مواصفات مقرر: جيوكيميا المياه

Course Specification of: Hydrogeochemistry

General information about the course المعلومات العامة عن المقرر						
.1	اسم المقرر Course Title	Hydrogeochemistry				
.2	رمز المقرر ورقمه Course Code and Number	GEOS464 جيوس464				
.3	الساعات المعتمدة للمقرر Credit Hours	Credit Hours الساعات المعتمدة				الإجمالي Total
		محاضرات Lecture	عملي Practical	سمنار/تمارين Seminar/Tutorial	تدريب Training	
		2	1	0	0	3
.4	المستوى والفصل الدراسي Study Level and Semester	Fourth/ 1st semester				
.5	المتطلبات السابقة المقرر (إن وجدت) Pre-requisites (if any)	PEN104, GEOS335				
.6	المتطلبات المصاحبة (إن وجدت) Co-requisites (if any)	None				
.7	البرنامج الذي يدرس له المقرر Program (s) in which the course is offered	Geosciences				
.8	لغة تدريس المقرر Language of teaching the course	English/Arabic				
.9	نظام الدراسة Study System	Semesters/ regular				
.10	مكان تدريس المقرر Location of teaching the course	Petroleum and Natural Resources Building				
.11	اسم معد(و) مواصفات المقرر Prepared by	Dr. Ahmed Saif Al-Mikhlafi				
.12	تاريخ اعتماد مجلس الجامعة Date of Approval	2020				

Course Description وصف المقرر

وصف المقرر بالإنجليزية	وصف المقرر بالعربية
Hydrogeochemistry course is a multidisciplinary course uses the chemistry tools to investigate the natural waters and the processes that alter their composition. Basic principles of hydrogeochemistry are introduced and then used to describe the main controls on the chemistry of pristine and polluted soil, surface, and ground water environments. The course covers quality of waters, chemical equilibria of solutions, including speciation, solubility, sorption, complexation, acid and bases, carbonate chemistry, ion exchange, and redox; thermodynamics and kinetics of reactions; water-rock reactions, reaction progress	مقرر جيوكيمياء المياه علم متفرع يستخدم مبادىء الكيمياء لدراسة تركيب المياه الطبيعية والعمليات اللاحقة التي تصاحب تكونه وتغير من طبيعته. يتضمن هذا المقرر المبادىء الأساسية لجيوكيمياء المياه والتي بدورها تستخدم لوصف الضوابط الرئيسة التي تحكم كيمياء التربة الملوثة وغير الملوثة، والبيئات السطحية والجوفية للمياه. هذا المقرر سوف يقوم بتغطية أنواع المياه ونوعيتها، التوازن الكيميائي للمحاليل، والذي يشمل الإنتواع، الذوبانية، الامتصاص، المركبات المعقدة، الأحماض والقواعد، كيمياء الكربونات، التبادل الأيوني والاختزال، كما يشمل قوانين الديناميكا الحرارية و

indicators; the chemistry of groundwater contaminants, and geochemical speciation modeling.	حركية التفاعلات، النظائر، التفاعلات بين المياه والصخور، كيمياء الملوثات للمياه الجوفية وغيرها.

Course Intended Learning Outcomes (CILOs) مخرجات تعلم المقرر

After completing the course, the student will be able to:		بعد الانتهاء من دراسة المقرر سوف يكون الطالب قادرا على أن:	
a1.	Describe in their own words the laws of the thermodynamics, acids and bases, oxidation and reduction, groundwater contaminants …	يصف بطريقته الخاصة قوانين الديناميكا الحرارية ، الأحماض والقواعد، الأكسدة والإختزال، ملوثات المياه الجوفية وأشياء أخري تتعلق بالمقرر.	- a1
a2.	Knowledge of water chemistry, controls on pH, cation and anion concentrations.	يعرف كيمياء المياه، المتحكمات في pH وتراكيز الكاتيونات والأنيونات في الماء.	– a2
b1.	Synthesize water quality data, and how to interpret any laboratory results by using the proper software package.	يجمع بيانات عن نوعية المياه ويفسرها باستخدام البرمجيات الحاسوبية.	–b1
b2.	Describe of the natural geochemical cycles of elements at the surface of the Earth, as well as the effects of human activities upon these cycles.	يصف الدورة الطبيعية للعناصر علي سطح الأرض، وكذا تأثير النشاط الانساني علي هذه الدورة.	- b2
c1.	Employ practical field and lab experience in sampling groundwater and measurement for a credible geochemical data acquisition.	يوظف خبرته الحقلية والمعملية في جمع عينات مياه جوفية وقياس الخواص الجيوكيمائية للمياه للحصول علي بيانات ذات مصداقية.	- c1
c2.	Demonstrate experience and confidence in performing quantitative analysis: calculations, spreadsheet analyses, and mathematical geochemical models using PHREEQC and spreadsheets.	يظهر الخبرة والثقة في تنفيذ تحليل كمي للماء علي شاكلة عمل حسابات، جداول تحليلية، ونماذج حاسوبية باستخدام برامج حاسوبية مثل phreeqc.	- c2
d1.	Developing skill in expressing oneself orally or in writing	يطور مهارات ذاتية في التعامل مع الأخرين شفويا وتحريريا.	- d1
d2.	Developing specific skills, competencies, and points of view needed by professionals in the field most closely related to this course.	يطور مهارات باختصاصات محددة بوجهة نظر مستقلة التي يحتاجها الأخصائيون كلا في مجاله.	- d2

