



# WATER CHEMISTRY

Hydrogeology Engineer MSc

2023/24 Semester II.

COURSE COMMUNICATION FOLDER

**University of Miskolc**  
**Faculty of Earth and Environmental Science and Engineering**  
**Institute of Water Resources and Environmental Management**

## Table of contents

|   |   |
|---|---|
| 1. Course introduction, teacher, number of lessons, credits ..... | 3 |
| 2. Course syllabus .....  | 4 |
| 3. Example Test .....   | 5 |

## 1. Course introduction, teacher, number of lessons, credits

| <b>Course Title:</b> Water chemistry   | <b>Code:</b> MFKHT726005   |            |      |       |      |         |       |          |               |          |          |          |                  |          |          |         |            |
|--|--|------------|------|-------|------|---------|-------|----------|---------------|----------|----------|----------|------------------|----------|----------|---------|------------|
| <b>Instructor:</b> Dr. Márton Tóth, assistant professor  | <b>Responsible department/institute:</b> Institute of Water Resources and Environmental Management |            |      |       |      |         |       |          |               |          |          |          |                  |          |          |         |            |
|  | Type of course: Compulsory   |            |      |       |      |         |       |          |               |          |          |          |                  |          |          |         |            |
| <b>Position in curriculum (which semester):</b> 2  | <b>Pre-requisites (if any):</b>  |            |      |       |      |         |       |          |               |          |          |          |                  |          |          |         |            |
| <b>No. of contact hours per week (lecture + seminar):</b> 1+1  | <b>Type of Assessment (examination/ practical mark / other):</b> practice mark                     |            |      |       |      |         |       |          |               |          |          |          |                  |          |          |         |            |
| <b>Credits:</b> 2  | <b>Course:</b> full time   |            |      |       |      |         |       |          |               |          |          |          |                  |          |          |         |            |
| <p><b>Course Description:</b><br/>The students will be familiar with the structure and chemical properties and reactivity of water molecule, and will learn about the main principle of the equilibriums exist in aquatic system.</p> <p><b>The short curriculum of the subject:</b><br/>Physical and chemical properties of water. The state diagram of water. Properties of ice, liquid water and steam. Supercritical state of water. The chemical structure of water molecule and its consequences. Behavior of water as a solvent. Dissolution process of gases, liquids and solids in water. Behavior of water as a chemical partner. Acid base equilibria, hydrolysis, complex formation and redox reactions. Isotopic, and chemical compositions of different waters. The main characteristic parameters used for description of water quality.</p> <p><b>Competencies to evolve:</b><br/>Knowledge: T1, T2, T6, T7, T8<br/>Ability: K1, K6, K9, K10, K11, K12, K15<br/>Attitude: A2, A5<br/>Autonomy and responsibility: F2, F5, F6</p> |  |            |      |       |      |         |       |          |               |          |          |          |                  |          |          |         |            |
| <p><b>Assessment and grading:</b><br/>Students will be assessed with using the following elements.</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 60%;">Final exam</td> <td style="text-align: right;">100%</td> </tr> <tr> <td>Total</td> <td style="text-align: right;">100%</td> </tr> </table> <p>Grading scale:</p> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">% value</th> <th style="text-align: left;">Grade</th> </tr> </thead> <tbody> <tr> <td>90 -100%</td> <td>5 (excellent)</td> </tr> <tr> <td>80 – 89%</td> <td>4 (good)</td> </tr> <tr> <td>70 - 79%</td> <td>3 (satisfactory)</td> </tr> <tr> <td>60 - 69%</td> <td>2 (pass)</td> </tr> <tr> <td>0 - 59%</td> <td>1 (failed)</td> </tr> </tbody> </table>  |  | Final exam | 100% | Total | 100% | % value | Grade | 90 -100% | 5 (excellent) | 80 – 89% | 4 (good) | 70 - 79% | 3 (satisfactory) | 60 - 69% | 2 (pass) | 0 - 59% | 1 (failed) |
| Final exam   | 100%   |            |      |       |      |         |       |          |               |          |          |          |                  |          |          |         |            |
| Total  | 100%   |            |      |       |      |         |       |          |               |          |          |          |                  |          |          |         |            |
| % value  | Grade  |            |      |       |      |         |       |          |               |          |          |          |                  |          |          |         |            |
| 90 -100%   | 5 (excellent)  |            |      |       |      |         |       |          |               |          |          |          |                  |          |          |         |            |
| 80 – 89%   | 4 (good)   |            |      |       |      |         |       |          |               |          |          |          |                  |          |          |         |            |
| 70 - 79%   | 3 (satisfactory)   |            |      |       |      |         |       |          |               |          |          |          |                  |          |          |         |            |
| 60 - 69%   | 2 (pass)   |            |      |       |      |         |       |          |               |          |          |          |                  |          |          |         |            |
| 0 - 59%  | 1 (failed)   |            |      |       |      |         |       |          |               |          |          |          |                  |          |          |         |            |
| <p><b>Compulsory or recommended literature resources:</b></p> <ul style="list-style-type: none"> <li>• Appelo, C. and Postma, D. (2005) Geochemistry, Groundwater and Pollution. 2nd Edition, Balkema, Rotterdam.</li> <li>• Stumm, W. and Morgan, J.J. (1996) Aquatic Chemistry, Chemical Equilibria and Rates in Natural Waters. 3rd Edition, John Wiley &amp; Sons, Inc., New York.</li> <li>• Brezonik, P. and Arnold, W. (2011) Water Chemistry: An Introduction to the Chemistry of Natural and Engineered Aquatic Systems. Oxford University Press, Oxford.</li> </ul>  |  |            |      |       |      |         |       |          |               |          |          |          |                  |          |          |         |            |

