

CHEN 3AA0 Chemical Engineering Progress Assessment II
(Concepts Inventory Exam)
Instructions and Information for Students
(Revised January 10, 2024)

This document is intended to familiarize students with the Auburn University Department of Chemical Engineering Progress Assessment II which is also referred to as the Concept Inventory Exam (CIE). The following material discusses the nature of the CIE and the CHEN 3AA0 course including the manner in which they are administered.

Purpose: The purpose of the CIE is to improve the department's educational program by determining the extent to which students can successfully recall, apply and explain chemical engineering principles. The requirement that each student successfully pass this CIE with an acceptable score ensures that all graduates of this department have demonstrated adequate proficiency in chemical engineering principles and concepts. Furthermore, information from this exam process will allow the department to identify subject matter and content needing additional coverage or a different approach to its instruction.

Nature of Exam: The CIE consists of 15 multiple choice questions and 5 explain/describe questions. Each question is worth 5% credit for an overall total of 100%. These questions are generally non-numerical in nature (in that they usually will not have a numerical answer) but may involve processing some numerical data. You are permitted to use an approved calculator during the exam. No outside reference materials are allowed to be used during the exam. There are several equivalent versions of the exam which may be employed simultaneously to obtain the broadest information about student retention of important chemical engineering concepts. The time allotment for completion of the exam is 2 hours. A Scantron sheet is required (provided by the department) for the multiple choice portion of the exam.

Administration: The CIE is offered in CHEN 3AA0 and is part of the passing criteria in CHEN 3AA0. Students passing the CIE and participating in the Resume Review Process are eligible to pass CHEN 3AA0 and are thereby allowed into Process Design Practice (CHEN 4470). During the first few weeks of the fall term, the CHEN 3AA0 instructor(s) of record will administer the exam. Students who do not pass the first offering of the exam are eligible to take the exam at a later time during the fall semester. The second offering is scheduled during the late part of the term (exact date announced by the instructor) to provide time to study material and topics the student determines they need to review. The CIE will also be offered one time toward the end of spring and one time toward the end of summer semesters. Therefore, the CIE will be offered a maximum of four times per calendar year. Students should not enroll in CHEN 3AA0 unless they are concurrently enrolled in CHEN 3650 or have previously taken CHEN 3650.

The exam will be conducted in two stages during the exam period. The first stage includes only the multiple choice questions. The second stage includes only the explain questions. All students will begin with the first stage of questions. When complete, students will signal the instructor and/or GTAs to turn in their multiple choice papers and

receive the explain question papers. It is up to the student to manage their time and decide when to switch stages during the exam. The total time allotment is 2 hours to complete both stages of the exam.

Passing Criteria: The passing criteria for the CIE are evaluated by the faculty on a yearly basis. For recordkeeping purposes, the start of the CIE yearly cycle is the spring semester. Due to the evolving nature of the exam content, each yearly cycle of offerings may have differing passing criteria in order to maintain the departmental standard of excellence. It is anticipated that changes to the passing criteria will occur primarily on a yearly basis. For the 2023 calendar year offerings, the CIE passing criteria are: 1) 50% or greater in the overall exam score AND 2) that at least two (2) of the five (5) explain questions are acceptable (passing). In addition, a response is required for all questions, even if the response is along the lines of “I don’t know” (IDK).

Scoring: It is the intention of this exam to accurately assess each student’s retention and understanding of important concepts covered in previous courses. Students are expected to seriously attempt to provide an answer on all questions. The multiple choice questions will have 5 possible choices and one of them will be the single correct/best answer. Explain questions have free-form responses, and are generally expected to be answered in a short paragraph (or at most two). Responses to multiple choice questions are either correct or incorrect and a correct response adds 5% to the exam score. Responses to explain style questions are scored as “acceptable” or “unacceptable” and acceptable response add 5% to the exam score. Incorrect or unacceptable responses do not add to or subtract from the exam score. Several sample questions of each type are provided at the end of this information sheet.

CHEN 3AA0 and its relationship to CHEN 4470: CHEN 3AA0 has been and will continue to be a prerequisite course for CHEN 4470. It is expected that students will fulfill the prerequisite by passing the CIE.

Coverage: The subject matter tested on in the CIE includes major topics and course outcomes from the following courses:

| | |
|---------------------------|---|
| CHEN 2100 | Principles of Chemical Engineering (Material and Energy Balances) |
| CHEN 2110 | Chemical Engineering Thermodynamics |
| CHEN 2610 | Transport I |
| CHEN 2650 | Chemical Engineering Applications of Mathematical Techniques |
| CHEN 3370 | Phase and Reaction Equilibria |
| CHEN 3600 | Computer-Aided Chemical Engineering |
| CHEN 3620 | Transport II |
| CHEN 3650 | Chemical Engineering Analysis |
| CHEN 3660 | Chemical Engineering Separations |
| CHEN 3700 | Chemical Reaction Engineering |

The course numbers above are clickable links to the corresponding course outlines. The course outcomes are contained within the course outline document.

