

**PRAIRIE VIEW A&M UNIVERSITY
ROY G. PERRY COLLEGE OF ENGINEERING
DEPARTMENT OF CHEMICAL ENGINEERING
CHEG 3304 Chemical Engineering Thermodynamics I
FALL 2021**

- I. COURSE DESCRIPTION IN ABET FORMAT**
- II STUDENT PERFORMANCE ASSESSMENT**
 - Course Outcomes Taught (None Assessed)**
 - Summary of Student Performance**
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(Summary of topics can be a separate page or include on the assignment itself)
 - Above Average (Graded original work)
 - Average (Graded original work)
 - Below Average (Graded original work)
- III. PROJECT ORAL REPORTS (VIDEO ARTICULATION)**
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(Summary of topics can be a separate page or include on the assignment itself)
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Course Description in ABET Format

CHEMICAL ENGINEERING DEPARTMENT CHEG 3304 CHEMICAL ENGINEERING THERMODYNAMICS II

1.	Course number and name:	CHEG 3304 Chemical Engineering Thermodynamics II
2.	Credits and contact hours:	3 credit hours; 3 contact hours
3.	Instructor's or course coordinator's name:	Dr. Irvin Osborne-Lee, Professor of Chemical Engineering
4.	Text book: Title:	Introduction to Chemical Engineering Thermodynamics
	Author:	J. M. Smith, H. C. Van Ness, and M. M. Abbott
	Publisher, Year & Edition:	7th edition, McGraw-Hill, 2001, ISBN: 0-07-310445-0 (preferred); or more recent edition. Authors website: http://www.mhhe.com/engcs/chemical/smith/
	a. Other Supplemental material	1. LearnChemE.com (last accessed 1/18/2021) http://www.learncheme.com/ . In particular, many of the screencasts on thermodynamics, http://www.learncheme.com/screencasts/thermodynamics 2. Devoe (last accessed 1/18/2021) http://www2.chem.umd.edu/thermobook/ , open source textbook.
5.	Specific course information	
	a. Brief description of the content of the course (catalog description)	Credit 3 semester hours. Properties of ideal and non-ideal binary and multi-component mixtures. Studies of equilibrium for single-and multi-component systems based on methods of corresponding states, equations of state and activity coefficients. Chemical equilibrium applied to both homogeneous and heterogeneous systems.
	b. Prerequisites or Co-requisites	CHEG 2334 (2043) and MATH 2320 (2043)
	c. *Indicate whether a required, elective, or selected elective (as per definition provided) course in the program	Required
6.	a. Specific goals for the course specific outcomes of instruction (e.g. The student will be able to explain the significance of current research about a particular topic.) <i>Students will be able to :</i>	b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course. <i>The specific goals for the course specific outcomes listed on the left column will address the following student learning outcomes:</i>
	1. Demonstrate knowledge of the 1st, 2nd and 3rd laws of thermodynamics	Outcome 1 An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
	2. Apply knowledge of 1st and 2nd laws of thermodynamics to identify, formulate and solve problems in energy conservation, power cycles, refrigeration cycles and liquefaction systems	

	3. Apply knowledge of multi-component mixture physical equilibrium, and chemical equilibrium to identify, formulate and solve problems in reacting and non-reacting systems		
	4. Demonstrate use of modern tools of the profession in solving multi-component mixture physical equilibrium problems in reacting and/or non-reacting systems		
7	Brief list of topics to be covered	Review 1 st , 2 nd & 3 rd laws (chapters 1-5) (6 hours) Ideal gas law (3 hours) Thermodynamic properties of fluids: states of matter, energy & entropy changes (6 hours) Maxwell's relations, equations of state, property relationships (3 hours) Residual properties (4 hours) Power & refrigeration cycles (6 hours) Vapor/liquid equilibrium (6 hours) Solution thermodynamics (6 Hours) Gamma Phi Formulation (3 hours) Project activities (3 hours) Total (45 hours)	

II STUDENT PERFORMANCE ASSESSMENT

Program Outcomes Assessed in this course: None

Program Outcomes Developed in this course: One outcome as shown below.

Outcome 1:

An ability to identify, formulate, and solve complex engineering problems (CEP) by applying principles of engineering, science, and mathematics.

.

