

Chem 208-02: General Chemistry II and Introduction to Inorganic Chemistry
Spring 2022; ISC 1127 Monday/Wednesday/Friday 9:00 – 9:50 am & <https://cwm.zoom.us/j/94238025837>
with ISC 1221 Exam/Help Session Block Wednesday 8:00 – 9:20 pm
Instructor: Professor Deborah C. Bebout (she/her); ISC 2039; 221-2558; dcbebo@wm.edu

Optional Zoom Help Sessions <https://cwm.zoom.us/j/99847387887>

Log into Zoom with your W&M e-mail address for access security; video on (if possible); please identify yourself by name
Monday and Wednesday starting at 8 pm ; 30-90 minutes depending on student interest (times out due to inactivity)

Virtual Help: Blackboard Discussion Board available for questions about course content and assignments

Please use the Discussion Board when other students might benefit & email (dcbebo@wm.edu) for time-sensitive individual concerns

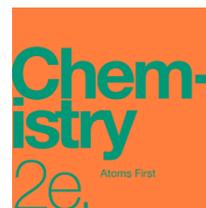
UPDATED COURSE CATALOG DESCRIPTION: (3 credits; Prerequisite CHEM 103 or equivalent) A continuation of the study of the principles of chemistry begun in Chemistry 103. Topics include aqueous equilibria, thermodynamics, electrochemistry, advanced bonding theories, nuclear chemistry, chemical kinetics, and coordination chemistry.

Recommended for students expecting to major chemistry, life sciences, geology, and physics. Chem 205 and 208 are interchangeable for the purposes of meeting biology, chemistry, geology, kinesiology, neuroscience and physics major degree requirements, chemistry and biochemistry minor degree requirements, as well as admission requirements for medical school. There is no coordination between these courses, nor between the two sections of Chem 208. Students enrolled in Chem 208 Section 02 should plan to consult Professor Bebout regarding all issues related to this course. A complementary laboratory course (CHEM 254 or CHEM 256) is offered separately; review degree and post-baccalaureate plans to see if laboratory course enrollment is needed.

NOTE: The sequence Gen Chem I, Orgo I, Orgo II, Gen Chem II is normal at W&M for those planning to take two years of college chemistry since Orgo I is only taught in the spring and summer. Although Chem 208 does not have organic chemistry as a prerequisite and may be taken immediately after Gen Chem I, students who have completed three semesters of college chemistry are naturally better prepared for academic success in this class. Furthermore, it is not advisable to take CHEM 208 after earning a grade of C- or lower in CHEM 103 without undertaking individual remediation, especially in the areas of equilibria, redox chemistry, stoichiometry, thermochemistry, atomic structure, chemical bonding and molecular geometry.

Course Objectives:

1. Study the content, principles and methods of chemistry.
2. Develop an appreciation for the relevance of chemistry in our daily lives.
3. Improve analytical and problem-solving skills.



Course related electronic resources:

1. <https://openstax.org/details/books/chemistry-atoms-first>: W. R. Robinson, P. Flowers, E. J. Neth, K. Theopold, R. H. Langley, *Chemistry: Atoms First 2e*, OpenStax: Houston, TX (2019) Required free virtual textbook & student resources
This text was required for all sections of CHEM 103 in Summer & Fall 2019-2021.
2. https://en.wikibooks.org/wiki/Introduction_to_Inorganic_Chemistry: Required free virtual textbook & student resources
3. <https://blackboard.wm.edu>: Syllabus, various course documents, lecture capture
4. <https://achieve.macmillanlearning.com/courses/fspwme>: Gen Chem II & Intro Inorg Chem – BEBOUT – CHEM 208 02 – Spring22
Registration for Achieve with W&M ID # and payment of the associated \$42 fee (free trial period through Feb 4), is required to access interactive unit homework, extra credit opportunities and associated instructional services.
5. <https://www.gradescope.com>: AI-assisted grading tool for exam. All students will be enrolled in the course site by the instructor.

GRADING POLICIES

Point totals required for specific grades will be calculated based on proportion of base point totals earned for timely submission of:

84 pts	Achieve Subunit Homework for Units 1-7 (Max of 3 pts each/four Subunits of seven Units)
28 pts	Lecture activities for Units 1-7 (Max of 1 pt each for four Subunits of seven Units)
140 pts	Timed Blackboard Subunit Quizzes (Max of 5 points each/four Subunits of seven Units)
480 pts	Three Dual Unit Exams: Max of 160 pts each (Unit 7 combined with final)
280 pts	Unit 7 Exam + Cumulative Final

1000 total base points + 12 points extra credit from subunit Homework and/or Lecture Activities

Based on 1000 total base points earned, grade breaks will be X7/X3/X0 for A (X = 9), B (X = 8), C (X = 7), D (X = 6) OR LOWER.

