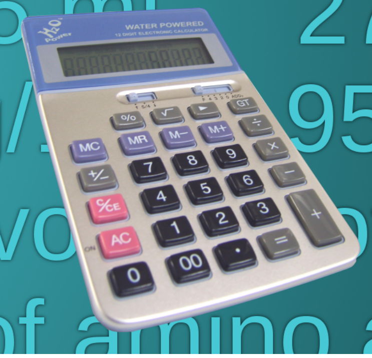
Chapter 17

mmol, mEq, mCi, & IU



"So if I get exposed to enough radiation at our field trip to a nuclear pharmacy, could I turn into the Hulk?"
"Probably not, but if you did it would be fairly short-lived since they primarily work with technetium-99 and that only has a 6 hour half-life."
--A discussion between a student and his instructor.

Many systems of measures for drugs are easily understandable, such as mass of drug (30 grams of ointment), volume of a solution (250 mL of NS), concentration as mass of drug per quantity of volume (400 mg E.E.S./tsp), percentage strength (50% Magnesium Sulfate = 50 g/100 mL), etc. Other forms require more manipulation to arrive at how they are calculated such as

- millimoles,
- milliEquivalents,
- millicuries, and
- international units.

Due to the concepts in this chapter, we need to take a brief moment and explain how to read a chemical formula. A chemical formula (or molecular formula) is a way of expressing information about the atoms that constitute a particular chemical compound. The chemical formula identifies each constituent element by its chemical symbol and indicates the number of atoms of each element found in each discrete molecule of that compound. If a molecule contains more than one atom of a particular element, this quantity is indicated using a subscript after the chemical symbol. Therefore, if you were to look at the chemical formula for water, H_2O, you would know that there are 2 hydrogen atoms and one oxygen atom in a single water molecule. (If you are not sure of the proper abbreviations for various elements, you may reference the periodic table that appears on the next page.)

Practice Problems

To ensure that you are comfortable with reading chemical formulas please attempt the following practice problems. Determine how many of each type of atom are present in the following molecules.

1) Salt - NaCl

2) Dextrose - $C_6H_{12}O_6$

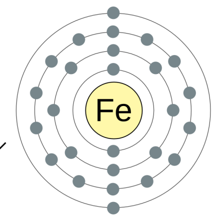
3) Dibasic sodium phosphate - Na_2HPO_4

4) Calcium hydroxide - $Ca(OH)_2$

1) 1 sodium, 1 chloride   2) 6 carbon, 12 hydrogen, 6 oxygen
3) 2 sodium, 1 hydrogen, 1 phosphorous, 4 oxygen   4) 1 calcium, 2 oxygen, 2 hydrogen

The Periodic Table of the Elements

- atomic mass (or most stable mass number): 55.845
- atomic number: 26
- most common oxidation states: +3 +2
- chemical symbol: Fe
- name: Iron
- electron configuration: [Ar] $3d^6 4s^2$



