### 1. Water in air (4 points; 1 each)

The data below describe a parcel of air. Answer the following questions using these data.
(a) What is the molar concentration of water vapor? (units: mol/m$^3$)
(b) What is the mole fraction of water vapor in the air? (units: —)
(c) What is the partial pressure of water vapor? (units: atm or Pa)
(d) What is the relative humidity? (units: — or %)

*Data:*

| | |
|---|---|
| $C_{H2O} = 4$ g m$^{-3}$ | mass concentration of water vapor in air |
| $T = 298$ K | air temperature |
| $P = 1$ atm $= 1.01325 \times 10^5$ Pa | air pressure |
| $P_{sat} = 3167$ Pa | (saturation) vapor pressure of water at 298 K |

### 2. Balancing a redox reaction (4 points)

Hypochlorous acid (HOCl) is used to disinfect drinking water. When HOCl is applied to water as a disinfectant, some of it is consumed rapidly because it oxidizes chemical impurities in the water. Write a balanced redox reaction for the oxidation of aqueous hydrogen sulfide ($H_2S$) to sulfate ($SO_4^{2-}$) by chlorine in hypochlorous acid (HOCl) being converted to chloride ($Cl^-$).

### 3. Kinetics in a batch reactor (4 points; 2 each)

Consider a batch reactor in which the following reaction occurs:

$$A + B \rightarrow \text{products} \qquad R = k\,[A] \qquad k = 0.15\ d^{-1}$$

At time t = 0, the concentrations in the reactor are [A](0) = 5 mM and [B](0) = 10 mM.
(a) What is [A] at t = 3 days?
(b) What is [B] at t = 3 days?

### 4. Naphthalene: No NAPL (4 points)

A sealed container contains liquid water and air. A quantity of *M* moles of naphthalene ($C_{10}H_8$, MW = 128 g/mol) is injected into container. Consider the equilibrium partitioning of naphthalene among its possible phases. If *M* is small, then the naphthalene will partition into two states: gas phase and aqueous phase. If *M* is large, then the naphthalene will be in three states: gas phase, aqueous phase, plus a nonaqueous phase liquid (NAPL). Given the data below, determine the *maximum* value of *M* that can be added to the container such that there is *no* NAPL of naphthalene in the system.

*Data:*

| | |
|---|---|
| $K_H = 2.3$ M atm$^{-1}$ | Henry's law constant for naphthalene |
| $P_{sat} = 10.6$ Pa | (saturation) vapor pressure of naphthalene |
| $C_{sat} = 31$ mg/L | water solubility of naphthalene |
| $T = 298$ K | temperature |
| $V_a = 30$ L $= 0.03$ m$^3$ | volume of air in the container |
| $V_w = 2$ L | volume of liquid water in the container |

### 5. Settling flux (4 points)

A cubical chamber is filled with 1 m$^3$ of water. To this is added 10 g of particulate matter. The particles are spherical and all have the same diameter and density so that they settle at a uniform velocity, $v_t = 5$ m h$^{-1}$. At time $t = 0$, the particle concentration is uniform throughout the chamber and the water is motionless. Consider a position that is slightly above the bottom of the chamber. Sketch a plot that shows the particle flux (y-axis) at this position as a function of time (x-axis). Be sure to label your coordinate axes and to indicate the proper numerical values off the flux and time scale.