NO CREDIT FOR WORK SUBMITTED AFTER DEADLINE UNLESS EXTREME EXTENUATING CIRCUMSTANCES!

Up to 41 pts are available in **OPTIONAL** extra credit for adjustment of point totals **AFTER** determination of base grade breaks.
Orientation activities (5 pts max)

Eight Gen Chem I Review Achieve Adaptive Quizzes (AQ) (1 pt max each; prorated based on 450+ LC pts earned/LC, 8 pts max)

One Achieve AQ/Unit (1 pt max each; prorated based on 450+ AQ score/AQ; 6 pts max, not available for Unit 5)

Final Achieve Review HW (10 pts max)

Points over 100 earned from Achieve Subunit HW and Lecture Activities (12 pts max)

Student Course Responsibilities & Course Policies:

This semester, the world will enter its third year with COVID. As we experience a fifth surge of pandemic with the highly transmissible omicron variant, it is reasonable to expect significant levels of infection at W&M. As an academic community based on faculty and students *convening*, spring 2022 courses will largely consist of in-person instruction. All of us will follow W&M requirements – vaccinations and boosters, indoor masking, as well as quarantine and isolation when ill. That last is really important: for those who have tested positive, W&M's requirements must be fulfilled before class can be attended in person, and, out of an abundance of caution, anyone with symptoms consistent with COVID – even if they don't have a positive test – should not come to class. During this very challenging time, this course will be administered in an equitable manner on the basis of a trustful relationship under the W&M Honor Code.

Time commitment: College level courses are typically structured to require an average of three to four hours per credit per week. Each student should expect to invest a weekly average of nine to twelve hours in this three-credit course even if they usually devote less time to their other courses. Students with a weaker background in chemistry may need to spend more than twelve hours on average per week to develop sufficient proficiency in General Chemistry I material prior to or while tackling CHEM 208 content.

Attendance Expectations: Consistent with W&M's belief that learning is most effective when the instructor and students convene, our course this semester is scheduled for in-person instruction. Except for reasonable cause, students are expected to be present at all regularly scheduled class meetings as stated in the W&M course catalog. Ideally, attendance expectations will be met through physical presence in ISC 1127 MWF 9:00 – 9:50 am to benefit from direct peer engagement. Please do your very best to attend class as you are able. In-person attendance is required for semester Exams and the Final. Help session Zoom attendance is optional.

***** Masks covering both mouth & nose are required of everyone throughout the lecture – no eating or drinking (including water)*****
***** A charged device with internet access will be required to access Blackboard during most lecture periods*****

While dealing with a pandemic ebbing towards an endemic, accommodations for impractical in-person attendance will be:

- **Discretionary student absences:** Students unable to physically attend class for any non-debilitating reason (including having tested positive for COVID, having symptoms consistent with COVID, or other manageable health matters) are expected to attend synchronously by Zoom (<https://cwm.zoom.us/j/94238025837>) and are responsible for completing any associated Lecture Activities before 9:50 am (all lecture activities occurring during the add/drop period will have a no-cost extension through Monday, February 7th at 9:50 am). Extensions for Lecture Activities will not be granted for discretionary absences.
- **Student absences for extenuating circumstances:** Students with documentable extenuating circumstances (eg. severe illness, hospitalization, death in the immediate family, scheduled professional development activities, college-related travel, etc.) are asked to contact Prof. Bebout as soon as practical by email to discuss adjustments needed for their individual situation.
- **Course Buddies:** To support remote engagement when necessary, I ask that everyone establish one or more Course Buddies during the add/drop period and exchange contact information by the end of class Monday, February 7th. In the event of discretionary course absence, please contact a Course Buddy before the start of class. Contacting the instructor is neither necessary nor expected for discretionary absences, as these absences will be accommodated through a combination of Course Buddies and remote, synchronous and asynchronous access to lectures by Zoom. If there are technical difficulties during the lecture (eg. poor audio), please ask your Course Buddy to let me know if I overlook your chat.
- **Instructor absences:** If personal circumstances prevent Prof. Bebout from delivering lecture in person, lectures will be delivered remotely. If possible, she will arrange to have someone project her live, remote lecture synchronously onto the screen in ISC 1127 and monitor the classroom for questions to preserve peer interactions. If it is impractical for her to lecture for any reason (eg. extreme laryngitis), she will send everyone an email and post Subunit videos recorded last year on Blackboard for asynchronous viewing.
- **School closures including one or more lecture periods:** Lectures will be recorded remotely by Zoom during the regular time period and a link posted on Blackboard as soon as practical OR a subunit lecture recorded last year will be posted on Blackboard at instructor discretion. Any associated Lecture Activities or other assignments due during a closure will be due 11:59 pm the day W&M reopens.