Assessment Summary of Class Semester Averages for Outcomes

Not applicable

Student Performance Summary (Class Averages by Assignment Category)

Gradebook Summary

**CHEMICAL ENGINEERING THERMODYNAMICS II
FALL 2021**

**Title of Assignment: UPLOAD LETTER REPORT FOR PROJECT 1
Refrigeration Cycle Design Project**

**TOPICS COVERED IN PROJECT 1
(Project Activity & Letter Report Weight Category 50%)**

Project 1 covered the following topics:

1. Review of the 1st and 2nd laws of thermodynamics
2. Introduction of refrigeration cycle with application of thermodynamic principles
 - a. Cycles and state properties
 - b. Isothermal, isobaric, reversible, and irreversible processes
 - c. Use of thermodynamic tables
 - d. Real vs. ideal gas behavior
3. Concept of efficiency: compressor efficiency, cycle efficiency and coefficient of performance
4. Phase diagrams (p-H and T-S diagrams) and their use in representing and analyzing a refrigeration cycle
5. Application of 2nd law and concept of approach temperature in selecting condenser & evaporator operating pressure
6. Refrigerant selection based on operating pressure/temperature and global warming potential (GWP)
7. Experience working in teams
8. Written communication

Refrigeration Cycle Design Project

This assignment is a collaborative learning assignment. Work in teams assigned. Teams may consult each other but each team must prepare a project results poster presentation in PowerPoint™ and submit a letter report done up in Word™.

Problem Statement

A refrigeration system is to be designed to maintain the temperature in the range T_{LOWmin} to T_{LOWmax} , while the outside temperature varies from $T_{HIGHmin}$ to $T_{HIGHmax}$, as given in the team assignment matrix below. The total thermal load on the storage unit is given as 33 kW. Obtain an initial design for the vapor compression refrigeration system shown in Figure 1. Choose a safe and suitable refrigerant. For safe operation and other factors, such as additional energy transfer, design the system using a safety factor of 1.3. The compressor efficiency could range from 60 to 80 percent.

In the course of your design you will need to specify or/and determine the temperatures and pressures at the different states and show the cycle with the vapor dome on a temperature entropy ($T-s$) diagram or pressure enthalpy ($p-H$) diagram, or both. Also, you must determine the coefficient of performance value and the mass flow rate of the working fluid.

Further guidance on the expectations for the presentation and letter report will be provided during this week. The team assignments and design condition are shown in the table. The temperature ranges for the LOW and HIGH operating temperatures for the cycle give the range of values that may be expected for T_{LOW} and T_{HIGH} , respectively.

Significant insight to the design strategy can be gained by reviewing the paper* published by Mulaweh and Arfad. Thermodynamic data is a crucial requirement for success in this design activity. There are various sources†‡ of such data readily available. You may need to do some searching to find data for a suitable refrigerant for your assigned conditions.

* Hosni I. Abu-Mulaweh & Abdulaziz A. Al-Arfaj. "Engineering design experience of an undergraduate thermodynamics course," World Transactions on Engineering and Technology Education, Vol.10, No.1, 2012, pp. 77-81. Available at <http://www.wiete.com.au/journals/WTE&TE/Pages/Vol.10,%20No.1%20%282012%29/12-12-Abu-Mulaweh-H.pdf>, last accessed August 31, 2020.

† ASHRAE Handbook – "Fundamentals, Thermophysical Properties of Refrigerants," Product & Application Handbook, Vol. V J191, 2013, pp. J191-J207. Available at <http://www.baltimoreaircoil.com/english/resource-library/file/1485>, last accessed August 31, 2020.

‡ The Engineering Toolbox, Available at https://www.engineeringtoolbox.com/refrigerants-d_902.html#:~:text=Physical%20properties%20of%20some%20common%20refrigerants%3A%20%20%20-252%20%2031%20more%20rows%20, last accessed August 31, 2020.

	Name of Team Members (Team Set Choice)	Team Number	$T_{LOW,min}$	$T_{LOW,max}$	$T_{HIGH,min}$	$T_{HIGH,max}$
1	Kalaya Anderson	1	-20°C	-10°C	15°C	25°C
2	Kennedy Dent	1				
3	Devin Lockett					
4	Kennedy Meeks	2	-25°C	-15°C	15°C	25°C
5	Edgar Mendoza	2				
6	Yazmine Rincon					
7	Kiara Graham	3	-15°C	-5°C	25°C	30°C
8	Dynasty Stephenson	3				
9	Erron Williams	3				
10	Byron Henderson	4	-10°C	0°C	30°C	35°C
11	Maya Spears	4				
12	Wesley Walsh	4				
13	Shelton Amaram	5	-5°C	5°C	30°C	35°C
14	Kelby Smith	5				
15	Isaiah Waters	5				
16	Kayla Freeman	6	0°C	10°C	40°C	45°C
17	Janeria Perry	6				
18	Nina Patthammavong	7	-50°C	-40°C	0°C	5°C
19	Vivian Patthammavong	7				
20	Jazmaine Carter	8	-40°C	-30°C	0°C	5°C
21	Ariel Kinsey	8				
22	Alexis Rabb	8				
23	Zenab Coulibaly-Diakite	9	-30°C	-20°C	5°C	10°C
24	Meibryth Salas	9				
25	Jeffrey Sanders	9				
	Example Set	10	-35°C	-25°C	0°C	5°C