مواءمة مخرجات تعلم المقرر مع مخرجات التعلم للبرنامج:

Alignment of CILOs (Course Intended Learning Outcomes) to PILOs (Program Intended Learning Outcomes)

مخرجات التعلم المقصودة من المقرر (Course Intended Learning Outcomes)		مخرجات التعلم المقصودة من البرنامج (Program Intended Learning Outcomes) (تكتب جميع مخرجات البرنامج كما هي رمزا ونصا)	
a1	Describe in their own words the laws of the thermodynamics, acids and bases, oxidation and	A1	Express knowledge and understanding of geological-specific theories,

	reduction, and radiogenic and stable isotopes within the context of water chemistry.		paradigms, concepts and principles, in addition to general literature and basic science.
a2	Knowledge of water chemistry, controls on pH, cation and anion concentrations.	**A2**	Explain fundamental geological principles and concepts in theoretical, practical and vocational situations and the possibility of applying them.
b1	Synthesize water quality data, and how to interpret any laboratory results by using the proper software package.	**B1**	Integrate synthesized geological data on a range of spatial and temporal scales to allow for scientific interpretations.
b2	Understanding of the natural geochemical cycles of elements at the surface of the Earth, as well as the effects of human activities upon these cycles.	**B3**	Compose geological information concisely and accurately using written, visual, and verbal means appropriate to the situation.
c1	Employ practical field and lab experience in sampling groundwater and measurement for a credible geochemical data acquisition	**C2**	Apply new and established technologies with efficiency to collect and interpret geological data, recognizing their strengths and limitations.
c2	Demonstrate experience and confidence in performing quantitative analysis: calculations, spreadsheet analyses, and mathematical geochemical models using PHREEQC and spreadsheets.	**C5**	Administer various geological data, integrate, scientifically interpret, and report them
d1	Developing skill in expressing oneself orally or in writing.	**D3**	Express general and impartial intellectual characteristics beyond the specialization.
d2	Developing specific skills, competencies, and points of view needed by professionals in the field most closely related to this course.	**D2**	Elucidate the necessary skills of practicing responsible and personal characteristics with discipline, and ability in making decision.

مواءمة مخرجات التعلم باستراتيجيات التعليم والتعلم والتقويم
Alignment of CILOs to Teaching and Assessment Strategies

أولا: مواءمة مخرجات تعلم المقرر (المعارف والفهم) باستراتيجية التعليم والتعلم والتقويم:
First: Alignment of Knowledge and Understanding CILOs

مخرجات المقرر/ المعرفة والفهم Knowledge and Understanding CILOs		استراتيجية التعليم والتعلم Teaching Strategies	استراتيجية التقويم Assessment Strategies
a1 -	Describe in their own words the	Interactive lecture	Quizzes

	laws of the thermodynamics, acids and bases, oxidation and reduction, and radiogenic and stable isotopes within the context of water chemistry.	Discussion Brain storming Presentation	Examination Reports
a2 -	Knowledge of water chemistry, controls on pH, cation and anion concentrations.		

ثانيا: مواءمة مخرجات تعلم المقرر (المهارات الذهنية) باستراتيجية التدريس والتقويم:

Second: Alignment of Intellectual Skills CILOs

مخرجات المقرر/ المهارات الذهنية Intellectual Skills CILOs		استراتيجية التعليم والتعلم Teaching Strategies	استراتيجية التقويم Assessment Strategies
b1 -	Synthesize water quality data, and how to interpret any laboratory results by using the proper software package.	Interactive lecture Discussion Brain storming Presentation	Quizzes Examination Reports
b2 -	Understanding of the natural geochemical cycles of elements at the surface of the Earth, as well as the effects of human activities upon these cycles.		