Textbook Readings: Students are responsible for assigned textbook content for Units 1-7 and associated review materials.

Achieve Subunit Homework: Working problems is important for reinforcing the chemical principles emphasized in the lectures and text. Students should both study the textbook readings and take notes on the lecture associated with each subunit (and earlier ones) before attempting the Achieve Subunit Homework. There will be four Achieve Subunit Homework assignments/unit, each worth 3 pts maximum (84 pts available). In addition, there is a semester review homework for **10 points optional extra credit**. Each student must have individual access to Achieve to submit homework responses. Students may work together on homework with the understanding that content mastery is an individual responsibility. Students may also get assistance with homework from the Blackboard Discussion Board or Zoom Q & A sessions with Prof. Bebout. Answers to all subunit homework assignments must be submitted via Achieve the indicated Sunday at 11:59 pm. **NO CREDIT FOR LATE HOMEWORK UNLESS EXTREME EXTENUATING CIRCUMSTANCES** (eg. documented hospitalization). Each homework assignment will consist of at least 10 problems and up to 15 problems (with differential weighting for difficulty). Individuals can keep trying to answer each question (often multipart) until they get it right with no penalty for incorrect answers. Individuals can view solutions when problems are complete or they give up on any question. Assignments are set up to be started, saved and resumed later numerous times. *Reminder: EVERY POINT MATTERS. Please take advantage of the opportunity to build your skills through the assigned homework.*

Blackboard Subunit Lecture Quizzes: To provide practice with multiple choice type problems, timed Subunit Lecture Quizzes (5 question, 5+ minutes) will be posted on Blackboard for each Subunit. Students should review each Subunit and earlier textbook reading, take notes on the associated and earlier Subunit lectures (in person, via Zoom and/or through recordings) and complete the associated Subunit and earlier Achieve Subunit Homeworks before attempting each Subunit quiz. Quizzes are open note and open book. Working with other people is not allowed. Quizzes are due 7:59 pm the Monday after Unit homeworks are due.

Dual Unit Exams: Semester Exams will be timed, closed-book, closed-note, individual exercises covering two units starting at 8:00 pm EST on selected Wednesdays (the Unit 7 Exam will be combined with the final). **NO MAKE-UP DUAL UNIT EXAMS WILL BE GIVEN.** For documented excused absences, the remaining Unit Exams and Final will be weighted more heavily to account for the missed exam. If you know that you will have a conflict with a scheduled exam due to a College function such as varsity sports, choir, etc., or documentable professional development event, please coordinate with Prof. Bebout **in advance** of your absence. Documentation for extraordinary circumstances requiring an exam absence must be obtained from the Dean of Students Office. Unexcused absences for scheduled exams, including early departures or late returns from weekends/spring break, fraternity/sorority functions, family reunions, undocumented “emergencies”, etc. will result in a grade of zero for the missed exam.

Final Exam: The final exam for Chem 208 02 is scheduled for Tuesday, May 17th from 9:00 am – noon. The final exam for this section will consist of a 50 min Unit 7 segment and a 120 min cumulative segment. Plan on taking the final exam at the scheduled time unless you meet the limited criteria for rescheduling a final (three consecutive examination periods on consecutive days or a conflict between scheduled examinations). The Dean of Students Office handles deferral requests from students unable to take their examinations at the time scheduled on account of documented illness or other extenuating circumstances (such as a death or other family emergency, conflict with a religious holiday, or participation in activities by a student representing the College). Final examinations that are deferred will normally be scheduled for second week of the Fall 2022 semester.

Optional Zoom Q&A Sessions/Office Hours (<https://cwm.zoom.us/j/99847387887>): Scheduled every Monday and Wednesday (except when an exam is scheduled) starting at 8:00 pm EST lasting 30-90 minutes depending on student interest (Zoom automatically times-out after ~30 minutes of inactivity). Log into Zoom with your W&M e-mail address for access security. Zoom sessions will be open Q&A sessions. Please have your video on (if possible) and identify yourself by name during Zoom participation.

