Marine Chemistry 12.742

Problem Set #1

Show calculations for all work

Problem 1:
Two elements, X1 (atomic mass=198.23) and X2 (atomic mass=172.33) have recently been discovered. As an aspiring, free-thinking graduate student, your advisor has ordered you to study the nature of these elements in the ocean. After years of working out your analytical techniques and making hundreds of field measurements, you are able to compile the following information:

	Mean Conc.		**Oceanic Sources**		**Residence Time**
Element	**Seawater**	**Rivers**	**Dry and Wet Deposition**	**Hydrother-mal Vents**	
X1	15.0 fmol/kg	11.5 pmol/kg	13.7 Mg/y	2.40 nmol/kg	
X2	3.82 pmol/kg	961 pptr	45.7 Gg/y		10 y

Use a river freshwater discharge of 1.2×10^6 m^3/s, an annual flux of fluid from hydrothermal vents of 70×10^9 m^3/y, an ocean volume of 1.35×10^9 km^3, and a mean seawater density of 1025 kg/m^3. Assuming steady-state (sources=sinks), fill in the two blank areas in the table.

Problem 2:
Consider the following chemical equation for the remineralization of generic marine organic matter.

$$\mathbf{(CH_2O)_{80}(CH_2)_{42}(NH_3)_{16}H_3PO_4} + 175\mathbf{O_2} \text{ ----> } 122\mathbf{CO_2} + 16\mathbf{HNO_3} + 138\mathbf{H_2O} + \mathbf{H_3PO_4}$$

" Redfield molecule"

a.) What is the molecular weight of the Redfield molecule?
b.) What is the molar ratio of carbon:nitrogen:phosphorus in the Redfield molecule (this is called the Redfield Ratio) ?
c.) If you have 30 mg of Redfield molecule, how many μmoles of O_2 are needed to complete this reaction.
d.) If you have 190 moles of Redfield molecule and 15 moles of O_2, which is the limiting reagent?

Problem 3:
Si isotopes have been used as paleoproxies for surface nutrient utilization. Given the following table of data:

a) Estimate the current mean $\delta^{30}Si$ value of silicic acid in seawater.

b) Plot the temporal evolution of mean ocean $\delta^{30}Si$ value if the $^{30}Si/^{28}Si$ of input Si were to change to 0.0335800 in a step function.

Si input to ocean: $7x10^{12}$ mol/yr
Mean silicic acid concentration: 70 μM
$^{30}Si/^{28}Si$ of standard (NBS-28): 0.0335320
$^{30}Si/^{28}Si$ of input Si: 0.0335589
fractionation factor for removal α=1.0015

Problem 4:
Measuring the concentration and isotopic composition of nitrate in the upper water column gives:

Depth (m)	[NO3] (μM)	$\delta^{15}N$ (per mille)
0	25	7
25	24.5	6.8
50	28	6.2
100	31	5.5
300	34.5	4.9
500	35	4.8
700	35	4.7
1000	34.5	4.75

a) Assuming that nitrate is supplied to the euphotic zone only by vertical upwelling from below 300m, estimate the fractionation factor (α) during nitrate uptake by phytoplankton. (Hint: assume Rayleigh fractionation for a closed system)

b) What would the $\delta^{15}N$ of surface nitrate be, if its concentration were reduced to 5μM by phytoplankton?