Purdue University
Chemistry 11610 and 11620 Advanced Credit Study Guide

This study guide describes the topics to be mastered prior to attempting the examination for credit in Chemistry 11610 and 11620. The material covered can be found in a number of books on the market, including the current textbooks used for CHM 11510/11610 at Purdue University. A list of possible textbooks is given below.

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IMPORTANT:

1. Only **ONE** attempt is allowed for each Chemistry Advanced Credit Exam.
2. To be eligible to take an Advanced Credit exam a student must: A) have no established grade for the course except a "W" and, B) cannot be enrolled in the course after the fourth (4th) week of the semester.
3. To be eligible to take the Advanced Credit exam for CHM 11610 and 11620, you must have credit for CHM 11510 and CHM 11520 or an equivalent course. Students who have recorded passing credit for both CHM 11100 AND 11200 are eligible to take the CHM 11610 and 11620 Advanced Credit exam.
4. Allowable calculators for Chemistry Advanced Credit Exams are restricted to one or two line TI-30X and TI-36X models. Must have TI-30X or TI-36X in the model name.
5. Read this material thoroughly if you expect to take the Advanced Credit Exam.
6. Study the material listed in the outline.
7. Work as many practice problems as possible.
8. When you feel prepared to take the Advanced Credit Exam, try the sample exam at the end of this study guide first.
9. Come to the examination rested and confident.
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Suggested Textbooks

Chemistry & Chemical Reactivity, 8th ed by Kotz, Treichel & Townsend; Thomson/Brooks/Cole. ISBN-13: 978-0840048288.

Chemistry: The Molecular Nature of Matter and Change, 10th edition, by Silberberg and Amateis; McGraw-Hill. ISBN-13: 9781266199233.

Chemistry, The Central Science by Brown, 14th edition by LeMay, Bursten, et. al.; Prentice-Hall. ISBN-13: 978-0134414232.

Test Topics/Preparation for Exam:

The subject matter of CHM 11610 and 11620 deals with the following topics: chemical thermodynamics, chemical equilibrium, kinetics, acids/bases/buffers, reduction-oxidation, and electrochemistry. Many of these topics are related, such as chemical equilibrium and acids/bases/buffers, or electrochemistry and thermodynamics. These topics rest upon a foundation of understanding fundamental concepts covered in a general chemistry I course, or CHM 11510.

The Advanced Credit exam will consist of two parts, for the lecture and lab components. CHM 11610 is the lecture component of the class; 11620 is the lab component of the class. You will have two hours (120 minutes) to complete the lecture component (CHM 11610) of the exam. If you pass the lecture component, you will be given 30 minutes to complete the lab component. If you get done with the lecture component of the exam before two hours is up, you do NOT get additional time for the lab component of the exam. You must pass the lecture part of the exam in order to be eligible to take the lab part of the exam.

You should study the topics listed in the attached outline prior to attempting the simple examination included with this study guide.

At the end of this study guide you will find a sample examination over this material. Naturally, it does not cover every topic, or every aspect of a topic. Following the sample exam are the answers to the questions.

Words of Advice
It is a student's responsibility to meet with his or her advisor to discuss myPurduePlan and to graduate on time with all requirements completed. Do not wait until the last weeks of your undergraduate program to establish credit in CHM 11610 and 11620 if it is part of your degree requirements.

If you fail the CHM 11610 and 11620 Advanced Credit Exam, your next best option is to take the CLEP exam https://admissions.purdue.edu/transfercredit/clep.php.

Do not request special consideration if you fail the CHM 11610 and 11620 Advanced Credit Exam and you are scheduled to graduate and have a job waiting. It is your responsibility to regularly meet with your advisor, to work within MyPurduePlan, and to complete your degree on time.

Listed below are a set of major topics may be covered on the CHM 11610 and 11620 Advanced Credit Exam. The exam contains a formula sheet for the exam that gives any formula and/or constant you may need to complete an item on the exam. You do not need to memorize formulas in order to pass the exam.

Chemical Thermodynamics

Define terms associated with thermodynamics such as system, surroundings, universe, and state functions.