Optional Textbook Problems: Working extra problems helps promote concept mastery. Answers to roughly half of the end-of-chapter problems are found in the back of the OpenStax text. Detailed solutions to these problems are found in the *Student Solutions Guide* available from OpenStax. Doing the end-of -chapter problems with solutions available for practice, focusing on areas of weakness, is optional and highly recommended.

Optional Extra Credit: Optional extra credit opportunities are provided for students who are willing and able to invest extra time in mastering CHEM 208 this semester. My teaching philosophy includes EVERY POINT MATTERS. Orientation activities associated with building our classroom community are offered for a maximum of 5 pts extra credit. General Chemistry I review activities are offered for a maximum of 8 points to motivate students to remediate if needed or desired. In lieu of extra credit, students may opt to not maximize points earned from homework (infinite tries/Blackboard Discussion Board/Instructor Q&A available) and Lecture Activities to balance other demands on their time. Ideally, 3 pts should be earned for EVERY Subunit homework and 1 pt from EVERY Subunit Lecture Activity. Furthermore, EVERY Subunit homework should be attempted since each Subunit homework covers different concepts and some questions are freebies (i.e. multiple choice problems with no penalties for multiple attempts). Finally, there is a Final Review Homework worth 10 points extra credit.

William & Mary Honor System

William & Mary has an Honor System detailing the academic responsibilities of all students. Students may work with other students on homework and extra credit but are required to submit their own answers. Quizzes will be open note, open book and independent within a tight time constraint. Exams will be closed book, closed note, independent and proctored by Honorlock. Non-emergency use of a cell phone or other unapproved resources during an exam is grounds for Honor Council proceedings, as well as an F on the exam or an F in the class at the discretion of Prof. Bebout. All content of this course is covered by US Copyright protection laws. Distribution of any course materials beyond the William & Mary community will be treated as a violation of the William & Mary Student Honor Code.

Mental and Physical Well-Being

William & Mary recognizes that students juggle different responsibilities and can face challenges that make learning difficult. There are many resources available at W&M to help students navigate emotional/psychological, physical/medical, material/accessibility concerns. Asking for help is a sign of courage and strength. If you or someone you know is experiencing any of these challenges, we encourage you to reach out to the following offices:

- For psychological/emotional stress, please consider reaching out to the W&M Counseling Center <https://www.wm.edu/offices/wellness/counselingcenter/>; or (757) 221-3620, 240 Gooch Dr., 2nd floor. Services are free and confidential.
- For physical/medical concerns, please consider reaching out to the W&M Health Center at <https://www.wm.edu/offices/wellness/healthcenter/>; or (757) 221-4386, 240 Gooch Drive.

- For additional support or resources, please contact the Dean of Students by submitting a Care Report at <https://www.wm.edu/offices/deanofstudents/services/caresupportservices/index.php>; or by calling 757-221-2510, or by emailing deanofstudents@wm.edu.
- For a list of many other resources available to students, see [Health and Wellness Resources for Students](#)

As your professor, I also ask you to reach out to me if you are facing challenges inside or outside the classroom; I will guide you to appropriate resources on campus.

Student Disability Accommodations

Students with disabilities will be accommodated in accordance with federal laws and University policy. Any student who feels he/she/they may need an accommodation based on the impact of a learning, psychiatric, or chronic health diagnosis should contact Student Accessibility Services staff at 757-221-2509 or at sas@wm.edu to determine if accommodations are warranted and to obtain an official letter of accommodation. For more information, please see www.wm.edu/sas. If you anticipate requiring specific accommodation based on documented disabilities, please let me know *no later than February 6* (by response to question 11 on the course survey, an email or personal contact) so I can make adjustments to minimize their impact on your performance in this class. Students with approved accommodations are responsible for contacting Prof. Bebout to confirm a common understanding of how accommodations will be implemented in this course.