CHEMICAL ENGINEERING THERMODYNAMICS II

FALL 2021

SAMPLE PROJECT REPORTS AND GRADING RUBRIC FOR PROJECT 1

Rubric for Grading Letter Report

Task Description: This assignment is a collaborative learning assignment. Work in teams assigned. Teams may consult each other but each team must prepare a project results poster presentation in Powerpoint™ and submit a letter report done up in Word.					
Criteria	weight	Excellent 4 Yes	Good 3 Yes, but	Fair 2 No, but	Unacceptable 1 No
Format	10%	☐ Directly relevant to letter report style	☐ Somewhat relevant to letter report style	☐ Remotely related to letter report style	☐ Totally unrelated to letter report style
Organization	10%	☐ Good organization; points are logically ordered; sharp sense of beginning and end	☐ Organized; points are somewhat jumpy; sense of beginning and ending	☐ Some organization; points jump around; beginning and ending are unclear	☐ Poorly organized; no logical progression; vague beginning and ending
Quality of Information	25%	☐ Supporting details specific to subject; figures and tables captioned, called out and well discussed	☐ Some details are non-supporting to the subject; figures and tables captioned, called out and discussed	☐ Details somewhat sketchy; do not support topic. Not all figures/ tables captioned, called out and discussed	☐ Unable to find specific details. Figures and tables not captioned, called out and discussed
Grammar, Usage, Mechanics, Spelling	25%	☐ No errors	☐ Only one or two errors	☐ More than two errors	☐ Numerous errors distract from understanding
References	10%	☐ Citations are used wherever needed and helpful; are called out and organized properly.	☐ Citations are used in most places where needed; are mostly called out and organized properly.	☐ Citations are sometimes used but are not consistently called out and organized properly.	☐ Citations are not used or are used improperly.
Neatness	10%	☐ Typed; clean; neatly bound in a report cover; illustrations provided	☐ Legible writing, well-formed characters; clean and neatly bound in a report cover	☐ Legible writing, some ill-formed letters, print too small or too large; papers stapled together	☐ Illegible writing; loose pages
Timeliness	10%	☐ Report on time	☐ Report one class period late	☐ Report two class periods late	☐ Report more than one week late

Comments:

ABOVE AVERAGE

Figure 1: Refrigerators Power Cycle Flow diagram

Objectives

We used the identify, formulate, and solve methodology to evaluate four main objectives for this project.

- Select a safe and suitable refrigerant for the design
- Determine the temperatures, pressures, enthalpies, and entropies of each stream.
- Calculate the refrigerant circulation rate, Coefficient of performance (COP), and compressor efficiency.
- Complete a pressure-enthalpy (P-H) diagram and a temperature-entropy (T-S) diagram of the cycle.

Assumptions

To successfully design this cycle, we must make the following assumptions based off our problem statement.

- The four processes or devices operate as an open system. The cycle also operates as steady-state, and steady-flow.
 - The evaporator, condenser, compressor, and expansion valve operate as open systems.
 - The compressor and the expansion valve behave adiabatically, meaning heat transfer is negligible.
 - The evaporator and condenser behave isobarically as constant pressure devices.
- (Mulaweh and Al-Arfa, 2012)

Results

The first objective was to design a refrigeration cycle and to find a safe and suitable refrigerant for this design. We used the **identify** step to determine our refrigerant, label our flow diagram, and label our P-H diagram. We selected R-22, Chlorodifluoromethane as our working fluid. This refrigerant has been used for decades in homes around the United States. Although this refrigerant is no longer produced or imported in the United states, it is still used in one choice of air conditioner or a heat pump system and still available for purchase where there is R-22 in surplus.

The second objective was to determine the temperatures, pressures, enthalpies, and entropies of each stream. All missing parameters can be found using the pressure-enthalpy (P-H) diagram shown in figure 4, including the temperatures, pressures, enthalpies, and entropies of each stream. Tables 1 and 2 below show all values we calculated based on this diagram. Key equations can also be found below. The key equations used were retrieved and manipulated from the textbook, Introduction to Chemical Engineering Thermodynamics, 8th Edition. See Appendix A for full detail of the calculations.

Within the **formulate** step, we needed to find key equations. The following equations were obtained from both the Mulaweh and Al-Arfaj report, and the textbook Introduction to Chemical Engineering Thermodynamics, 8th Edition found in references. The equations listed below were used to solve key parameters of our refrigeration cycle.