Be able to state the First Law of Thermodynamics in terms of changes in internal energy accompanied by heat flow and work done on or by the system. Be careful to note the sign conventions when stating this law.

Be able to describe two types of work associated with chemical reactions. If discussing pressure-volume work, be able to calculate this quantity at constant opposing pressure.

Use the Second Law of Thermodynamics to describe the spontaneity of a system. Describe spontaneity and entropy. Predict the sign of an entropy change from a chemical reaction based upon the states of the products and reactants.

Calculate standard entropy, enthalpy, and Gibbs energy changes for a chemical reaction given data.

Apply Hess's Law – meaning find the change in enthalpy for a specific reaction given chemical reactions and change in enthalpy values of other reactions.
Know how Gibbs energy is related to entropy and enthalpy, and how Gibbs energy defines spontaneous processes.

Relate cell potentials and Gibbs energy.

Chemical Equilibrium.

Write an equilibrium constant for a chemical reaction and calculate its value for given concentrations of reactants and products.

Describe chemical equilibrium in terms of forward and reverse reaction rates, and changes in concentration of reactants and products, and using graphs.

Be able to use the reaction quotient Q to calculate if a reaction is at equilibrium and determine which way the reaction must proceed to reach equilibrium.

Describe and apply Le Chatelier's Principle to chemical systems.

Kinetics

Describe a reaction rate in terms of a change in concentrations divided by a change in time. Calculate a rate law from given data.

Know the integrated rate equations and half-life for zero order, first order, and second order reactions and associated graphs. Be able to give the rate constant in appropriate units for each order.

Describe how the energy of molecules affects their ability to react and how this can be represented in graphical form. Know how collision frequency, kinetic energy, and orientation of collision affect the rate of reaction.

Know how activation energy is experimentally determined using the Arrhenius Equation.

Describe how a catalyst impacts the rate of a chemical reaction and how this can be represented graphically.

Acids and Bases

Use the following models to describe acids and bases (this includes comparing and contrasting the models): Arrhenius, Bronsted-Lowry, and Lewis.

Know the term K_w and be able to write the dissociation reaction for water. What are the concentrations of H_3O^+ and OH^- at 25^oC?

Define pH and be able to calculate pH and pOH for any solution.

Define K_a and/or K_b and be able to calculate it for weak acids/bases.

Describe how a buffer functions, be able to identify buffer systems, and apply the concept of buffer capacity. Be able to calculate the effect on pH of adding an acid or a base to a buffer using the Henderson-Hasselbach equation.

Redox (Oxidation and reduction) reactions

Balance an oxidation/reduction reaction and be able to define the oxidation numbers of all atoms.

Given a redox reaction, identify the species being oxidized and reduced, and the oxidizing agent and reducing agent.

Identify strongest oxidizing agent or reducing agent from experimental data.

Electrochemistry

Be able to calculate cell potentials using the Nernst equation. If the cell potential is known, then know how to calculate Gibbs energy and equilibrium constant.

Draw electrochemical cell and identify the anode, cathode, solutions, salt bridge, and species being oxidized and reduced. Identify the direction in which electrons flow.

Describe an electrolytic and galvanic cell.