Semester Calendar (Subject to change by W&M administration mandate/conflicting local natural disaster/extended power outage)

Unit Scope		S	M	T	W	R	F	S	Unit Scope
0: Orientation & Review Achieve practice activities (if needed) 8 Achieve Adaptive Review Quizzes	J A N					6	7	8	Optional Extra Credit activities (£R) due February 6 at 11:59 pm
		9	10	11	12	13	14	15	
		16	17	18	19	20	21	22	
1: Acid-Base Equilibria <i>Review 3.7, 351-6; 7.1,3;13.1-4</i> Read 14.1-5; 15.2(not K _a); W3.1 Four Subunit LA/HW/BQ & 1 AQ	F E B	23	24	25	26	27	28	29	2: Advanced Aqueous Equilibria <i>Review 348-351;13.2;14.1-5;W3.1</i> Read 14.6,7; 15.1-3 4 Subunit LA/HW/BQ & 1 AQ
		30	31	1	2	3	4†	5	
		6 [£] 1 ^{£R}	7 [§] 1	8	9	10	11	12	
3: Thermodynamics & Electrochemistry <i>Review 356-63; 9.3; 12.1-4</i> Read 16.1-7; W4.2,3,4 Four Subunit LA/HW/BQ & 1 AQ	M A R	13	14	15	16	17	18	19	4: Hybridization & MO Theory <i>Review 3.3, 4.1,4-6</i> Read 5.1-4 4 Subunit LA/HW/BQ & 1 AQ
		20 ^{£2}	21 ^{§2}	22 ^{£12}	23 ^{£12}	24	25	26	
		27	28	1	2	3	4	5	
5: Transition Metal Chemistry <i>Review 3.3, 4; 4.3, 6; 5.4; 15.2</i> Read 19.1-3; W 3.2; 5.1-10 Four Subunit LA/HW/BQ & 1 AQ	A P R	6 ^{£3}	7 ^{§3}	8	9	10	11	12	6: Kinetics Read 17.1-7 4 Subunit LA/HW/BQ & 1 AQ
		13	14	15	16	17	18	19	
		20	21	22	23	24	25	26	
7: Nuclear & Radiochemistry <i>Review 17.3, 4</i> Read 20.1-5 Four Subunit LA/HW/BQ & 1 AQ	M A Y	27 ^{£4}	28 ^{§4‡}	29 ^{£34}	30 ^{£34}	31	1	2	Final May 17 7-10 pm EST Extra credit review HW 25 min Nuclear & Radiochemistry 2 hr Cumulative Final
		3	4	5	6	7	8	9	
		10 ^{£5}	11 ^{§5}	12	13	14	15	16	
		17	18	19	20	21	22	23	
		24 ^{£6}	25 ^{§6}	26 ^{£56}	27 ^{£56}	28	29	30	
		1	2	3	4	5	6	7	
		8 ^{£87}	9	10	11	12	13	14	
		15 ^{£R}	16 ^{£7}	17 ^{7Ω}					

KEY: Darker shading used for potential Lecture Activity (LA) days

Openstax section or page readings in orange

Wikibooks section readings in maroon

† Add/drop period ends at 11:59 pm February 4, 2022

‡ Withdraw period ends 11:59 pm EST Monday, March 28, 2022

£ Four Subunit Achieve Homework (HW) due 11:59 pm

§ Four Unit Blackboard Quizzes (BQ) due at 7:59 pm

£ Achieve Adaptive Quizzes due at 7:59 pm for exam units

£ 50 min. Dual Unit Exam in ISC 1221; starts at 8:00 pm

Spring Break

7Ω Unit 7 exam + Cumulative Final 9 am – 12 pm

Overview of Critical General Chemistry I and Math Knowledge

Common Symbols & Abbreviations used in Lecture (atomic symbols and constants not listed)

∴ Therefore eq = equation H = Enthalpy e⁻ = electron k = rate constant t = time
Rxn = reaction ρ = density S = Entropy p = proton °C (K) = degrees Celsius (Kelvin) T = Temperature
Soln = solution E = Energy G = Free Energy n = neutron K = equilibrium constant P = Pressure
m = mass M = Molarity J = Joule n = # moles Q = Reaction quotient V = Volume

Arrows: → used if reaction goes “to completion” (approximation); ⇌ or ⇆ used for equilibria (always valid); ↔ used for resonance
[A] = Molar concentration of A (moles A/liter solute); (s), (l), (g) = solid, liquid, gas, respectively
 ${}^A_Z X$ = Atomic symbol where A = Mass Number = # protons + # neutrons, Z = Atomic number = # protons, X = element symbol

Significant Figures

Rounding: Carry all the digits available through calculations to avoid round off error. If ≥ 5 , round up; if < 5 round down.

Addition & Subtraction: Modify the result to have the same number of *decimal places* as the number with the *fewest decimal places*.

Multiplication & Division: Modify the result to have the same number of *significant figures* as the number with the *fewest sig. figs.*

Combined calculations: Apply above rules in the same order as their respective operations in performing calculation.