- **Second Law of Thermodynamics analysis:**

$$\Delta S = \frac{Q}{T}$$

- **First Law of Thermodynamics analysis:**

$$d(mU)_{cp}/dt = -\Delta[\dot{m} (U + 1/2 u^2 + zg)]_{fs} + Q + \text{work rate}$$

- $\dot{m} = \frac{Q_L}{\Delta H}$
- $\dot{W}_c = \dot{m}\Delta H$ (work into the compressor)
- $\dot{Q}_H = \dot{m}\Delta H$ (heat rejected by condenser)
- $COP = \frac{\dot{Q}_L}{\dot{W}_c}$
- $\eta = \frac{H1 - H2}{H1 - H2'}$

The final step of the 3-step methodology is **solve**. Using the P-H and T-S diagram to determine values of each state, allowed our team to calculate values such as mass flow rate, heat rejected, compression work, and coefficient of performance. We were also able to determine the quality (x) of each state. Tables 1 and 2 below list the thermodynamic properties and design values we calculated.

Table 1: Thermodynamic Properties at the relevant states

State	T (°C)	P (MPa)	H (kJ/kg)	S (kJ/kgK)	x
1	-26	0.2	385	1.79	1
2(Ideal)	60	1.2	445	1.79	N/A
2'(Actual)	85	1.2	465	1.85	N/A
3	32	1.2	230	0.7	0
4	-26	0.2	230	1.13	0.26

The third objective was to calculate the refrigeration circulation rate, also known as the mass flow rate, $\dot{m}$. The circulation rate of R-22 of this design. We also calculated the coefficient of performance to be 2.58. We determined the compressor efficiency to be 75% based on the range of compressor efficiency found in our Introduction to Chemical Engineering Thermodynamics, 8th Edition textbook in references. Calculations for these values can be found in Appendix A.

Table 2: Initial Design Values

Q_L (kW)	42.9
Q_H (kW)	-59.5
W_c (kW)	16.6
$\dot{m}$ (kg/s)	0.277
COP	2.58

The fourth objective was to design a pressure-enthalpy (P-H) diagram and a temperature-entropy (T-S) diagram to show the cycle behaviors. Figure 3 and Figure 4 display these diagrams.

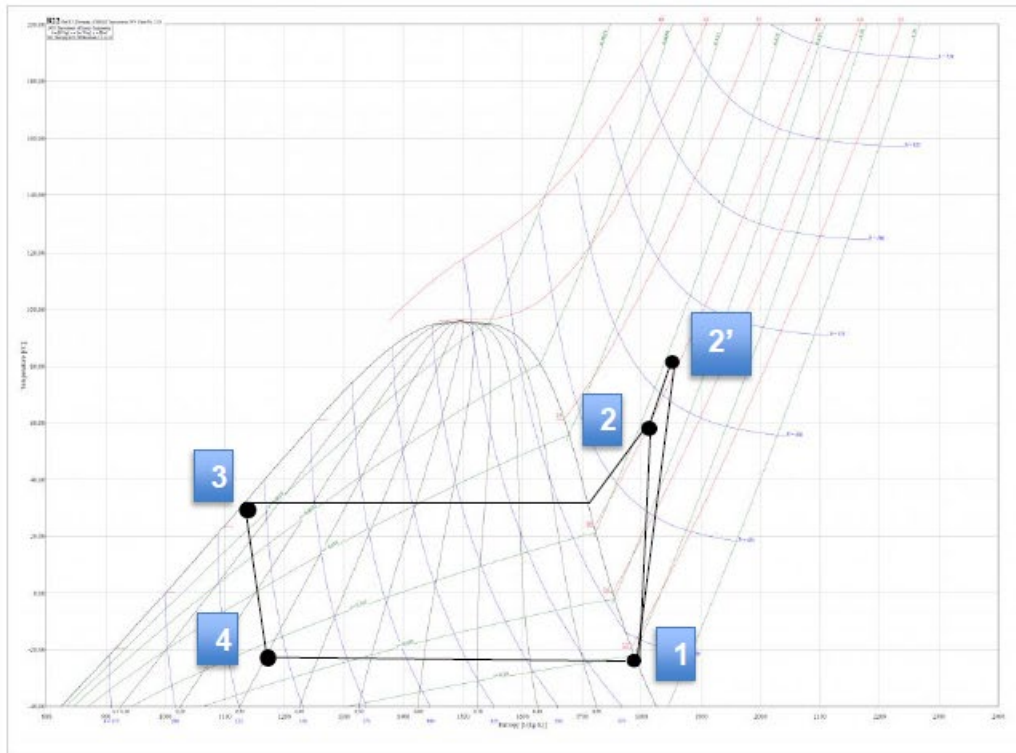


Figure 3: Temperature-Entropy plot of Refrigerant-22
(Temperature in Celsius and Entropy in kJ/kg K)

