CHEM1101 Worksheet 1

Model 1: Writing numbers in scientific notation

Calculations in chemistry often use numbers that are very large or very small, so it is not practical to write the number out in full. This problem is often addressed by using prefixes to indicate smaller or larger quantities (examples we use every day are 1 metre = 100 *centi*metres and 1000 grams = 1 *kilo*gram). When performing calculations, it is more common to use scientific notation, in which numbers are written in the form a x 10^b. It is important to be able to convert between prefixes and scientific notation. Common prefixes are shown in the tables below.

Prefix	Symbol	Exponential
Tera	T	10^{12}
Giga	G	10^{9}
Mega	M	10^{6}
Kilo	k	10^{3}
Hecto	h	10^{2}
Deca	da	10^{1}

Prefix	Symbol	Exponential
Deci	d	10^{-1}
Centi	c	10^{-2}
Milli	m	10^{-3}
Micro	μ	10^{-6}
Nano	n	10^{-9}
Pico	p	10^{-12}

Whenever you perform a calculation or conversion, it is essential that you consider the number of significant figures that you give in your answer. For revision of significant figures, have a look here http://firstyear.chem.usyd.edu.au/iChem/significant_figures.shtml

Critical thinking questions

1. Fill in the following table

Unit with prefix	Scientific notation (no prefix)
5 ns	
3.4 mCi	
	1.8 x 10^6 Bq
3 dL	
	1.5 x10^{-12} s
18 μSv	
348 nm	
	3 x 10^8 L

Model 2: Converting between different units

Often, more than one unit can be used to describe the same quantity. Conversion factors can be used to interchange between units. It is most common to express quantities in terms of their SI units, and using scientific notation. Important units and their conversion factors are shown in the table below.

Quantity	SI unit	Alternative unit	Conversion
Mass	Kilogram (kg)	Atomic mass unit (amu)	1 amu = 1.66×10^{-27} kg
Radiation activity	Becquerel (Bq)	Curie (Ci)	1 Ci = 3.7×10^{10} Bq
Energy	Joule (J)	Electron volt (eV)	1 eV = 1.6×10^{-19} J

Critical thinking questions

2. Convert the following quantities to the unit specified.
   a. 1.00 kg in amu
   b. 1.0 Bq in Ci
   c. 1.0 J in eV
   d. 5.69×10^{-25} kg in amu
   e. 6.2×10^{-7} Ci in Bq
   f. 4.8×10^{-17} J in eV
   g. 1.0 GBq in Ci
   h. 11 MeV in J

Model 3: The Atomic Symbol

The atomic symbol, X, is used to identify the element to which an atom belongs and the number of electrons, protons and neutrons it contains.

$$ {}^{A}_{Z}X $$

A *neutral* atom of an element has the same number of electrons and protons:

number of protons = number of electrons = atomic number = Z

The mass number is equal to the number of protons plus the number of neutrons:

number of neutrons = mass number - number of protons = $A - Z$

Ions have different numbers of protons and electrons and so have any overall charge. **Anions** have gained electrons so have a negative charge. **Cations** have lost electrons so have a positive charge. The overall charge is written as a superscript after the symbol:

${}^{A}_{Z}X^{n-}$ is an anion: it has n more electrons than protons. ${}^{A}_{Z}X^{n+}$ is a cation: it has n fewer electrons than protons

Critical thinking questions

3. How many electrons, protons and neutrons are there in each of the species below?

	species	number of electrons	number of protons	number of neutrons
(a)	$^{24}_{12}\mathrm{Mg}$			
(b)	$^{26}_{12}\mathrm{Mg}$			
(c)	$^{24}_{12}\mathrm{Mg}^{2+}$			
(d)	$^{79}_{35}\mathrm{Br}$			
(e)	$^{81}_{35}\mathrm{Br}^{-}$			

4. Alpha and beta particles, and gamma rays are important in radioactive decay. How many protons and neutrons are in each species? What are the charges and the (integer) masses of the species below?

Species	Alpha particle α or $^{4}_{2}\mathrm{He}$	High speed electron β^- or $^{0}_{-1}\beta$	Positron β^+ or $^{0}_{1}\beta$	Gamma radiation $^{0}_{0}\gamma$
Number of protons				
Number of neutrons				
Charge				
Mass				

Model 4: Isotopes

Each element found in nature occurs as a mixture of isotopes. Isotopic abundances can vary appreciably on an astronomical scale – e.g. in the Sun versus the Earth. On Earth, however, natural abundance varies little from place to place.

Table 1. Natural abundance and atomic masses for various isotopes

Isotope	Natural Abundance on Earth (%)	Atomic Mass (amu)
$^{1}\mathrm{H}$	99.985	1.0078
$^{2}\mathrm{H}$	0.015	2.0140
$^{35}\mathrm{Cl}$	75.77	34.9689
$^{37}\mathrm{Cl}$	24.23	36.9659

1 amu = 1.6606×10^{-24} g

Critical thinking questions

5. How many isotopes of hydrogen occur naturally on Earth?

6. Describe what these isotopes of hydrogen have in common and also how they are different.

7. If you select one chlorine atom at random, what is the mass of that atom most likely to be (in amu)?

8. What is the mass (in amu) of 100 ^{35}Cl atoms? Of 100 ^{37}Cl atoms?

9. If you select one hundred chlorine atoms at random, what will the total mass most likely be?

   (a) 3496.89 amu
   (b) between 3496.89 amu and 3600.00 amu
   (c) 3600.00 amu
   d) between 3600.00 amu and 3696.59 amu
   (d) 3696.59 amu

Explain your reasoning.