Logarithms: Number of decimal places in the log is equal to the number of significant figures in the original number.

Approximations: $100 - x \cong 100$ when $x \ll 100$

Nomenclature

General: Cations first by element name(oxidation state) then simple anions Xide; Compounds are **neutral**

Number prefixes: 1-10 = mono- (rarely used), di-, tri-, tetra-, penta-, hexa-, hepta-, octa-, nona-, deca-

Oxyanions: if two O max XO_n = Xite, XO_{n+1} = Xate; if four O max XO = hypoXite; XO_2 = Xite; XO_3 = Xate; XO_4 = perXate

Important types of solution reactions

Acid-base reactions: typically involve a transfer of H^+ ions (more generally electron pair donor/acceptor chemistry)

Precipitation reactions: formation of a solid occurs

Oxidation-reduction reactions: involve electron transfer [organic: reduction (oxidation) gain H (O) OR lose O (H), not both!]

Bonding & Orbitals

Ionic bond: electrons are transferred to form ions

Covalent bond: equal sharing of electrons

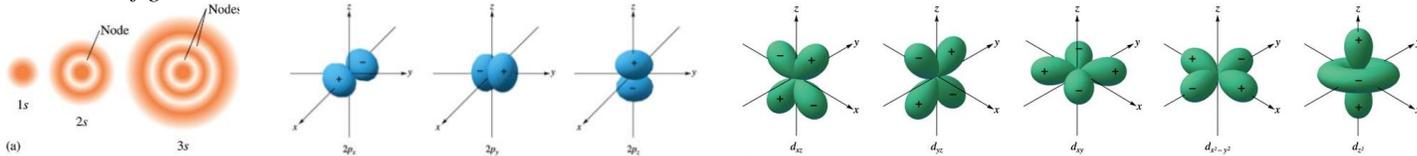
Polar covalent bond: unequal electron sharing

Octet Rule: Main group elements tend to bond in manner that each atom has eight electrons (strict for C, N, O & F only)

Electronegativity: Relative ability of atom to attract shared e⁻; polarity of bond depends on relative electronegativity of bonded atoms

VSEPR Model: Valence shell Electron Pair Repulsion model = minimization of electron pair repulsion dictates geometry

Orbital Configurations:



Electron configurations: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10}$ etc. & periodic table representation

Valence Shell Electron Pair Repulsion (VSEPR) Theory: Predicts molecules will adopt an arrangement that minimizes e⁻ repulsion

Thermodynamics

First law of thermodynamics: Energy is conserved.

Second law of thermodynamics: Entropy of the universe increases in a spontaneous process.

Third law of thermodynamics: The entropy of a perfect crystal at 0 K is zero.

State functions: Functions which are path independent and only depend on endpoints (eg. energy, enthalpy, entropy, free energy)

Standard state: 1 M concentrations, 1 atm, 25.00 °C = 298.15 K

Exothermic: Energy as heat flows out of system; opposite of endothermic

Rxn(G, H, S): $\Delta X^\circ_{Rxn} = \Sigma X^\circ_{Products} - \Sigma X^\circ_{Reactants}$ (Reminder: $H^\circ(\text{element}) = 0$; $G^\circ(\text{element}) = 0$; $S^\circ(\text{element}) > 0$)

$\Delta G^\circ = \Delta H^\circ - T \Delta S^\circ$ used to determine dependence of spontaneity on T; @ eq, $\Delta G^\circ = 0 \therefore T = \Delta H^\circ / \Delta S^\circ$; $\Delta S^\circ_{Universe} = \Delta S^\circ_{Sys} + \Delta S^\circ_{Sur}$

Equilibria

K = Equilibrium Constant = $\frac{[\text{product}]}{[\text{reactants}]} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$ for the reaction $aA + bB \rightleftharpoons cC + dD$

Q = Reaction Quotient; If $Q > K$, rxn will shift toward reactants, if $Q < K$ rxn will shift toward products

Standard practices for K and Q: Molar concentrations used for all solutes; partial pressures in atmospheres used for all gases; both K and Q are “unitless” themselves but must be calculated using numbers with the right units

Equilibria are temperature, concentration, and pressure (volume) dependent

Le Châtelier's Principle: when a stress is placed on a system at equilibrium, the system shifts in the direction that relieves the stress

Dynamic State: At equilibrium, reactants and products are interconverted continually; Forward rate = Reverse rate

Mass Balance: Products come from reactants in a stoichiometry dependent manner; Facilitates calculations based on change