ثالثا: مواءمة مخرجات تعلم المقرر (المهارات المهنية والعملية) باستراتيجية التدريس والتقويم:

Third: Alignment of Professional and Practical Skills CILOs

مخرجات المقرر/ المهارات المهنية والعملية Professional and Practical Skills CILOs		استراتيجية التعليم والتعلم Teaching Strategies	استراتيجية التقويم Assessment Strategies
c1-	Employ practical field and lab experience in sampling groundwater and measurement for a credible geochemical data acquisition.	Interactive lecture Discussion Brain storming Presentation Practical work Problem solving	Quizzes Examination Reports Practical work
c2-	Demonstrate experience and confidence in performing quantitative analysis: calculations, spreadsheet analyses, and mathematical geochemical models using PHREEQC and spreadsheets.		

رابعا: مواءمة مخرجات تعلم المقرر (المهارات العامة) باستراتيجية التدريس والتقويم:

Fourth: Alignment of Transferable (General) Skills CILOs

مخرجات المقرر Transferable (General) Skills CILOs		استراتيجية التعليم والتعلم Teaching Strategies	استراتيجية التقويم Assessment Strategies
d1-	Developing skill in expressing oneself orally or in writing	Discussion Cooperative learning Presentation Problem solving	Quizzes Examination Reports
d2-	Developing specific skills, competencies, and points of view needed by professionals in the field most closely related to this course.		

Course Content محتوى المقرر

Theoretical Aspect موضوعات الجانب النظري

الرقم Order	الموضوعات الرئيسة/ الوحدات Topic List / Units	الموضوعات الفرعية Sub Topics List	عدد الأسابيع Number of Weeks	الساعات الفعلية Contact Hours	رموز مخرجات التعلم للمقرر (CILOs)
1	**Introduction**	- The scope of hydrogeochemisty 1. Relationship to other geologic and environmental disciplines 2. Definition of hydrogeochemistry - Measurement: units of concentrations; molality, molarity, millequivalent…	1	2	a1, a2
2	**Natural Water Composition**	- Atomic structure and bonding - The structure of water molecules and interaction among them -Water as a solvent -The behavior of solutes in water - Dissolution of salts	1	2	a1,a2, b1,b2, c1, c2
3	**Water Chemistry**	-Specific conductance and total dissolved solids - Ionic strength and total dissolved solids - Graphical displays of water chemistry data - Statistical treatment of water chemistry Data - Precipitation-dissolution of trace metals	1	2	a1,a2, b1,b2, c1, c2
4	**Equilibrium Constant (Law of Mass Action)**	- Mass action and equilibrium constants - Thermodynamics and chemical equilibrium	2	4	a1,a2, b1,b2, c1, c2,

		- Mineral solubility and equilibrium (saturation) - Relationship between concentration and activity - Complexation and solubility - Speciation and chemical equilibrium - The kinetics of geochemical processes			d1
5	**Chemical Thermodynam-ics and Kinetics**	Principles of chemical thermodynamics -Chemical potential and activity of solutions The equilibrium constant: temperature and pressure effects Kinetics vs. thermodynamics Rates, mechanisms, and elementary reactions	2	4	a1,a2, b1,b2, c1, c2
6	**Carbonate Chemistry**	- Chemical weathering of minerals and Rocks -Water-rock interactions -Dissolved carbon dioxide and pH control - Alkalinity, Hardness and Corrosivity - Carbonate Minerals and Water Chemistry -Groundwater Chemistry in Carbonate rocks - Congruent silicate mineral dissolution -Incongruent dissolution and stability diagrams - Silicate Weathering and Water Chemistry	2	4	a1,a2, b1,b2, c1, c2
7	**Electrochemical Equilibria**	- Oxidation-reduction reactions and the electron activity in subsurface nvironments - Kinetics of redox processes - Thermodynamic description of redox reactions and pE-pH diagrams - Redox reactions of inorganic contaminants: Arsenic and selenium, and Chromium - Redox conditions in natural waters - Colloids, adsorption, and ion exchange - Use of stable isotopes in hydrogeology - Use of radioisotopes in hydrogeology	1	2	a1,a2, b1,b2, c1, c2, d1
8	**Surface Chemistry and Contaminant Sorption Reactions**	- Solid-liquid interface characteristics of soils and aquifer solids - Kinetics of sorption reactions - Inorganic and organic solute sorption reactions - Thermodynamic description of sorption reactions - Molecular adsorption models for metal sorption modeling - Contaminant sorption to mobile	1	2	a1,a2, b1,b2, c1, c2, d1

		colloids and facilitated transport.			
9	**Metal Complexation in Aqueous Solutions**	- Hydrolysis of metal ions - Natural and anthropogenic inorganic and organic ligands - Metal ions and ligands: classification of metals - Chemical speciation in natural waters: toxicity of heavy metals	1	2	a1,a2, b1,b2, c1, c2
10	**Transport and mass transfer processes**	- Transport processes: advection, diffusion, dispersion - Mass transfer processes: adsorption, precipitation, radioactive decay, biodegradation, inactivation	1	2	a1,a2, b1,b2, c1, c2, d1
11	**Contaminant Reactions in Soil Solution and Groundwaters**	- Sampling the solution phase - Inorganic complexation reactions -Thermodynamic speciation modeling of inorganics -Ion Exchange	1	2	a1,a2, b1,b2, c1, c2, d1
عدد الأسابيع والساعات الفعلية **Number of Weeks /and Contact Hours Per Semester**			**14**	28	