ADDITIONAL STUDY FOR THE CHM 11620 SECTION OF THE EXAM

The ideas of science and engineering cannot be engaged in and applied in the absence of inquiry and discourse that allow for the development and refinement of models and ideas. These are more than skills in the sense that they are applied knowledge that is specific to each practice below. These topics will be the covered on the lab part of the exam, in addition to the application of the concepts listed above.
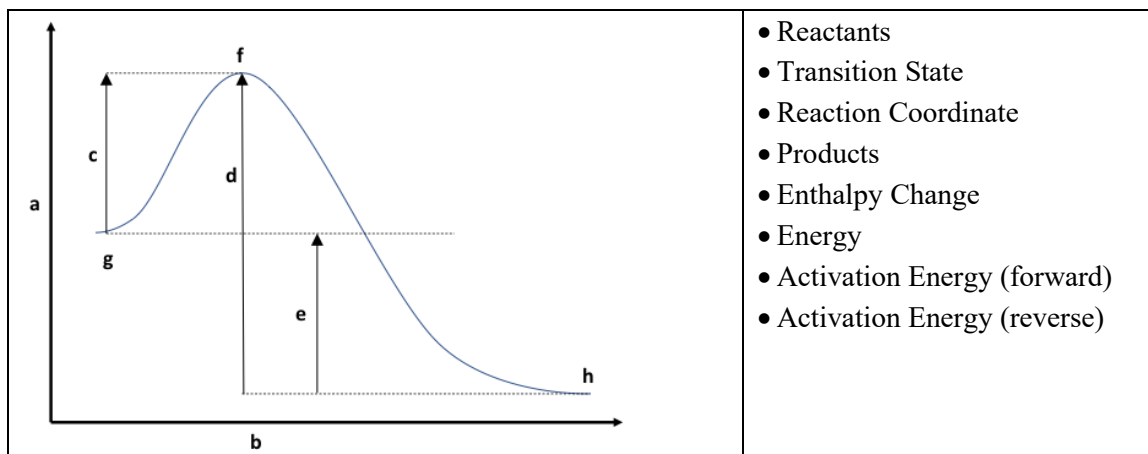
- Analyze and interpret numeric and spectroscopic data
- Use math and computational thinking
- Construct explanations (and evaluate them)
- Develop an argument from evidence (and evaluate it)

Chemistry 11610 Advanced Credit Practice Exam

_____ 1. Consider the reaction below. If the rate of reaction of nitric oxide is 0.066 M/s, what is the rate of consumption of oxygen?

$$2 \text{ NO } (g) + O_2 (g) \rightarrow 2 \text{ NO}_2 (g)$$

(a) 0.132 M/s

(b) 0.066 M/S

(c) 0.033 M/s

(d) −0.132 M/s

_____ 2. In 500. ml of a 0.15 M solution of NaCl what is the concentration of sodium ions?

(a) 0.30 M

(b) 0.15 M

(c) 8.8 g

(d) 4.4 g

_____ 3. Calculate the pH of a solution containing 0.15 M NH_3 and 0.35 M NH_4Cl.

K_a = 5.6 x 10^{-10}.

(a) 10.1

(b) 9.62

(c) 8.88

(d) 8.40

_____ 4. What is the concentration (in M) of hydronium ions in a solution at 25°C with pH = 4.282?

(a) 1.92 x 10^{-10} M

(b) 5.22 x 10^{-5} M

(c) 5.22 x 10^{-4} M

(d) 9.718

_____ 5. Which has the highest normal boiling point?

(a) CH_4

(b) C_2H_6

(c) C_3H_8

(d) C_4H_{10}

6. Find the pH of a 0.235 M solution of acetic acid, CH_3COOH. The K_a for acetic acid is 1.8×10^{-5}.

   (a) 4.23×10^{-6} M

   (b) 2.06×10^{-3} M

   (c) 2.69

   (d) 5.37

7. Which of the following liquids has the lowest vapor pressure at room temperature and 1 atm pressure?

   (a) CH_4

   (b) CH_3CH_3

   (c) CH_3OH

Use the following diagram for questions 8-11

• Reactants
• Transition State
• Reaction Coordinate
• Products
• Enthalpy Change
• Energy
• Activation Energy (forward)
• Activation Energy (reverse)

8. Which identifies the activation energy?

   (a) c

   (b) d

   (c) e

   (d) d-c

9. Which identifies the enthalpy change?

   (a) c

   (b) d

   (c) e

(d) d-c

10. Which identifies the transition state?

(a) g

(b) f

(c) h

(d) b

11. Which identifies the products?

(a) g

(b) f

(c) h

(d) b

For questions 12. and 13. Use the following reaction and data table. Consider the reaction:
$P_4 (g) + 6 H_2 (g) \rightarrow 4 PH_3 (g)$

[P₄] (M)	[H₂] (M)	Initial Rate (M/s)
0.0110	0.0075	3.20×10^{-4}
0.0110	0.0150	6.40×10^{-4}
0.0220	0.0150	6.39×10^{-4}

