1. The phosphorous concentration in Brannen Lake was measured to be **0.14 ppm P**. Convert this to μmol L^{-1} of total phosphate. What additional information is required to calculate the concentration of the phosphate ion? Explain. [4]

2. Define and state the environmental significance of **THREE** of the following. [6]

a) chelation

b) thermal pollution

c) residence time

d) polyphosphates

3. Provide balanced chemical equations to illustrate **TWO** of the following. [4]

a) reduction of $\mathbf{SO_4^{2-}}$ to $\mathbf{HS^-}$

b) dissolution of $\mathbf{CaCO_3}$ in the presence of aqueous carbon dioxide

c) aquatic photosynthesis in the presence of $\mathbf{Ca^{2+}}$
(use $\{CH_2O\}$ to represent carbohydrate biomass)

4. Use the attached pe-pH diagrams to answer the following. [4]

a) Estimate the value of K_a for $\mathbf{HCrO_4^-}$

b) Predict the dominant form/s of arsenic, chromium and lead for acid mine drainage water (pH < 4, pe > 10)

c) Predict the dominant form/s of lead in highly productive photosynthetic marine water

d) Predict the dominant form/s of arsenic in slightly acidic groundwaters, where methane gas in known to exist

5. Using the value of K_a for hydrofluoric acid (**HF**), sketch a labelled diagram for the speciation of **HF** as a function of pH. Derive an expression for the fractional abundance for **HF** (α_{HF}) in terms of [$\mathbf{H^+}$] and K_a. [5]

6. A water sample with a pH 7.0 was analyzed for ammonium ion ($\mathbf{NH_4^+}$) and found to contain **0.5 mmol/L**. If the pe of this water is estimated to be 4, predict the concentration of concentration of $\mathbf{NO_3^-}$. [4]

7. Hydrogen sulfide (H_2S) is considerably more toxic to fish than either $\mathbf{HS^-}$ or $\mathbf{S^{2-}}$. If concentrations greater than **5 μM $\mathbf{H_2S}$** are harmful to fish health, calculate the minimum safe pH when the total sulfide concentration is **20 μM**? [4]

8. A water sample has a measured pH of **8.0** and a total alkalinity reported to be **80 mg $\mathbf{CaCO_3}$/L**. Determine the molar concentration of $\mathbf{HCO_3^-}$, $\mathbf{CO_3^{2-}}$ and $\mathbf{OH^-}$. [4]

9. The pe-pH diagram for selenium is given below.
a) Add the boundary lines for the oxidation and reduction of **$\mathbf{H_2O}$,** respectively (i.e., stability region). [2]

b) Calculate the **slope** of the boundary between $\mathbf{HSeO_4^-}$ and $\mathbf{H_2SeO_3}$. [4]
(hint; $pe = pe^o - m\ pH$ is in the form of $y = m\ x + b$ where m represents the slope.)

10. Briefly describe the difference between **TWO** of the following. [4]

a) COD versus BOD

b) pH vs alkalinity

c) pe^o versus $pe^o(w)$

pe – pH for selenium

pe – pH for chromium, lead, and arsenic

pe – pH for carbon, sulfur, nitrogen, iron

pH for H_2S, H_2CO_3, H_3PO_4

get Gof for selenium species