Practical Aspect (if any) الموضوعات العملية (إن وجدت)

الرقم Order	التجارب العملية/ التمارين / تدريبات Practical / Exercises/ Tutorials topics	عدد الأسابيع Number of Weeks	الساعات الفعلية Contact Hours	رموز مخرجات التعلم Course ILOs
1	▪ Instrumentation in geochemical analyses	1	2	a1,a2, b1,b2, c1, c2, d1
2	▪ Convert mass concentrations to units of molarity and normality…	1	2	a1,a2, b1,b2, c1, c2, d1
3	▪ Groundwater sampling and analysis	1	2	a1,a2, b1,b2, c1, c2, d1
4	▪ Composite quality Indicators Calculation: - Electrical Conductivity (EC), Total Dissolved Solid (TDS), Total Hardiness (TH), Sodium Adsorption Ratio (SAR)	1	2	a1,a2, b1,b2, c1, c2, d1
5	▪ Water quality data graphical interpretation: Create graphical depictions of water chemistry and	2	4	a1,a2, b1,b2, c1, c2, d1

Prepared by
Assoc.Prof. Adel Al-Matary

Quality Assurance Unit
Assoc.Prof. Adel Al-Matary

Dean of the Faculty
Assoc.Prof. Bassim AlKhirbash

Dean of the Development & Quality Assurance Center
Assoc.Prof. Huda Al-Emad

Rector of Sana'a University
Prof. Dr. Al Qaseem Mohammed Abas

	interpret their significance. - Stiff Diagram, circular diagram, Piper Diagram, Schoeller diagram…			
6	▪ Lab analyses of groundwater sample (visit to the Sana'a Laboratory)	1	2	a1,a2, b1,b2, c1, c2, d1
7	▪ Thermodynamics: activity, ionic strength, ionic coefficient from available water chemistry	2	4	a1,a2, b1,b2, c1, c2, d1
8	▪ Solubility Equilibria: Calculate the Ksp, qualitative, prediction of precipitation (SI), the common ion effect and solubility, pH and solubility, complex ion equilibria and solubility	1	2	a1,a2, b1,b2, c1, c2, d1
9	▪ Hydrogeochemical applications using computer programs: Calculation of Saturation Indices and other parameters using PHREEQC program. Student use Aquachem plot to represent the data.	2	4	a1,a2, b1,b2, c1, c2, d1
اجمالي الأسابيع والساعات الفعلية Number of Weeks /and Contact Hours Per Semester		**12**	**24**	

Teaching Strategies استراتيجيات التعليم والتعلم

- **Interactive lecture**
- **Discussion**
- **Brain storming**

Tasks and Assignments الأنشطة والتكليفات

م No	التكليف/ الواجب Assignments/ Tasks	نوع التكليف (فردي/ تعاوني)	الدرجة المستحقة Mark	أسبوع التنفيذ Week Due	خرجات التعلم CILOs (symbols)
1	Attendance and Participation	Individual	5	throughout	all
2	Class activity & Problem solving	individual	5	throughout	all
	Total Score إجمالي الدرجة		**10**		

Learning Assessment تقييم التعلم

الرقم No.	أنشطة التقييم Assessment Tasks	أسوع التقييم Week due	الدرجة Mark	نسبة الدرجة إلى الدرجة النهائية Proportion of Final Assessment	مخرجات التعلم CILOs (symbols)

Prepared by
Assoc.Prof. Adel Al-Matary

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1	الأنشطة والتكليفات Tasks and Assignments	Throughout	10	6.66	a1,a2, b1,b2, c1, c2, d2
2	Quizzes	W4,W8	5	3.33	a1,a2, b1,b2, c1, c2, d2
3	Midterm Exam (practical)	W6	(15)	10	a1,a2, b1,b2, c1, c2, d2
	Lab activity and Participation	Throughout	(5)	3.33	a1,a2, b1,b2, c1, c2, d2
4	Midterm Exam (theoretical)	W7	15	10	a1,a2, b1,b2, c1, c2, d2
6	اختبار نهاية الفصل (عملي) Final Exam (practical)	W 14	(30)	20	a1,a2, b1,b2, c1, c2, d2
7	اختبار نهاية الفصل (نظري) Final Exam (theoretical)	W16	70	46.66	a1,a2, b1,b2, c1, c2, d2
Total الإجمالي			150	%100	

Learning Resources مصادر التعلم

توثق المراجع حسب نظام APA (اسم المؤلف، سنة النشر، اسم الكتاب، دار النشر، بلد النشر).