Students with Accommodations: Students that have approved accommodations must arrange to take their exam with the Office of Accessibility and be proctored by that office. The proctored exam may not be held before the date and time of the established exam offering. The Department of Chemical Engineering does not have the staffing or resources to offer proctored exams in CHEN 3AA0 for students with accommodations.

Resume Review Process: Students in CHEN 3AA0 have the option to participate in a resume review program operated by the Department of Chemical Engineering Alumni Council. Students that choose to take advantage of this opportunity do so by submitting their resume (through Canvas). Resumes are due to the instructor approximately one month prior to the final exam offering in the term. The exact cutoff date for submission will be communicated by email and set as the due date in the canvas upload assignment. Before submission of the resume Alumni Council review, students should first make use of the available reviewing services (<https://career.auburn.edu/students/resume> and <https://www.eng.auburn.edu/cdcr/undergraduate/resumes>) to refine their resume.

Sample Problems: The following problems are typical of those making up the CIE.

Sample Problem (A)

Identical rigid tanks contain two different ideal gases. Tank 1 contains pure gas “A” while Tank 2 contains an equimolar mixture of “A” and “B”. The molecular weight of “A” is twice that of “B”.

If the pressure in both tanks is equal and temperature in both tanks is equal, what can be said about the molar density of the gases in the two tanks?

- Both have the same molar density since T, P and volume are the same.
- The molar density in Tank 1 is twice the density in Tank 2 because the molecular weight of gas “A” is twice that of gas “B”.
- The molar density in tank 1 is half the density in tank 2 because the molecular weight of gas “A” is twice that of gas “B”.
- Nothing can be said about the molar density because the volume of the tank is not specified.
- The molar density of the gases within the two tanks can never be equal since the molecular weights of “A” and “B” are different.

Sample Problem (B)

Consider the following set of energy balance equations that model a particular heat exchange system.

$$\rho_L C_L S_L \frac{\partial T}{\partial t} = -\rho_L C_L S_L v \frac{\partial T}{\partial z} + h_L A_L (T_w - T_L)$$

$$\rho_w C_w S_w \frac{\partial T_w}{\partial t} = +h_s A_s (T_s - T_w) - h_L A_L (T_w - T_L)$$

Assume usual variable declarations, and assume all boundary conditions and constants are known. Which of the following statements best describes the model?

- The model is a steady state, lumped parameter, coupled system.
- The model is an unsteady steady state, lumped parameter, non-coupled system.
- The model is an unsteady state, distributed parameter, coupled system.
- The model is a steady state, distributed parameter, non-coupled system.

- e. The model is an unsteady state, lumped parameter, coupled system.

Sample Problem (C)

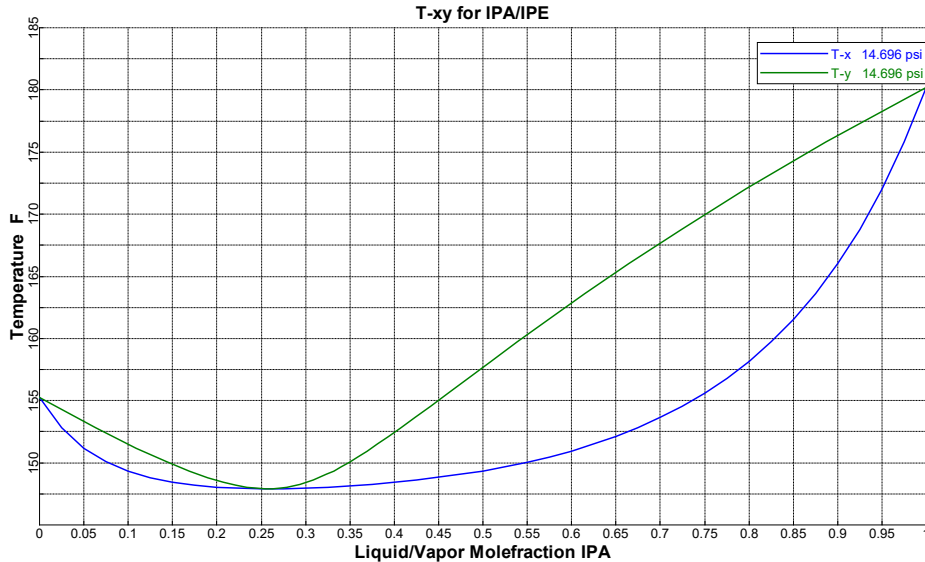
In your first assignment in a professional engineering capacity upon graduation from Auburn University, you are asked to participate in a plug flow reactor (PFR) design project. In conversations with fellow engineers, you are asked to give a brief review of isothermal reactor design principles.

Which statement is true?

