

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

The data below describe a parcel of air. Answer the following questions using these data.

- What is the molar concentration of water vapor? (units: mol/m³)
- What is the mole fraction of water vapor in the air? (units: —)
- What is the partial pressure of water vapor? (units: atm or Pa)
- What is the relative humidity? (units: — or %)

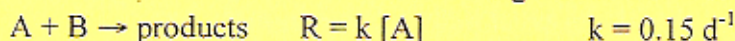
Data: $C_{\text{H}_2\text{O}} = 4 \text{ g m}^{-3}$ mass concentration of water vapor in air
 $T = 298 \text{ K}$ air temperature
 $P = 1 \text{ atm} = 1.01325 \times 10^5 \text{ Pa}$ air pressure
 $P_{\text{sat}} = 3167 \text{ Pa}$ (saturation) vapor pressure of water at 298 K

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 (H₂S) to sulfate (SO₄²⁻) 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:



At time $t = 0$, the concentrations in the reactor are $[A](0) = 5 \text{ mM}$ and $[B](0) = 10 \text{ mM}$.

- What is $[A]$ at $t = 3$ days?
- 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 (C₁₀H₈, 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:

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

5. Settling flux (4 points)

A cubical chamber is filled with 1 m³ 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, $v_t = 5 \text{ m h}^{-1}$. 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.