Required Textbook(s) المراجع الرئيسة (لا تزيد عن مرجعين)

Clark, I., 2015. Groundwater Geochemistry and Isotopes, CRC Press, Taylor & Francis Group, New York.

Kehew, 2001. Applied chemical hydrogeology textbook.

Essential References المراجع المساندة

Holting, B., and Coldewey, W.G., 2019. Hydrogeology, Springer-Verlag GmbH Germany, part of Springer Nature.

Langmuir, *Aqueous Environmental Geochemistry*. Prentice Hall. 1997 or other advanced geochemistry textbook.

Appelo and Postma, *Geochemistry, Groundwater, and Pollution*, 2nd edition, by Appelo and Postma, CRC Press.

Electronic Materials and Web Sites *etc.* المصادر الإلكترونية ومواقع الإنترنت

Course Policies الضوابط والسياسات المتبعة في المقرر

1 Class Attendance حضور الفعاليات التعليمية

- Attendance is compulsory at all scheduled lectures and practical sessions. A student should attend not less than 75 % of total hours of the subject; otherwise he/she will not be able to take the exam and will be considered as exam failure and will be required to retake the course again.

2 Tardy الحضور المتأخر

- For late in attending the class, the student will be initially notified. If he repeated lateness in attending class, he/she will be considered as absent.

3 Exam Attendance/Punctuality ضوابط الامتحان

	- The student should attend the exam on time. He/she is allowed to attend the exam within half an hour from the beginning of the exam, after that if late he/she will not be permitted to take the exam and will be considered as absent.
4	**Assignments & Projects** التعيينات والمشاريع - Student has to submit all the assignments/reports for checking on time, mostly one week after given the assignment.
5	**Cheating** الغش - Any student caught cheating will be expelled from the exam hall, and referred to a disciplinary council to apply the penalties as stipulated in the Student Affairs Regulations (SAR). Usually student will be assigned a course grade of F (Fail), more actions will be applied subject to the case in agreement with the SAR.
6	**Plagiarism** الانتحال - Plagiarism means if you copy the work of another person and turn it in as your own, so plagiarism is one of the worst academic sins. - Academic integrity, with its embodied values, is seen as a foundation of Sana'a University. It is the responsibility of all students to be familiar with behaviours and practices associated with academic integrity. Instructors are required to provide students and faculty with information on plagiarism and other forms of academic dishonesty, and has resources to help students succeed honestly. Such behavior will lead to severe punishment liable to faculty/department evaluation.
7	**Other policies** سياسات أخرى - During class lectures, please make sure that all cell phones must be off or on silent and put away in your pocket, or backpack or purse. They should not be visible during class. Audio and/or visual recording devices including, but not limited to, computers, personal digital assistants (PDA's), iPods, tape recorders, and cameras are not permitted to be on-they should be turned off and put away in your pocket, backpack or purse. Failure to comply with these policies will result in exclusion from the class. - Students are not allowed to carry a cell phone or any relevant material into the exam hall, otherwise any such act will be treated as a cheating case, and disciplinary action will be taken according to University rules as above.

قسم/ برنامج: العلوم الجيولوجية
العام الجامعي: 2019-2020م

خطة مقرر: جيوكيميا المياه
Course Plan (Syllabus): Hydrogeochemistry

Information about Faculty Member Responsible for the Course معلومات عن أستاذ المقرر							
الاسم Name	Dr.Ahmed Saif Al-Mikhlafi	الساعات المكتبية (أسبوعيا) Office Hours					
المكان ورقم الهاتف Location &Telephone No.	+967 777554655, Sana'a	السبت SAT	الأحد SUN	الاثنين MON	الثلاثاء TUE	الأربعاء WED	الخميس THU
البريد الإلكتروني E-mail	ahmed.almikhlafi@fulbrightmail.org						

General information about the course معلومات عامة عن المقرر						
.1	اسم المقرر Course Title	Hydrogeochemistry				
.2	رمز المقرر ورقمه Course Code and Number	GEOS464 جيوس464				
.3	الساعات المعتمدة للمقرر Credit Hours	Credit Hours الساعات المعتمدة				الإجمالي Total
		محاضرات Lecture	عملي Practical	سمنار/تمارين Seminar/Tutorial	تدريب Training	
		2	1			3
.4	المستوى والفصل الدراسي Study Level and Semester	Fourth Year/ 1st semester				
.5	المتطلبات السابقة للمقرر Pre-requisites	PEN104, GEOS335				
.6	المتطلبات المصاحبة (إن وجدت) Co –requisite					
.7	البرنامج الذي يدرس له المقرر Program (s) in which the course is offered	Geosciences				
.8	لغة تدريس المقرر Language of teaching the course	English/ Arabic				
.9	مكان تدريس المقرر Location of teaching the course	Petroleum and Natural Resources Building				