12. What is the rate law for this reaction?

(a) Rate = $k[P_4][H_2]$

(b) Rate = $k[P_4]$

(c) Rate = $k[H_2]$

(d) Rate = $k[P_4][H_2]^6$

13. What is the value and units of the rate constant, k?

(a) $3.87 \ M^{-1} \ s^{-1}$

(b) $0.0291 \ s^{-1}$

(c) $0.0427 \ s^{-1}$

(d) $2.18 \times 10^{13} \ M^{-6} \ s^{-1}$

14. In which substance does bromine have an oxidation number of +1?

(a) Br_2

(b) HBr

(c) HBrO

(d) $HBrO_2$

_____ 15. In aqueous solution, Fe^{2+} reacts with permanganate ion (MnO_4^-) to form Fe^{3+} and Mn^{2+}. What is the reducing agent in this reaction?

(a) H_2O

(b) Fe^{2+}

(c) MnO_4^-

(d) Fe^{3+}

(e) Mn^{2+}

_____ 16. In which of the following species does sulfur have the same oxidation number as it does in H_2SO_4?

(a) H_2SO_3

(b) $S_2O_3^{2-}$

(c) S^{2-}

(d) S_8

(e) SO_2Cl_2

Use the following for 17-19: The data in the table below were obtained for the reaction:

$$2\ ClO_2\ (aq) + 2\ OH^-\ (aq) \rightarrow ClO_3^-\ (aq) + ClO_2^-\ (aq) + H_2O$$
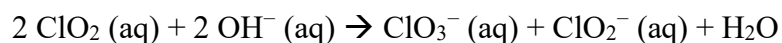
Experiment number	$[ClO_2]$ (M)	$[OH^-]$ (M)	Initial Rate (M/s)
1	0.060	0.030	0.0248
2	0.020	0.030	0.00276
3	0.020	0.090	0.00828

_____ 17. What is the order of the reaction with respect to ClO_2?

(a) 4

(b) 1

(c) 0

(d) 2

(e) 3

_____ 18. What is the order of the reaction with respect to OH^-?

(a) 0

(b) 1

(c) 2

(d) 3

(e) 4

_____ 19. What is the overall order of the reaction?

(a) 0

(b) 1

(c) 4

(d) 3

(e) 2

_____ 20. What is the magnitude of the rate constant for the reaction?

(a) 115

(b) 1.15×10^4

(c) 713

(d) 4.6

(e) 230

_____ 21. For a first-order reaction, a plot of _____ versus _____ is linear.

(a) $\ln [A]_t$, t

(b) $1/[A]_t$, t

(c) $\ln [A]t$, $1/t$

(d) $[A]_t$, t

(e) t, $1/[A]_t$

_____ 22. The thermodynamic quantity that expresses the degree of disorder in a system is _____.

(a) entropy

(b) internal energy

(c) heat flow

(d) enthalpy

(e) bond energy

_____ 23. Which one of the following is always positive when a spontaneous process occurs?

(a) ΔH_{univ}

(b) ΔH_{surr}

(c) ΔS_{surr}

(d) ΔS_{univ}

(e) ΔS_{sys}

_____ 24. $N_2(g) + 3 H_{2(g)} \rightarrow 2 NH_{3(g)}$

The reaction indicated above is thermodynamically spontaneous at 298 K, but becomes nonspontaneous at higher temperatures. Which of the following is true at 298 K?

(a) ΔG, ΔH, and ΔS are all positive.

(b) ΔG, ΔH, and ΔS are all negative.

(c) ΔG and ΔH are negative, but ΔS is positive.

(d) ΔG and ΔS are negative, but ΔH is positive.

(e) ΔG and ΔH are positive, but ΔS is negative.

_____ 25. When solid NH_4SCN is mixed with solid $Ba(OH)_2$ in a closed container, the temperature drops and a gas is produced. Which of the following indicates the correct signs for ΔG, ΔH, and ΔS for the process?

	ΔG	ΔH	ΔS
(a)	−	−	−
(b)	−	+	−
(c)	−	+	+
(d)	+	−	+
(e)	+	−	−

_____ 26. The energy diagram for the reaction $X + Y \rightarrow Z$ is shown. The addition of a catalyst to this reaction would cause a change in which of the indicated energy differences?