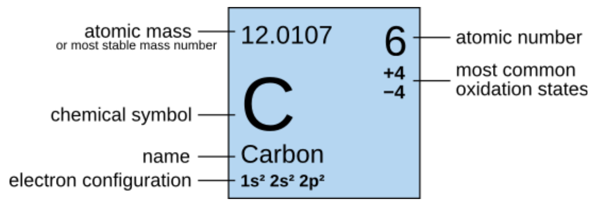
	group 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
period 1	1.00794 1 +1 −1 H Hydrogen $1s^1$																	4.002602 2 He Helium $1s^2$
2	6.941 3 +1 Li Lithium $1s^2 2s^1$	9.012182 4 +2 Be Beryllium $1s^2 2s^2$											10.811 5 +3 B Boron $1s^2 2s^2 2p^1$	12.0107 6 +4 −4 C Carbon $1s^2 2s^2 2p^2$	14.0067 7 +5 −3 N Nitrogen $1s^2 2s^2 2p^3$	15.9994 8 −2 O Oxygen $1s^2 2s^2 2p^4$	18.998403 9 −1 F Fluorine $1s^2 2s^2 2p^5$	20.1797 10 Ne Neon $1s^2 2s^2 2p^6$
3	22.98976 11 +1 Na Sodium [Ne] $3s^1$	24.3050 12 +2 Mg Magnesium [Ne] $3s^2$											26.98153 13 +3 Al Aluminium [Ne] $3s^2 3p^1$	28.0855 14 +4 −4 Si Silicon [Ne] $3s^2 3p^2$	30.97696 15 +5 +3 −3 P Phosphorus [Ne] $3s^2 3p^3$	32.065 16 +6 +4 +2 −2 S Sulfer [Ne] $3s^2 3p^4$	35.453 17 +7 +5 +3 +1 −1 Cl Chlorine [Ne] $3s^2 3p^5$	39.948 18 Ar Argon [Ne] $3s^2 3p^6$
4	39.0983 19 +1 K Potassium [Ar] $4s^1$	40.078 20 +2 Ca Calcium [Ar] $4s^2$	44.95591 21 +3 Sc Scandium [Ar] $3d^1 4s^2$	47.867 22 +4 Ti Titanium [Ar] $3d^2 4s^2$	50.9415 23 +5 V Vanadium [Ar] $3d^3 4s^2$	51.9962 24 +6 +3 Cr Chromium [Ar] $3d^5 4s^1$	54.93804 25 +7 +4 +2 Mn Manganese [Ar] $3d^5 4s^2$	55.845 26 +3 +2 Fe Iron [Ar] $3d^6 4s^2$	58.93319 27 +3 +2 Co Cobalt [Ar] $3d^7 4s^2$	58.6934 28 +2 Ni Nickel [Ar] $3d^8 4s^2$	63.546 29 +2 Cu Copper [Ar] $3d^{10} 4s^1$	65.38 30 +2 Zn Zinc [Ar] $3d^{10} 4s^2$	69.723 31 +3 Ga Gallium [Ar] $3d^{10} 4s^2 4p^1$	72.64 32 +4 +2 −4 Ge Germanium [Ar] $3d^{10} 4s^2 4p^2$	74.92160 33 +5 +3 −3 As Arsenic [Ar] $3d^{10} 4s^2 4p^3$	78.96 34 +6 +4 +2 −2 Se Selenium [Ar] $3d^{10} 4s^2 4p^4$	79.904 35 +7 +5 +3 +1 −1 Br Bromine [Ar] $3d^{10} 4s^2 4p^5$	83.798 36 +2 Kr Krypton [Ar] $3d^{10} 4s^2 4p^6$
5	85.4678 37 +1 Rb Rubidium [Kr] $5s^1$	87.62 38 +2 Sr Strontium [Kr] $5s^2$	88.90585 39 +3 Y Yttrium [Kr] $4d^1 5s^2$	91.224 40 +4 Zr Zirconium [Kr] $4d^2 5s^2$	92.90638 41 +5 Nb Niobium [Kr] $4d^4 5s^1$	95.96 42 +6 +4 Mo Molybdenum [Kr] $4d^5 5s^1$	(98) 43 +7 +4 Tc Technetium [Kr] $4d^5 5s^2$	101.07 44 +4 +3 Ru Ruthenium [Kr] $4d^7 5s^1$	102.9055 45 +3 Rh Rhodium [Kr] $4d^8 5s^1$	106.42 46 +4 +2 Pd Palladium [Kr] $4d^{10}$	107.8682 47 +1 Ag Silver [Kr] $4d^{10} 5s^1$	112.441 48 +2 Cd Cadmium [Kr] $4d^{10} 5s^2$	114.818 49 +3 In Indium [Kr] $4d^{10} 5s^2 5p^1$	118.710 50 +4 +2 −4 Sn Tin [Kr] $4d^{10} 5s^2 5p^2$	121.760 51 +5 +3 −3 Sb Antimony [Kr] $4d^{10} 5s^2 5p^3$	127.60 52 +6 +4 +2 −2 Te Tellurium [Kr] $4d^{10} 5s^2 5p^4$	126.9044 53 +7 +5 +3 +1 −1 I Iodine [Kr] $4d^{10} 5s^2 5p^5$	131.293 54 +6 +4 +2 Xe Xenon [Kr] $4d^{10} 5s^2 5p^6$
6	132.9054 55 +1 Cs Cæsium [Xe] $6s^1$	137.327 56 +2 Ba Barium [Xe] $6s^2$	174.9668 71 +3 Lu Lutetium [Xe] $4f^{14} 5d^1 6s^2$	178.49 72 +4 Hf Hafnium [Xe] $4f^{14} 5d^2 6s^2$	180.9478 73 +5 Ta Tantalum [Xe] $4f^{14} 5d^3 6s^2$	183.84 74 +6 +4 W Tungsten [Xe] $4f^{14} 5d^4 6s^2$	186.207 75 +4 Re Rhenium [Xe] $4f^{14} 5d^5 6s^2$	190.23 76 +4 Os Osmium [Xe] $4f^{14} 5d^6 6s^2$	192.217 77 +4 +3 Ir Iridium [Xe] $4f^{14} 5d^7 6s^2$	195.084 78 +4 +2 Pt Platinum [Xe] $4f^{14} 5d^9 6s^1$	196.9665 79 +3 Au Gold [Xe] $4f^{14} 5d^{10} 6s^1$	200.59 80 +2 +1 Hg Mercury [Xe] $4f^{14} 5d^{10} 6s^2$	204.3833 81 +3 +1 Tl Thallium [Xe] $4f^{14} 5d^{10} 6s^2 6p^1$	207.2 82 +4 +2 Pb Lead [Xe] $4f^{14} 5d^{10} 6s^2 6p^2$	208.9804 83 +3 Bi Bismuth [Xe] $4f^{14} 5d^{10} 6s^2 6p^3$	(210) 84 +4 +2 −2 Po Polonium [Xe] $4f^{14} 5d^{10} 6s^2 6p^4$	(210) 85 +1 At Astatine [Xe] $4f^{14} 5d^{10} 6s^2 6p^5$	(220) 86 Rn Radon [Xe] $4f^{14} 5d^{10} 6s^2 6p^6$
7	(223) 87 +1 Fr Francium [Rn] $7s^1$	(226) 88 +2 Ra Radium [Rn] $7s^2$	(262) 103 +3 Lr Lawrencium [Rn] $5f^{14} 7s^2 7p^1$	(261) 104 +4 Rf Rutherfordium [Rn] $5f^{14} 6d^2 7s^2$	(262) 105 +5 Db Dubnium	(266) 106 +6 Sg Seaborgium	(264) 107 +7 Bh Bohrium	(277) 108 +8 Hs Hassium	(268) 109 Mt Meitnerium	(271) 110 Ds Darmstadium	(272) 111 Rg Roentgenium	(285) 112 Cn Copernicium	(284) 113 Uut Ununtrium	(289) 114 Uuq Ununquadium	(288) 115 Uup Ununpentium	(292) 116 Uuh Ununhexium	117 Uus Ununseptium	(294) 118 Uuo Ununoctium