Course Description وصف المقرر

Introduction to the geochemistry of natural waters and the processes that alter their composition. Basic principles of hydrogeochemistry are introduced and then used to describe the main controls on the chemistry of pristine and polluted soil, surface, and ground water environments. The course covers quality of waters, chemical equilibria of solutions,	مقرر جيوكيمياء المياه علم متفرع يستخدم مبادىء الكيمياء لدراسة تركيب المياه الطبيعية والعمليات اللاحقة التي تصاحب تكونه وتغير من طبيعته. يتضمن هذا المقرر المبادىء الأساسية لجيوكيمياء المياه والتي بدورها تستخدم لوصف الضوابط الرئيسة التي تحكم كيمياء التربة الملوثة وغير الملوثة، والبيئات السطحية والجوفية للمياه. هذا المقرر سوف يقوم

including speciation, solubility, sorption, complexation, acid and bases, carbonate chemistry, ion exchange, and redox; thermodynamics and kinetics of reactions; water-rock reactions, reaction progress indicators; the chemistry of groundwater contaminants, and geochemical speciation modeling.	بتغطية أنواع المياه ونوعيتها، التوازن الكيميائي للمحاليل، والذي يشمل الإنتواع، الذوبانية، الامتصاص، المركبات المعقدة، الأحماض والقواعد، كيمياء الكربونات، التبادل الأيوني والاختزال، كما يشمل قوانين الديناميكا الحرارية و حركية التفاعلات، النظائر، التفاعلات بين المياه والصخور، كيمياء الملوثات للمياه الجوفية وغيرها.

Course Intended Learning Outcomes (CILOs) مخرجات تعلم المقرر

After completing the course, the student will be able to:	بعد الانتهاء من دراسة المقرر سوف يكون الطالب قادرا على أن:
a1. Describe in their own words the laws of the thermodynamics, acids and bases, oxidation and reduction, groundwater contaminants …	a1. يصف بطريقته الخاصة قوانين الديناميكا الحرارية ، الأحماض والقواعد، الأكسدة والإختزال، ملوثات المياه الجوفية وأشياء أخري تتعلق بالمقرر.
a2. Knowledge of water chemistry, controls on pH, cation and anion concentrations.	a2. يعرف كيمياء المياه، المتحكمات في pH وتراكيز الكاتيونات والأنيونات في الماء.
b1. Synthesize water quality data, and how to interpret any laboratory results by using the proper software package.	b1. يجمع بيانات عن نوعية المياه ويفسرها باستخدام البرمجيات الحاسوبية.
b2. Describe of the natural geochemical cycles of elements at the surface of the Earth, as well as the effects of human activities upon these cycles.	b2. يصف الدورة الطبيعية للعناصر علي سطح الأرض، وكذا تأثير النشاط الانساني علي هذه الدورة.
c1. Employ practical field and lab experience in sampling groundwater and measurement for a credible geochemical data acquisition.	c1 . يوظف خبرته الحقلية والمعملية في جمع عينات مياه جوفية وقياس الخواص الجيوكيمائية للمياه للحصول علي بيانات ذات مصداقية.
c2. Demonstrate experience and confidence in performing quantitative analysis: calculations, spreadsheet analyses, and mathematical geochemical models using PHREEQC and spreadsheets.	c2. يظهر الخبرة والثقة في تنفيذ تحليل كمي للماء علي شاكلة عمل حسابات، جداول تحليلية، ونماذج حاسوبية باستخدام برامج حاسوبية مثل phreeqc.
d1. Developing skill in expressing oneself orally or in writing.	d1. يطور مهارات ذاتية في التعامل مع الآخرين شفويا وتحريريا.
d2. Developing specific skills, competencies, and points of view needed by professionals in the field most closely related to this course.	d2. يطور مهارات باختصاصات محددة بوجهة نظر مستقلة التي يحتاجها الأخصائيون كلا في مجاله.

