times \frac{1\text{ hr}}{60\text{ km}} = 0.95\text{ hr} \quad \boxed{1\text{ hr}}$$

---

**"Only those who have the patience to do simple things perfectly, will acquire the skill to do difficult things easily."**

~ Johann von Schiller (German philosopher)

WARNING! The unit conversion method is used ***EXTENSIVELY*** in Chemistry 11, ***learn it and love it!***

## B. Multiple Unit Conversions ~ Chain Conversions

perfect values = unlimited sig figs $\infty$

1. How many minutes are there in 3 days?

$$3\text{ day} \times \frac{24\text{ hr}}{1\text{ day}} \times \frac{60\text{ min}}{1\text{ hr}} = 4320\text{ min}$$

$$\boxed{4000\text{ min}}$$

2. The energy needed to melt 1kg of ice requires 334kJ. The largest known iceberg has a volume of about $3.1 \times 10^{13}$ m$^3$. How much heat was required to melt the iceberg if 1m$^3$ of ice has a mass of 917kg?

* find the connections!

$$3.1 \times 10^{13}\text{ m}^3 \times \frac{917\text{ kg}}{1\text{ m}^3} \times \frac{334\text{ kJ}}{1\text{ kg}} = 9.4946 \times 10^{18}\text{ kJ}$$

$$\boxed{9.5 \times 10^{18}\text{ kJ}}$$

is

3. How far does a car go in 10 seconds if it si moving at 50km/h?

$$10\text{ sec.} \times \frac{1\text{ hr}}{3600\text{ sec.}} \times \frac{50\text{ km}}{\text{hr}} = 0.1388\text{ km}$$

$$\boxed{0.1\text{ km}}$$

4. If 1 yard = 3 feet, 1 foot = 12 inches, and 1 inch = 2.54cm, how many meters are in 50 yards?

$$50\text{ yd} \times \frac{3\text{ ft}}{1\text{ yd}} \times \frac{12\text{ in}}{1\text{ ft}} \times \frac{2.54\text{ cm}}{1\text{ in}} \times \frac{1(10^{-2})\text{ m}}{1\text{ cm}} = 45.72\text{ m}$$

$$\boxed{50\text{ m}}$$

5. A sprinter can run 100 metres in 10 seconds. How fast is the sprinter moving in km/h?

$$\frac{100\ \cancel{\text{m}}}{10\ \cancel{\text{s}}} \times \frac{1\text{ km}}{1(10^3)\ \cancel{\text{m}}} \times \frac{3600\ \cancel{\text{s}}}{1\text{ hr}} = 36\text{ km/hr}$$

WARNING! The unit conversion method is used ***EXTENSIVELY*** in Chemistry 11, *learn it and love it!*

## C. Derived Quantities

- Quantities made up by combining two or more other values.
- Derived unit is a unit made by combining two or more units.

area ($m^2$) volume ($cm^3$) density (g/L)

**Examples:**(Hint: $cm^2$ = cm x cm, the value of the power tells you how many times you must convert the unit!)

$1.5 cm^2 = 1.5 cm \times cm$

1. Convert 1.5$cm^2$ to $m^2$.

$$1.5 \cancel{cm}^{\cancel{2}} \times \frac{1(10^{-2})m}{1\ \cancel{cm}} \times \frac{1(10^{-2})m}{1\ \cancel{cm}} = \boxed{1.5 \times 10^{-4} m^2}$$

2. Convert 25$m^3$ to $cm^3$.

$25 m^3 = 25 m \times m \times m$

$$25 m^3 \times \frac{cm}{(10^{-2})m} \times \frac{cm}{(10^{-2})m} \times \frac{cm}{(10^{-2})m} = \boxed{2.5 \times 10^{7} cm^3}$$

3. If an iron bar has a volume of 5.0L and a mass of 39kg, what is the density of the iron bar in g/L?

$$\frac{39\ kg}{5.0\ L} \times \frac{(10^{3})g}{kg} = 7800 \frac{g}{L}$$

4. What is the volume occupied by 35g of mercury. The density of mercury is 13.6g/mL.

$$35 g \times \frac{1\ mL}{13.6\ g} = 2.573\ mL \qquad \boxed{2.6\ mL}$$

5. Convert 50km/h into m/s.

$$50 \frac{km}{h} \times \frac{(10^{3})m}{km} \times \frac{1\ h}{3600 s} = 13.88 \frac{m}{s} \qquad \boxed{10\ m/s}$$