(a) I only

(b) II only

(c) III only

(d) I and II only

(e) I, II, and III
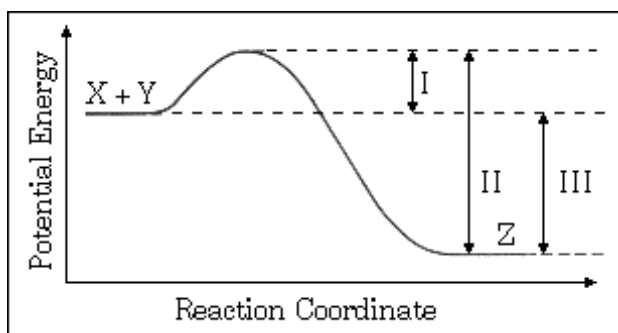
_____ 27. Given the following balanced chemical equation: $3\ C_2H_{2(g)} \rightarrow C_6H_{6(g)}$

What is the standard enthalpy change, $\Delta H°$, for the reaction represented above?
($\Delta H°_f$ of $C_2H_{2(g)}$ is 230 kJ mol^{-1} ; $\Delta H°_f$ of $C_6H_{6(g)}$ is 83 kJ mol^{-1})

(a) −607 kJ

(b) −147 kJ

(c) −19 kJ

(d) + 19 kJ

(e) +773 kJ

_____ 28. Calculate the pH of a solution prepared by dissolving 2×10^{-3} moles of HCl in enough water produce 1.0 L of solution.

(a) –2.7

(b) 2.3

(c) 2.7

(d) 3.3

_____ 29. Which of the following statements about a 0.10 M solution of NH_4Cl is correct?

(a) The solution is basic.

(b) The solution is neutral.

(c) The solution is acidic.

(d) The values for K_a and K_b for the species in solution must be known before a prediction can be made.

_____ 30. Calculate the $[H_3O^+]$ concentration (in M) in a 0.1 M aqueous solution of NH_3

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$[K_b = 1.8 \times 10^{-5}]$

(a) 7.5×10^{-12} M   (c) 1.8×10^{-6} M

(b) 3.0×10^{-10} M   (d) 1.3×10^{-3} M

_____ 31. A pH buffer is best described as a solution containing:

(a) a weak acid.
(b) a strong acid.
(c) a mixture of a weak acid and a strong acid.
(d) a mixture of a weak acid and the salt of a weak acid.

_____ 32. Which of the following best describes all the intermolecular forces exhibited by a pure sample of CH_3NH_2?

(a) dispersion only
(b) dipole-dipole and hydrogen bonding
(c) dispersion and hydrogen bonding
(d) dispersion, dipole-dipole, and hydrogen bonding
(e) dispersion and dipole-dipole

_____ 33. The pH of a solution prepared by mixing 50.0 mL of 0.125 M KOH and 50.0 mL of 0.125 M HCl is _____.

(a) 0.00
(b) 6.29
(c) 8.11
(d) 5.78
(e) 7.00

_____ 34. The boiling point for isomers of $C_2H_4O_2$ are shown in the figure below. The reason acetic acid has a higher boiling point is

Acetic acid	(structure: H–C with 3 H's, –C double bond O, OH)	118°C
Methyl acetate	(structure: O double bond C, H, O–CH₃)	56.9°C

(a) Acetic acid has a larger molar mass.

(b) Methyl acetate has stronger dispersion forces between its molecules.

(c) The –CH$_3$ group on the methyl acetate interacts with the carbon oxygen double bond differently than in acetic acid.

(d) Acetic acid forms hydrogen bonds while methyl acetate does not.

ANSWERS

1. C		26. D	
2. B		27. A	
3. C		28. C	
4. B		29. C	
5. D		30. A	
6. C		31. D	
7. C		32. D	
8. A		33. E	
9. C		34. D	
10. B			
11. C			
12. C			
13. C			
14. C			
15. B			
16. E			
17. D			
18. B			
19. D			

20. E

21. A
22. A
23. D
24. B
25. C