Lanthanide Series	138.9054 57 +3 La Lanthanum [Xe] $5d^1 6s^2$	140.116 58 +4 +3 Ce Cerium [Xe] $4f^1 5d^1 6s^2$	140.9076 59 +3 Pr Praseodymium [Xe] $4f^3 6s^2$	144.242 60 +3 Nd Neodynium [Xe] $4f^4 6s^2$	(145) 61 +3 Pm Promethium [Xe] $4f^5 6s^2$	150.36 62 +3 Sm Samarium [Xe] $4f^6 6s^2$	151.964 63 +3 +2 Eu Europium [Xe] $4f^7 6s^2$	157.25 64 +3 Gd Gadolinium [Xe] $4f^7 5d^1 6s^2$	158.9253 65 +3 Tb Terbium [Xe] $4f^9 6s^2$	162.500 66 +3 Dy Dysprosium [Xe] $4f^{10} 6s^2$	164.9303 67 +3 Ho Holmium [Xe] $4f^{11} 6s^2$	167.259 68 +3 Er Erbium [Xe] $4f^{12} 6s^2$	168.9342 69 +3 Tm Thulium [Xe] $4f^{13} 6s^2$	173.054 70 +3 Yb Ytterbium [Xe] $4f^{14} 6s^2$
Actanide Series	(227) 89 +3 Ac Actinium [Rn] $6d^1 7s^2$	232.0380 90 +4 Th Thorium [Rn] $6d^2 7s^2$	231.0358 91 +5 Pa Protactinium [Rn] $5f^2 6d^1 7s^2$	238.0289 92 +6 U Uranium [Rn] $5f^3 6d^1 7s^2$	(237) 93 +5 Np Neptunium [Rn] $5f^4 6d^1 7s^2$	(244) 94 +4 Pu Plutonium [Rn] $5f^6 7s^2$	(243) 95 +3 Am Americium [Rn] $5f^7 7s^2$	(247) 96 +3 Cm Curium [Rn] $5f^7 6d^1 7s^2$	(247) 97 +3 Bk Berkelium [Rn] $5f^9 7s^2$	(251) 98 +3 Cf Californium [Rn] $5f^{10} 7s^2$	(252) 99 +3 Es Einsteinium [Rn] $5f^{11} 6s^2$	(257) 100 +3 Fm Fermium [Rn] $5f^{12} 7s^2$	(258) 101 +3 Md Mendelevium [Rn] $5f^{13} 7s^2$	(259) 102 +3 No Nobelium [Rn] $5f^{14} 7s^2$