Course Content محتوى المقرر

Theoretical Aspect خطة تنفيذ الموضوعات النظرية

الرقم Order	الوحدات (الموضوعات الرئيسة) Units	الموضوعات التفصيلية Sub Topics	الأسبوع Week Due	الساعات الفعلية Con. H
1	Introduction	- The scope of hydrogeochemisty:	W1	2

		relationship to other geologic and environmental disciplines; definition of hydrogeochemistry - Measurement: units of concentrations; molality, molarity, millequivalent…		
2	**Natural Water Composition**	- Atomic structure and bonding - The structure of water molecules and interaction among them -Water as a solvent -The behavior of solutes in water - Dissolution of salts	W2	2
3	**Water Chemistry**	- Specific conductance and total dissolved solids - Ionic strength and total dissolved solids - Graphical displays of water chemistry data - Statistical treatment of water chemistry data - Precipitation-dissolution of trace metals	W3	2
4	**Equilibrium Constant (Law of Mass Action)**	- Mass action and equilibrium constants - Thermodynamics and chemical equilibrium - Mineral solubility and equilibrium (saturation) - Relationship between concentration and activity - Complexation and solubility - Speciation and chemical equilibrium - The kinetics of geochemical processes	W4	2
5	**Chemical Thermodynam-ics and Kinetics**	- Principles of chemical thermodynamics - Chemical potential and activity of solutions - The equilibrium constant: temperature and pressure effects	W5	2
		- Kinetics vs. thermodynamics - Rates, mechanisms, and elementary reactions	W6	2
6	**Carbonate Chemistry**	- Chemical weathering of minerals and rocks - Water-rock interactions - Dissolved Carbon Dioxide and pH Control - Alkalinity, Hardness and Corrosivity - Carbonate Minerals and Water Chemistry	W7	2
		- Groundwater Chemistry in Carbonate Rocks - Congruent Silicate Mineral Dissolution - Incongruent Dissolution and Stability Diagrams - Silicate Weathering and Water Chemistry	W8	2
7	**Midterm Exam**	All previous lectures	W9	2

8	**Electrochemical Equilibria**	- Oxidation-reduction reactions and the electron activity in subsurface environments - Kinetics of redox processes - Thermodynamic description of redox reactions and pE-pH diagrams - Redox reactions of inorganic contaminants: Arsenic and selenium, and Chromium	W10	2
		- Redox conditions in natural waters -Colloids, adsorption, and ion exchange -Use of stable isotopes in hydrogeology - Use of radioisotopes in hydrogeology	W11	2
9	**Surface Chemistry and Contaminant Sorption Reactions**	- Solid-liquid interface characteristics of soils and aquifer solids - Kinetics of sorption reactions - Inorganic and organic solute sorption reactions - Thermodynamic description of sorption reactions - Molecular adsorption models for metal sorption modeling - Contaminant sorption to mobile colloids and facilitated transport.	W12	2
10	**Metal Complexation in Aqueous Solutions**	- Hydrolysis of metal ions - Natural and anthropogenic inorganic and organic ligands - Metal ions and ligands: classification of metals - Chemical speciation in natural waters: toxicity of heavy metals	W13	2
11	**Transport and mass transfer processes**	-Transport processes: advection, diffusion, dispersion - Mass transfer processes: adsorption, precipitation, radioactive decay, biodegradation, inactivation	W14	2
12	**Contaminant Reactions in Soil Solution and Groundwaters**	- Sampling the solution phase - Inorganic complexation reactions -Thermodynamic speciation modeling of inorganics - Ion Exchange	W15	2
13	**Final Exam**	▪ All previous lectures	W16	**2**
عدد الأسابيع والساعات الفعلية Number of Weeks /and Contact Hours Per Semester			**16**	**32**

Practical / Training/ Tutorials/ Exercises Aspects خطة تنفيذ موضوعات الجانب العملي

الرقم Order	موضوعات العملي/ المهام / التمارين Practical/ Tutorials/ Exercises Aspects	الأسبوع Week Due	الساعات الفعلية Cont. H
1	▪ Instrumentation in geochemical analyses	W1	**2**
2	▪ Convert mass concentrations to units of molarity and	W2	**2**

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	normality…		
3	▪ Groundwater sampling and analysis	W3	**2**
4	▪ Composite quality Indicators Calculation: - Electrical Conductivity (EC), Total Dissolved Solid (TDS), Total Hardiness (TH), Sodium Adsorption Ratio (SAR)	W4	**2**
5	▪ Water quality graphical representations: Create graphical depictions of water chemistry and interpret their significance. - Stiff Diagram, circular diagram, Schoeller diagram…	W5	**2**
6	▪ Graphical representation: Piper Diagram and interpret its significance.	W6	**2**
7	▪ Mid-Term Exam	W7	**2**
8	▪ Lab analyses of groundwater sample (visit to the Sana'a Laboratory)	W8	**2**
9	▪ Thermodynamics: activity, ionic strength, ionic coefficient from available water chemistry	W9	**2**
10	▪ Solubility Equilibria: Calculate the Ksp, qualitative, prediction of precipitation (SI), the common ion effect and solubility, pH and solubility, complex ion equilibria and solubility	W10	**2**
11	▪ Hydrogeochemical applications using computer programs: Calculation of Saturation Indices using PHREEQC, Aquachem…	W11&12	**4**
12	▪ Final Exam	W13	**2**
اجمالي الأسابيع والساعات الفعلية Number of Weeks /and Contact Hours Per Semester		**13**	**26**

