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ES476/576 Hydrology
Review Problems: Physical Properties of Water

Show all of your math work and unit algebra below. Draw a sketch where required.

1. Determine the following pressure equivalents:
   a. Average atmospheric pressure at the Earth's surface is 1013 millibars (mb) (weight of a column of air pressing down on you; determine the pressure equivalent in:

      psi 14.69 $1.013\,bar \cdot \frac{14.5\,psi}{bar}$

      bar 1.013 $1013\,mb \cdot \frac{bar}{1000\,mb}$

      Pa 101300 $1.013\,bar \cdot \frac{100\,kPa}{bar} \cdot \frac{1000\,Pa}{kPa}$

      kPa 101.3

   b. At the deepest depths of the ocean along the Mariana trench, hydrostatic pressure is approximately 1086 bars; determine the pressure equivalent in

      psi 15747 $1086\,bar \cdot \frac{14.5\,psi}{bar}$

      mb 1.086×10^6 $1086\,bar \cdot \frac{1000\,mb}{bar}$

      Pa 1.086×10^8 $1086\,bar \cdot \frac{100\,kPa}{bar} \cdot \frac{1000\,Pa}{bar}$

      kPa 108600

   c. The base of the Earth's continental crust is at a depth of approximatly 10 km, with a lithostatic pressure equivalent of 10 Kb (kilobars); determing the pressure equivalent in

      psi 145000 $10\,Kb \cdot \frac{1000\,bar}{Kb} \cdot \frac{14.5\,psi}{bar}$

      mb 1.0×10^7 $10000\,bar \cdot \frac{1000\,mb}{bar}$

      Pa 1.0×10^9 $10000\,bar \cdot \frac{100\,kPa}{bar} \cdot \frac{1000\,Pa}{kPa}$

      kPa 1.0×10^6

2. The following is a listing of the average densities of the atmosphere, hydrosphere and lithosphere: D_{air} = 0.001225 g/cm³ D_{water} = 1 g/ cm³ D_{rock} = 2.7 g/ cm³

   Calculate the following density equivalents:

   D_{air}= 1.225 kg/ m³ $0.001225\,\frac{g}{cm^3} \cdot \frac{kg}{1000\,g} \cdot \frac{100^3\,cm}{m^3}$

   D_{water} = 1000 kg/ m³ $1 \cdot \frac{kg}{1000\,g} \cdot \frac{100^3\,cm}{m^3}$

   D_{rock} = 2700 kg/ m³ $2.7 \cdot \frac{kg}{1000\,g} \cdot \frac{100^3\,cm}{m^3}$

   Calculate the following weight density equivalents (aka specific weight):

   D_{air}= 12.005 N/ m³ $1.225\,\frac{kg}{m^3} \cdot 9.8\,m/s^2$

   D_{water} = 9800 N/ m³ $1000\,\frac{kg}{m^3} \cdot 9.8\,m/s^2$

   D_{rock} = 26460 N/ m³ $2700\,\frac{kg}{m^3} \cdot 9.8\,m/s^2$

3. Average ocean salinity is approximately a 3.5% solution of dissolved salts and ions (Cl, Na, Mg, Ca). Given that the density of water is 1 g/cm^3, and that 1 cm^3 = 1 ml in volume equivalents, determine the density of water in Kg/L.

D_{water} = 1 kg/ L $\quad 1 g/cm^3 \cdot \frac{kg}{1000g} \cdot \frac{1cm^3}{mL} \cdot \frac{1000mL}{L}$

a. What is the percent concentration of a salt solution in which 1 kg of salt is dissolved in 1 L of water (%concentration = mass of solute / mass of solvent x 100%).

$1 kg/L \cdot 1L = 1 kg$ water $\quad \frac{1 \text{ kg salt}}{1 \text{ kg water}} \cdot 100 = \boxed{100\%}$

b. Determine the following concentrations of a saline solution in which 5 g of salt is dissolve in 1 liter of water:

ppt 5

ppm 5000

ppb 5×10^6

$1L \cdot 1 kg/L = 1 kg$ water $\quad 5g \cdot \frac{kg}{1000g} = 0.005$ kg salt $\quad \frac{0.005 kg}{1 kg} \cdot 100 = 0.5\%$

$\frac{0.5 \text{ parts}}{100} \cdot \frac{1000}{1}$; $\frac{0.5 pts}{100} \cdot \frac{1\times10^6}{1}$; $\frac{0.5 pts}{100} \cdot \frac{1\times10^9}{1}$

4. A storage tank holds 500,000 gallons of water with an input of 50 cfs and output of 73 cfs. Determine the following:

i. Inflow 22440 gpm
ii. Outflow 2.067×10^6 cms
iii. Change in storage flux per unit time 23 cfs
iv. How much water is gained or lost from the storage tank after 1.3 hours?

805147 gallons
107640 cubic feet
3.050×10^6 kg

$50 \frac{ft^3}{s} \cdot \frac{7.48 gal}{ft^3} \cdot \frac{60 s}{min}$

$73 \frac{ft^3}{s} \cdot \frac{m^3}{35.31 ft^3} \cdot \frac{100^3 cm}{m^3}$

$73 - 50 = 23 \frac{ft^3}{s} \cdot \frac{3600 s}{hr} \cdot 1.3 hr = 107640 ft^3 \cdot \frac{7.48 gal}{ft^3} = 805147 gal$

$1 kg/L \cdot 805147 gal \cdot \frac{L}{0.264 gal} = 3.050\times10^6 kg$