radioactive elements have masses in parenthesis

Millimoles

The mole (symbol: mol) is the System International (SI) base unit that measures an amount of substance. One mole contains Avogadro's number (approximately 6.022×10^{23}) entities. A mole is much like "a dozen" in that both are absolute numbers (having no units) and can describe any type of elementary object, although the mole's use is usually limited to measurement of subatomic, atomic, and molecular structures. The goal is to acquire a sufficient quantity of a material to be able to measure it and since individual atoms and molecules are so small having an entire mole of a substance makes it easier to work with. Once you acquire a mole of a particular substance you may reference its atomic mass to know how much its mass in grams is. Let's look at carbon as an example:



A mole of carbon-12 (which has an atomic mass of 12) would have a mass of 12 g.

In medicine we tend to look at items in slightly smaller quantities, hence the need to measure some substances in millimoles (symbol: mMol). A mMol is one-one thousandth (1/1000) of a mole and mass would be measured in milligrams instead; therefore **1 mol = 1,000 mMol** and a mMol of carbon 12 would weigh 12 mg.

Let's look at an example problem with dibasic sodium phosphate (Na_2HPO_4).

Example:

> A patient needs an infusion with 15 mMol of dibasic sodium phosphate (Na_2HPO_4) in 150 mL of NS. How many milligrams of dibasic sodium phosphate do you need to make this infusion?
>
> Na = 23×2 = 46
> H = 1
> P = 31
> O = 16×4 = 64
>
> $46+1+31+64=132$ atomic mass units in a molecule of Na_2HPO_4.
>
> Therefore, a mMol of Na_2HPO_4 would have a mass of 146 mg. With that in mind the problem becomes pretty straight forward to solve from there.
>
> $\frac{15\text{ mMol}}{1} \times \frac{146\text{ mg}}{1\text{ mMol}}$ = **2190 mg of Na_2HPO_4**

Attempt the practice problem on the next page to verify you comprehension of this concept.

Practice Problem

A patient needs an infusion with 12 mMol of monobasic potassium phosphate (KH_2PO_4) in 150 mL of NS. How many milligrams of monobasic potassium phosphate do you need to make this infusion?

1,632 mg of monobasic potassium phosphate

MilliEquivalents

The equivalent (symbol: Eq or eq) is a measurement unit used in chemistry and the biological sciences such as pharmacy. It is a measure of a substance's ability to combine with other substances and is a comparison of an ion's charge in comparison to a mole of the product. As an example if you look at potassium on a periodic table you will find that it typically has an ionic charge of +1 when it binds to other ions. Therefore 1 mole of potassium would equal 1 equivalent of potassium. Likewise, if we look at oxygen it typically has a charge of -2 when it combines with other elements so 1 mole of oxygen equals 2 equivalents of oxygen.

Much like pharmacy typically looks at items in slightly smaller quantities than moles, you'll find that it also looks at quantities slightly smaller than Eq. Just like 1,000 mMol are equal to 1 mole, 1,000 milliequivalents (symbol: mEq or meq) are equal to 1 Eq. Therefore 1 mMol of potassium equals 1 mEq of potassium and 1 mMol of oxygen equals 2 mEq of oxygen. Before expanding on this concept, try a couple of practice problems.

Practice Problems

Determine how many mEq are in a millimole of each of the following elements.

1) 1 mMol H 2) 1 mMol Ca 3) 1 mMol Cl

1) 1 mEq H 2) 2 mEq Ca 3) 1 mEq Cl

Now, let's add a some steps to this concept using volume of a solution, mass of a compound, millimoles of that compound, and milliequivalents of a particular ion. Procede to the next page for examples of using these concepts.

Example:

1) If a patient required 4.2 g of sodium bicarbonate ($NaHCO_3$), how many mEq of sodium (Na) is the patient receiving?

   Na = 23
   H = 1
   C = 12
   O = 16×3 = 48

   $23+1+12+48=84$ is the atomic mass of $NaHCO_3$, therefore 1 mMol = 84 mg.