WARNING! The unit conversion method is used ***EXTENSIVELY*** in Chemistry 11, ***learn it and love it!***

## D. Challenging Unit Conversions:

1. Light travels at a rate of 3.00x $10^8$m/s. It takes light 8.3 minutes to travel from the sun to Earth. What is the distance from the sun to Earth in kilometres?

$$8.3\ \text{min} \times \frac{60\ \text{sec}}{1\ \text{min}} \times \frac{3.00\times10^{8}\ \text{m}}{\text{sec}} \times \frac{1\ \text{km}}{1(10^{3})\ \text{m}} = 1.494\times10^{8}\ \text{km}$$

$$\boxed{1.5\times10^{8}\ \text{km}}$$

2. The Cullinan diamond, the largest diamond ever found, has an uncut volume of 177mL. If 1mL of diamond has a mass of 3.51g and 1carat = 0.200g, how many carats was the Cullinan diamond?

$$177\ \text{mL} \times \frac{3.51\ \text{g}}{1\ \text{mL}} \times \frac{1\ \text{carat}}{0.200\ \text{g}} = 3106.35\ \text{carats} \qquad \boxed{3110\ \text{carats}}$$

3. Express 0.0098cL/ms$^2$ in kL/s$^2$

$$\frac{0.0098\ \text{cL}}{\text{ms}^{2}} \times \frac{1(10^{-2})\ \text{L}}{1\ \text{cL}} \times \frac{1\ \text{kL}}{1(10^{3})\ \text{L}} \times \frac{1\ \text{ms}^{2}}{1(10^{-3})\ \text{s}^{2}} = \boxed{9.8\times10^{-5}\ \frac{\text{kL}}{\text{s}^{2}}}$$

4. The pressure in a hot air balloon is 9.0lb/in$^3$. Convert the pressure inside the balloon to kg/m$^3$.

$$9.0\ \frac{\text{lb}}{\text{in}^{3}} \times \frac{1\ \text{kg}}{2.2\ \text{lb}} \times \frac{(1\ \text{in})^{3}}{(2.54\ \text{cm})^{3}} \times \frac{(1\ \text{cm})^{3}}{(1(10^{-2})\ \text{m})^{3}} = 300\ 000\ \frac{\text{kg}}{\text{m}^{3}}$$

$$\boxed{3.0\times10^{5}\ \frac{\text{kg}}{\text{m}^{3}}}$$

5. A Celtic chicken farmer wants to buy a gift for his wife. The gift was worth 2 horses. At the local market, 3 horses were worth 5 cows, 1 cow was worth 4 pigs, 3 pigs were worth 4 goats, and 1 goat was worth 9 chickens. How much was the gift going to cost the farmer, who had to pay in chickens?

$$\underbrace{1\ \text{gift} \times \frac{2\ \text{horses}}{1\ \text{gift}} \times \frac{5\ \text{cows}}{3\ \text{horses}} \times \frac{4\ \text{pigs}}{1\ \text{cow}} \times \frac{4\ \text{goats}}{3\ \text{pigs}} \times \frac{9\ \text{chickens}}{1\ \text{goat}}}_{\text{all are perfect values} \therefore \text{unlimited sig figs} \therefore \text{why???}} = \boxed{160\ \text{chickens}}$$

6. The largest iceberg in the world requires 6.53 x $10^7$kJ of heat energy to melt. One kilogram of TNT or dynamite releases 1.5 x $10^4$kJ of energy when exploded. Provided that all of the energy of an explosion went into melting the iceberg, how many pounds of TNT would be needed?

$$6.53\times10^{7}\ \text{kJ} \times \frac{1\ \text{kg}}{1.5\times10^{4}\ \text{kJ}} \times \frac{1(10^{3})\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{lb}}{454\ \text{g}} = 9588.83\ \text{lb}$$

$$\boxed{9600\ \text{lb}}$$

7. Express 50.0024 mL/min$^2$ in µL/s$^2$

$$\frac{50.0024\ \text{mL}}{\text{min}^{2}} \times \frac{1(10^{-3})\ \text{L}}{1\ \text{mL}} \times \frac{1\ \mu\text{L}}{1(10^{-6})\ \text{L}} \times \frac{1\ \text{min}}{60\ \text{sec}} \times \frac{1\ \text{min}}{60\ \text{sec}}$$

$$= \boxed{13.8895\ \frac{\mu\text{L}}{\text{s}^{2}}}$$