## 2. Course syllabus

**Water chemistry  
Syllabus  
Spring semester  
Hydrogeological Engineer MSc, Semester II., Compulsory course**

|       |  |
|-------|--|
| 02.14 | The structure and physical properties of water   |
| 02.21 | Inorganic chemical composition of natural waters |
| 02.28 | Dissolution                                      |
| 03.06 | Thermodynamic basis for equilibrium chemistry    |
| 03.13 | Acid-base systems                                |
| 03.20 | Acid-base systems – The carbonate system         |
| 03.27 | Labor I.   |
| 04.03 | Holiday  |
| 04.10 | Redox equilibria I.                              |
| 04.17 | Redox equilibria II.                             |
| 04.24 | Labor II.  |
| 05.01 | Holiday  |
| 05.08 | Test   |
| 05.15 | Test repetition                                  |

### 3. Example Test

#### Water chemistry

TEST 1.

2022.05.04

##### Short questions:

**Total point: 10**

1. What is electrostriction?
2. What are the most common anions in water?
3. Exothermic process when...?
4. What is carbonate alkalinity?
5. What is reduction?
6. What is evaporation heat?
7. What is incongruent solution?
8. What is Raoult-law?
9. How the pH changes during solution of  $\text{Na}_2\text{CO}_3$ ?
10. What is reducing agent?

##### Questions:

**Total point: 20**

1. What do you know about viscosity of water?
2. What do you know about the major anions chemical properties in water?
3. What do you know about the solution of  $\text{CO}_2$  in water? (forms, pH dependency, alkalinity definitions)
4. Derive the redox equation of oxidation of Fe(II) by  $\text{O}_2$ ?

##### Calculation exercises:

**Total point: 20**

1. What is the  $\Delta G^\circ$  for acid-mediated dissolution of goethite ( $\text{FeOOH}$ )? (take care about the stoichiometric coefficients)  
( $G_f^\circ$  for  $\text{FeOOH}$  is  $-488.6$  kJ/mol,  $G_f^\circ$  for  $\text{Fe}^{3+}$  is  $-4.6$  kJ/mol,  $G_f^\circ$  for  $\text{H}_2\text{O}$  is  $-237.18$  kJ/mol)
2. The chemical analysis of a water sample is:

| Ca   | K   | Mg   | Na   | $\text{SO}_4^{2-}$ | $\text{Cl}^-$ | $\text{HCO}_3^-$ |
|------|-----|------|------|--------------------|---------------|------------------|
| ppm  | ppm | ppm  | ppm  | ppm                | ppm           | ppm              |
| 83.2 | 9.9 | 23.5 | 60.2 | 92.5               | 25.7          | 421.4            |

Is there charge balance between cations and anions? If there is not balance give suggestion what could be the problem!

3. Calculate the ionic strength of the previous water sample!
4. Calculate the activity coefficient of  $\text{SO}_4^{2-}$  in the previous water sample by Davis equation?  
( $A=0.5042$  ( $T=20^\circ\text{C}$ ))