   Also, a mMol of $NaHCO_3$ contains 1 mMol of Na and 1 mMol of Na = 1 mEq, so you can solve the problem as follows:

   $$\frac{4.2\,\text{g}}{1} \times \frac{1000\,\text{mg}}{1\,\text{g}} \times \frac{1\,\text{mMol}}{84\,\text{mg}} \times \frac{1\,\text{mEq}}{1\,\text{mMol}} = \textbf{50 mEq of sodium}$$

2) How many mEq of sodium and how many mEq of chloride are in one liter of normal saline (0.9% w/v NaCl)?

   Na = 23
   Cl = 35.5

   23+35.5=58.5 is the atomic mass of NaCl, therefore 1 mMol = 58.5 mg.

   1 mMol Na = 1 mEq
   1 mMol Cl = 1 mEq

   $$\frac{1\,\text{L}}{1} \times \frac{1000\,\text{mL}}{1\,\text{L}} \times \frac{0.9\,\text{g}}{100\,\text{mL}} \times \frac{1000\,\text{mg}}{1\,\text{g}} \times \frac{1\,\text{mMol}}{58.5\,\text{mg}} \times \frac{1\,\text{mEq}}{1\text{mMol}} = 154\text{ mEq}$$

   154 mEq sodium
   154 mEq chloride

Now that you've seen a couple of example problems, attempt the following practice problems.

Practice Problem

1) How many mEq of calcium are in 111 mg of $Ca(OH)_2$.

2) How many mEq of sodium and how many mEq of chloride are in a 50 mL minibag of half-normal saline (0.45% w/v NaCl)?

1) 3 mEq Ca   2) 3.85 mEq Na & 3.85 mEq Cl

Millicurie

A curie (Ci) is a unit measuring the activity of radioactive isotopes and is named after french born scientists Pierre and Marie Curie whom did a significant quantity of early research on radioactive isotopes.

Nuclear pharmacy involves the preparation of radioactive materials that will be used to diagnose and treat specific diseases. Nuclear pharmacies typically work with weak radioactive isotopes and will commonly measure the activity level of the substances they are working with a smaller unit known as a millicurie (symbol: mc or mCi).

In nuclear pharmacy, radioactive isotopes with relatively short half-lives are typically used in order to limit a patient's exposure. This also creates an added challenge for those actually preparing the kits as they need to know not just what the activity level is when they are preparing it, but that it will have the correct activity level when given to the patient. While software exists to help pharmacy personnel perform these calculations, it is a good idea to understand the formula being used. The following is the exponential decay formula:

$$a_t = a_0 e^{-\lambda t}$$

a_t = quantity at end of time(t)
a_0 = quantity at beginning of time(t)
e = the value of base e from a natural logarithm (2.71828...)
λ = the exponential decay constant for a particular substance
t = time

Some common values for lambda (λ) when time (t) is provided in hours would include:

Technetium-99m (^{99m}Tc) = 0.11514
Iodine-131 (^{131}I) = 0.00359
Thalium-201 (^{201}Tl) = 0.00950

Example:

A common request for a stress test is to take a drug called sestamibi and reconstitute it with either technetium-99m or thalium-201 as the sestamibi is drawn to the heart and then the isotope helps it to show up for imaging. If a physician requests a dose of sestamibi with 10 millicuries of ^{99m}Tc for 0900 how many mCi would you need if you were drawing this dose up at 0100?

a_t = 10 mCi
a_0 = quantity at beginning of time, this is what you are solving for.
e = 2.71828...
λ = 0.11514
t = 8 hours

$$10\,\mathrm{mCi} = a_0 e^{-0.11514 \times 8}$$

$$\frac{10\,\mathrm{mCi}}{e^{-0.11514 \times 8}} = a_0$$

$$a_0 = \mathbf{25.1\,mCi}$$

Now that you know you need 25.1 mCi of ^{99m}Tc you find that your stock bottle has an activity level of 57.9 mCi/mL when you are ready to draw it up how many mL would you add to the sestamibi vial?

$$\frac{25.1\,\mathrm{mCi}}{1} \times \frac{\mathrm{mL}}{57.9\,\mathrm{mCi}} = \mathbf{0.43\,mL}$$

Practice Problem:

A physician requests a dose of tetrofosmin with 30 millicuries of ^{99m}Tc for 1100. How many mCi would you need if you were also drawing this dose up at 0100? If your stock bottle has an activity level of 57.9 mCi/mL when you are ready to draw it up how many mL would you add to the tetrofosmin?