Teaching Strategies استراتيجيات التعليم والتعلم

- Interactive Lecture
- Discussion
- Brain Storming
- Presentation

Tasks and Assignments الأنشطة والتكليفات

م No	التكليف/ الواجب Assignments	نوع التكليف (فردي/تعاوني)	الدرجة المستحقة Mark	أسبوع التنفيذ Week Due
1	Attendance and Participation	Individual	5	throughout
2	Class activity & Problem solving	individual	5	throughout
	Total Score إجمالي الدرجة		**10/150**	

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Learning Assessment تقويم التعلم

م No	أساليب التقويم Assessment Method	موعد(أسبوع) التقويم Week Due	الدرجة Mark	الوزن النسبي% Proportion of Final Assessment
1	الأنشطة والتكليفات Tasks and Assignments	Throughout	10	6.66
2	Quizzes	W4,W8	5	3.33
3	Midterm Exam (practical)	W6	(15)	10
4	Lab activity and Participation	Throughout	(5)	3.33
5	Midterm Exam (theoretical)	W7	15	10
6	اختبار نهاية الفصل (عملي) Final Exam (practical)	W 14	(30)	20
7	اختبار نهاية الفصل (نظري) Final Exam (theoretical)	W16	70	46.66
	Total المجموع		150	100 %

Learning Resources مصادر التعلم

توثق المراجع حسب نظام APA (اسم المؤلف، سنة النشر، اسم الكتاب، دار النشر، بلد النشر).

Required Textbook(s) المراجع الرئيسة (لا تزيد عن مرجعين)

Clark, I., 2015. Groundwater Geochemistry and Isotopes, CRC Press, Taylor & Francis Group, New York.

Kehew, 2001. Applied chemical hydrogeology textbook.

Essential References المراجع المساندة

Holting, B., and Coldewey, W.G., 2019. Hydrogeology, Springer-Verlag GmbH Germany, part of Springer Nature.

Langmuir, *Aqueous Environmental Geochemistry*. Prentice Hall. 1997 or other advanced geochemistry textbook.

Geochemistry, Groundwater, and Pollution, 2nd edition, by Appelo and Postma, CRC Press.

Electronic Materials and Web Sites *etc.* المصادر الإلكترونية ومواقع الإنترنت

Course Policies الضوابط والسياسات المتبعة في المقرر

1	**Class Attendance حضور الفعاليات التعليمية** - Attendance is compulsory at all scheduled lectures and practical sessions. A student should attend not less than 75 % of total hours of the subject; otherwise he/she will not be able to take the exam and will be considered as exam failure and will be required to retake the course again.
2	**Tardy الحضور المتأخر** - For late in attending the class, the student will be initially notified. If he repeated lateness in attending class, he/she will be considered as absent.

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3	**Exam Attendance/Punctuality** ضوابط الامتحان - The student should attend the exam on time. He/she is allowed to attend the exam within half an hour from the beginning of the exam, after that if late he/she will not be permitted to take the exam and will be considered as absent.
4	**Assignments & Projects** التعيينات والمشاريع - Student has to submit all the assignments/reports for checking on time, mostly one week after given the assignment.
5	**Cheating** الغش - Any student caught cheating will be expelled from the exam hall, and referred to a disciplinary council to apply the penalties as stipulated in the Student Affairs Regulations (SAR). Usually student will be assigned a course grade of F (Fail), more actions will be applied subject to the case in agreement with the SAR.
6	**Plagiarism** الانتحال - Plagiarism means if you copy the work of another person and turn it in as your own, so plagiarism is one of the worst academic sins. - Academic integrity, with its embodied values, is seen as a foundation of Sana'a University. It is the responsibility of all students to be familiar with behaviours and practices associated with academic integrity. Instructors are required to provide students and faculty with information on plagiarism and other forms of academic dishonesty, and has resources to help students succeed honestly. Such behavior will lead to severe punishment liable to faculty/department evaluation.
7	**Other policies** سياسات أخرى - During class lectures, please make sure that all cell phones must be off or on silent and put away in your pocket, or backpack or purse. They should not be visible during class. Audio and/or visual recording devices including, but not limited to, computers, personal digital assistants (PDA's), iPods, tape recorders, and cameras are not permitted to be on-they should be turned off and put away in your pocket, backpack or purse. Failure to comply with these policies will result in exclusion from the class. - Students are not allowed to carry a cell phone or any relevant material into the exam hall, otherwise any such act will be treated as a cheating case, and disciplinary action will be taken according to University rules as above.