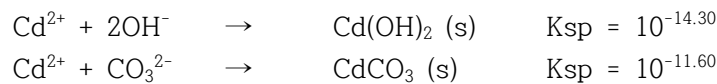# Soil and Groundwater Pollution

1. **(10)** Explain that 'the mobility of Cd is closely related to the surrounding pH' using the following chemical reactions.

$$Cd^{2+} + 2OH^- \rightarrow Cd(OH)_2 \text{ (s)} \qquad Ksp = 10^{-14.30}$$
$$Cd^{2+} + CO_3^{2-} \rightarrow CdCO_3 \text{ (s)} \qquad Ksp = 10^{-11.60}$$

2. **(10)** Give four major terminal electron acceptors (TEA), and explain the oxygen is the most preferred one for bacterial biodegradation in soil. During the aerobic biodegradation of benzene, what is the key metabolite before ring fission occurs?

3. **(10)** Describe Fenton's reaction briefly. Also, determine which is reactive to the reaction between benzene ($C6H6$) and carbon tetrachloride ($CCl4$). Why?

4. **(10)** Construct an equation to calculate soil saturation concentration of an organic compound using chemical properties (water solubility, Henry's constant), sorption coefficient (K_d) and soil properties such as dry bulk density (ρ_b), water-filled soil porosity (θ_w), air-filled soil porosity (θ_a). Be sure to include the unit of each term.

5. **(10)** If you want to treat As and Cr in groundwater by using the following means, what would be your strategies?
   (1) Toxicity reduction
   (2) Physical removal

6. **(10)** Explain the volatilization of methanol and DDT using Henry's law

	methanol	DDT
water solubility (mg/L)	miscible	0.0024
vapor pressure (mmHg)	127	1.9×10^{-7}

7. **(10)** Assuming that the contaminants in the Table below are released into a soil with pH 7 and are to be "**adsorbed**" only, which chemical would be the most

severly **"adsorbed"**? Give your rationale.

Contaminants	pKa
pentachlorophenol	4.75
2,4,6-trichlorophenol	6.15
aniline	9.37
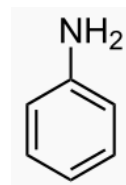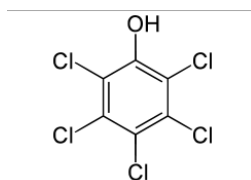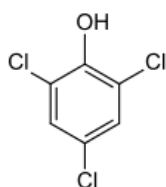
(mm Hg)

8. **(10)** Read the following sentences, and give your answer and rationale for the decision by incorporating "risk" and "exposure".

> Consider two contaminated sites, A and B. Site A is a pesticide formulation area that is characterized by 500 gallons of spillage of the insecticide malathion over 10 years. The soil is a silty loam high in natural organic matter, and the depth to ground water is 45 ft. Site B is a soil pit behind a dry cleaner that received 50 gallons of the waste solvent perchloroethylene over 2 years. The surface soil is a sandy loam containing low organic matter, and the depth to ground water is 45 ft.

9. **(10)** Assume that you isolated a bacterium from soil, and observed the following results in the laboratory.

> a) on contaminant X -------> growth observed
> b) on contaminant Y -------> no growth
> c) on contaminants X and Y --> growth observed/ a metabolite Y' accumulated

(1) If you apply the compounds X and Y into a field soil (i.e., natural environment where diverse microbial activities are present) you may not be able to observe the accumulation of the metabolite Y'. Why?
(2) Give an example of typical pollutants you can observe the above phenomenon.

10. **(10)** Draw hypothetical Freundlich isotherm graphs when benzene is sorbed to (a) a soil with an organic carbon content of 15% and (b) a soil with 80% sand.

11. **(10)** Explain the transport model including advection and dispersion in porous media. If transformation occurs what would happen? Describe the difference by using breakthrough curves.

12. **(10)** Define Darcy velocity and show how it is different from porewater (seepage) velocity in porous media.

13. (10) Briefly explain the soil washing, and discuss the factors that affect the washing efficiency in terms of <u>particle size, type of contaminant, and washing agent.</u>

14. **(4 each)** Briefly explain the following terms.
(1) retardation factor
(2) K_d and K_{oc}
(3) reductive dechlorination of TCE
(4) pseudo-first order reaction
(5) cation exchange capacity (CEC)