- a. When there is a decrease in the number of moles with the chemical reaction in the gas phase, then the volumetric flow rate increases as the fluid moves through the reactor.
- b. For both liquid-phase and gas-phase reactions, the effects of pressure drop must be properly accounted for.
- c. As a general rule of thumb, for reaction orders greater than zero order, the conversion will be greater when there is a pressure drop than in the absence of a pressure drop.
- d. For gas-phase reactions with orders greater than zero, the reaction rate will be less than in the case of no pressure drop.
- e. All of the above.

Sample Problem (D)

Binary mixtures of iso-propyl-alcohol (IPA) and iso-propyl-ether (IPE) at 14.696 psi exhibit the vapor-liquid equilibria outlined in the figure below:



Ordinary distillation is used for the separation of a mixture consisting of 10% IPA.

Which of the following statements is true:

- The highest achievable concentration of IPE in the distillate is 100%.
- The IPA content of the distillate cannot exceed 25%.
- The maximum temperature in the reboiler is 180°F, and the minimum temperature in the condenser is 155°F
- The maximum temperature in the reboiler is 155°F, and the minimum temperature in the condenser is 148°F
- Both (b) and (d).

Sample Problem (E)

Consider the need to insulate a flat wall using three different insulating materials, each having the same thickness. The materials have constant thermal conductivities, k , of 1, 2, and 3 $\text{Wm}^{-1}\text{K}^{-1}$. You are asked to advise workers on the proper installation order of the three materials so that the final composite will be the most effective at reducing heat loss from the wall. Which statement is true?

- The insulation must be arranged in order of increasing k starting with the lowest k material at the wall surface.
- The insulation must be arranged in order of decreasing k starting with the highest k material at the wall surface.

- c. The insulation can be arranged in any order.
- d. It is impossible to decide because the temperatures are not specified and the order will depend on the ΔT .
- e. The insulation with the lowest k should be nearest the wall, and the order of the other two is irrelevant.

Sample Problem (F)

A small piece of metal at a temperature of 75 °C is placed into a covered insulated beaker of water at a temperature of 25 °C. The masses of water and metal are equal. After a long period of time, how would the temperatures of the water and metal be related assuming that no significant energy loss occurs through the beakers walls and cover?

- a. Since the mass of water and metal are the same, the system will end up at 50 °C.
- b. The temperature of the metal and water will be the same and will be somewhere between 25 °C and 75 °C depending on the heat capacity of the metal and water.
- c. The temperature of the metal and water will be the same and will be somewhere between 25 °C and 75 °C depending on the thermal conductivity of the metal and water.
- d. The metal will always remain slightly hotter than the water because metal stores energy better than water does.
- e. The temperature of the metal and water will be the same at 100 °C.

Sample Problem (G)

Explain the concept of accumulation. (Do not merely cite a general mass or energy balance equation, but rather clearly explain the meaning of the term “accumulation”.)

Acceptable Answer: Accumulation is the time rate of change of an extensive property, such as mass or total energy, within a control volume (fixed region in space). For processes operating in a steady state, the accumulation is zero.

Why it is acceptable: major engineering and science concepts are cited (e.g., control volume, extensive property, time rate of change) and a properly constructed explanation is then developed using these key concepts. Additional statements can be provided that demonstrate an understanding and application of the concept.

Unacceptable answer: Accumulation is the concept where an object flows into a system and its generation is greater than its flow out.

Why it is unacceptable: No identification of rate concept, control volume or extensive property. Also this response is erroneous and not general.

Unacceptable answer: $F_{A,0} - F_A + r_A V = \frac{dN_A}{dt}$ where $\frac{dN_A}{dt}$ is the accumulation.

Why it is unacceptable: Just citing an equation, not general and it does not identify the key concepts or demonstrate knowledge.

Unacceptable answer: For fluid flowing into a tank with fixed volume, the rate of mass and energy of the system entering the tank are equal to the rate of accumulation of mass and energy, assuming there is no mass and energy leaving the tank.

Why it is unacceptable: The concept of a control volume is confused with a specific tank volume. Accumulation is being illustrated in a specific example, not broadly defined or explained in general.

Unacceptable answer: Accumulation is defined as a buildup of substance within a volume in which it moves. Essentially, when performing a mole balance of a substance, exiting rates will be lower and entering rates. Generally, this happens when molecules bind to the microscopically rough surface within a pipe or reactor.

Why it is unacceptable: Concept of control volume is confused, significant erroneous information.

Sample Problem (H)

Explain the concepts of specific gravity, specific weight and density and how they relate to each other.

Sample Problem (I)

Explain the concept of a convective heat transfer coefficient and how it is employed.

Sample Problem (J)

State the equation for Fourier's Law and explain the meaning of every parameter in the equation including typical SI units.

Acceptable answer: $q = -k \frac{dT}{dz}$ where q is the heat flux, (usually W m^{-2}), k is the thermal conductivity (usually $\text{W m}^{-1} \text{K}^{-1}$) and $\frac{dT}{dz}$ is the temperature gradient in the z direction (usually K m^{-1}).