94.9 mCi and 1.64 mL

International Units

In pharmacology, the International unit (IU, alternatively abbreviated UI, from French unit internationale) is a unit of measurement for the amount of a substance, based on measured biological activity (or effect). It is used for vitamins, hormones, some drugs, vaccines, blood products and similar biologically active substances. Despite its name, the IU is not part of the International System of Units used in physics and chemistry.

The precise definition of one IU differs from substance to substance and is established by international agreement. To define an IU of a substance, the Committee on Biological Standardization of the World Health Organization provides a reference preparation of the substance, (arbitrarily) sets the number of IUs contained in that preparation, and specifies a biological procedure to compare other preparations to the reference preparation. The goal here is that different preparations with the same biological effect will contain the same number of IUs.

For some substances, the equivalent mass of one IU is later established, and the IU is then officially abandoned for that substance. However, the unit often remains in use nevertheless, because it is convenient. For example, Vitamin E exists in a number of different forms, all having different biological activities. Rather than specifying the precise type and mass of vitamin E in a preparation, for the purposes of pharmacology it is sufficient to simply specify the number of IUs of vitamin E.

Below are examples mass equivalents of 1 IU for selected substances:

> 1 IU Insulin: the biological equivalent of about 45.5 mcg pure crystalline insulin (1/22 mg exactly)
> 1 IU Vitamin A: the biological equivalent of 0.3 mcg retinol, or of 0.6 μg beta-carotene
> 1 IU Vitamin C: 50 mcg L-ascorbic acid
> 1 IU Vitamin D: the biological equivalent of 0.025 mcg cholecalciferol/ergocalciferol
> 1 IU Vitamin E: the biological equivalent of about 0.667 mg d-alpha-tocopherol (2/3 mg exactly), or of 1 mg of dl-alpha-tocopherol acetate

Example:

A vial of insulin with 1000 units of insulin contains how many actual mg of insulin?

$$\frac{1000\text{ units}}{1}\times\frac{45.5\text{ mcg}}{1\text{ unit}}\times\frac{1\text{ mg}}{1000\text{ mcg}}=\mathbf{45.5\,mg}$$

Practice Problem:

A vitamin E softgel capsule contains 500 IU of d-alpha-tocopherol and 500 IU of dl-alpha-tocopherol acetate. How many milligrams of each are in the capsule?

333 mg of d-alpha-tocopherol and 500 mg of dl-alpha-tocopherol acetate

Worksheet 17-1

Name:

Date:

Solve the following problems.

1) Determine how many of each type of atom are present in the following molecules:

   a) Calcium gluconate - $C_{12}H_{22}CaO_{14}$

   b) Monobasic sodium phosphate - NaH_2PO_4

   c) Potassium acetate - CH_3CO_2K

   d) Ethanol - C_2H_5OH

2) A patient needs an infusion with 7.5 mMol of monobasic potassium phosphate (KH_2PO_4) and 7.5 mMol of dibasic potassium phosphate (K_2HPO_4) in 150 mL of NS.

   a) How many mg monobasic potassium phosphate (KH_2PO_4) of are in the infusion?

   b) How many mg monobasic potassium phosphate (KH_2PO_4) of are in the infusion?

3) If a gram of calcium gluconate ($C_{12}H_{22}CaO_{14}$) was added to an IV bag:

   a) How many mMol of calcium gluconate ($C_{12}H_{22}CaO_{14}$) were added to the IV bag?

   b) How many mEq of calcium were added to the IV bag? (Calcium has a charge of +2)

4) A 10 mL potassium chloride (KCl) vial has a concentration of 2 mEq of potassium/mL. How many mg of KCl are in the vial?

5) A physician requests a dose of tetrofosmin with 30 millicuries of ^{201}Tl for 1100.

   a) How many mCi would you need if you were also drawing this dose up at 0100?

   b) If your stock bottle has an activity level of 59.7 mCi/mL when you are ready to draw it up, how many mL would you add to the tetrofosmin vial?

6) Whenever dealing with radioactive iodine nuclear pharmacy typically measures the activity level with Grays (Gy) instead of millicuries, but all the calculations are still done the same way. If a patient with thyroid cancer required a capsule of ^{131}I with a activity level of 150 Gy 72 hours from now, what should the activity level be when preparing the capsule?

7) A vitamin D-400 tablet contain 400 IU of cholecalciferol. How many mcg of cholecalciferol are in the tablet?

8) A particular vitamin C (ascorbic acid) injection has a concentration of 500 mg/mL. How many IU are in 1 mL of this ascorbic acid preparation?