Final Exam Calculations for IPOL 512 Fall 2012

The complete list of possible calculations will provide the best review (http://institutebishop.org/IPOL_512_Fall_2012_Exam_Calc.pdf), but you might emphasize the following calculations for the final exam.

1. Do unit conversions for the following types of unit conversions
   a. Percentages as conversion factors
   b. Use molar mass to convert between moles and mass
   c. Mass biomass ↔ mass carbon in that biomass (about 0.4 g C per g biomass)
   d. kg biomass ↔ MJ (16 MJ per kg biomass)
   e. g C in biomass ↔ kJ (40 kJ per g carbon in biomass)
   f. From one energy unit to another
      J ↔ cal ↔ Btu ↔ kWh ↔ quad
   g. Mass ratio ↔ ppm(mass) or ppm(w)
   h. Volume ratio ↔ ppm(v)
2. Given two of the following three values, calculate the third: energy, power, and time.
3. Calculate stocks for the following situations.
   a. Steady State
      $S(t) = S_0 = Ft$
   b. $F_{in} - F_{out}$ = constant
      $S(t) = S_0 + \Delta Ft$
   c. Exponential Growth of Stocks
      $S(t) = S_0 e^{rt}$
   d. Exponential decline (decay) of Stocks
      $S(t) = S_0 e^{-rt}$
   e. Exponential growth of outflows
      $$S(t) = S_0 - \frac{F_0}{r}(e^{rt} - 1)$$
4. Calculate doubling time for exponential growth.
5. Calculate the half-life for exponential decay.
6. Use box diagrams to organize calculations. (See problems 5 and 6 of homework 4.)

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7. Do unit analysis calculations using the average density of coal use in the U.S. (100 t/km^2/y), the average percent sulfur in coal (2.5%), the emission density of sulfur from coal (2.5 g(S)/m^2/y), the emission of sulfur from coal deposited as H_2SO_4 (0.6 g(S)/m^2/y), the emission density of nitrogen in nitrogen oxides (1.5 g(N)/m^2/y), and the wet deposition as nitrogen as nitric acid (0.23 g(N)/m^2/y).
8. Calculate the [H^+] and pH of precipitation containing 0.6 g(S)/m^2/y deposited as H_2SO_4 in the ≈1 m/y of precipitation.
9. Calculate the [H^+] and pH of the rain if 0.23 g(N)/m^2/y are deposited as HNO_3 in ≈1 m/y of precipitation.

10. Calculate the [H+] and pH of the rain if 0.23 g(N)/m^2/y are deposited as HNO_3 and 0.6 g(S)/m^2/y are deposited as H_2SO_4 in ≈1 m/y of precipitation.
11. Given two of the following three values, calculate the third: the concentration of the solute in mol/L, the partial pressure of the solute in the gas above the solution, Henry's constant for a gas/solvent combination.
12. Do calculation using the following equations.

$$[H^+][OH^-] = 1.0 \times 10^{-14}$$

$$[CO_2] = P_{CO_2}\ (0.03400\ \text{mol/L}\cdot\text{atm}) = 1.34 \times 10^{-5}\ \text{mol/L} = [H_2CO_3^*]$$

$$K_{a1} = \frac{[H^+][HCO_3^-]}{[H_2CO_3^*]} = 4.6 \times 10^{-7}$$

$$K_{a2} = \frac{[H^+][CO_3^{2-}]}{[HCO_3^-]} = 4.69 \times 10^{-11}$$

$$[H^+] = [OH^-] + [HCO_3^-] + 2[CO_3^{2-}]$$

13. Using the equations above, calculate the pH of natural water.
14. Do calculations using the solubility product of calcium carbonate.

    $CaCO_3(s) \rightleftharpoons Ca^{2+}(aq) + CO_3^{2-}(aq)$

    $K_{sp} = [Ca^{+2}]\ [CO_3^{-2}] = 4.47\times10^{-9}$ mole^2/liter^2 in fresh H_2O
15. Given either the half-life or the decay constant for a radioactive nuclide, calculate the other.
16. Given all but one of the following, calculate the one not given: the amount of a radioactive substance initially (S_0), the amount at time t (S_t), the time (t), and the decay constant (k).
17. Given two of the following three, calculate the third: physical dose of a radioactive substance (in rads or grays), the relative biological effectiveness of the radiation, and the biological dose (in rems or Sieverts).
18. Given the radiation exposure in biological dose per time (e.g. mSv/h) and time of exposure, calculate the approximate increase in risk of cancer.

Student Topic

Energy Balance Models

1. At present the emission temperature of the Earth is 255 K, and its albedo is 30%. How would the emission temperature change if:

   (a) the albedo were reduced to 10% (and all else were held fixed);

   (b) the infrared absorptivity of the atmosphere — ϵ in Fig.2.8 — were doubled, but albedo remains fixed at 30%.

2. Suppose that the Earth is, after all, flat. Specifically, consider it to be a thin circular disk (of radius 6370 km), orbiting the Sun at the same distance as the Earth; the planetary albedo is 30%. The vector normal to one face of this disk always points directly towards the Sun, and the disk is made of perfectly conducting material, so both faces of the disk are at the same temperature. Calculate the emission temperature of this disk, and compare with Eq.(2.4) for a spherical Earth.

Global Warming Potential

Given the mass of a greenhouse and its GWP value, calculate the CO_2 equivalent emissions of the gas.