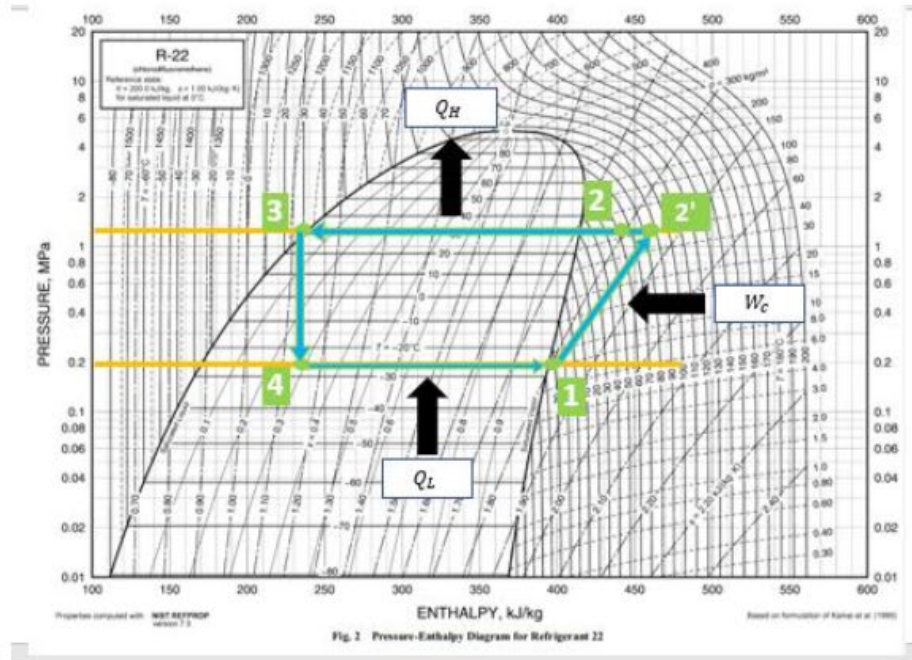


Figure 4: Pressure-Enthalpy (P-H) plot for the Refrigerant cycle
(Pressure in MPa and Enthalpy in kJ/kg)

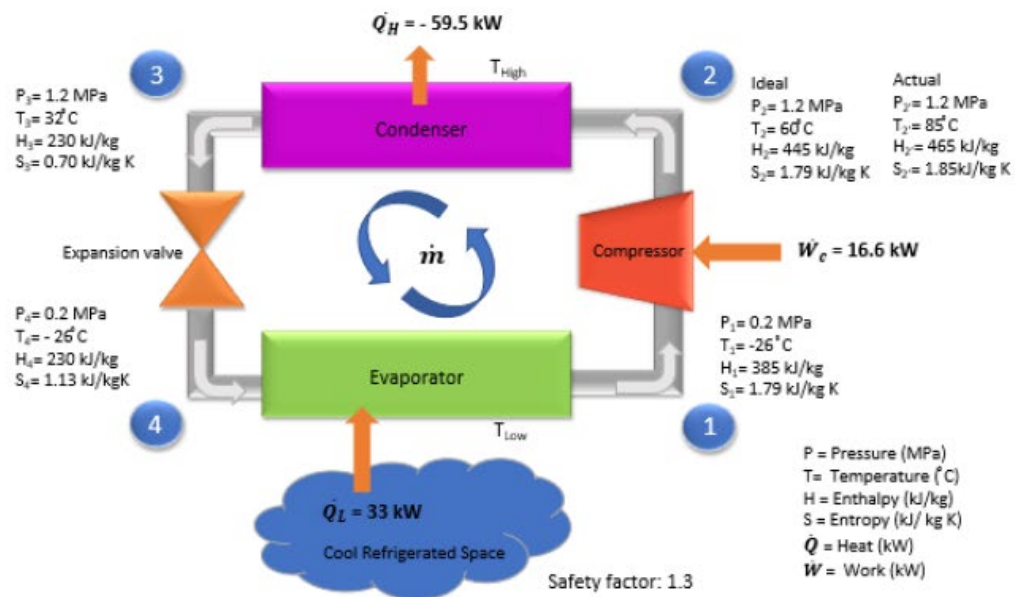


Figure 5: Refrigerators Power Cycle Flow diagram with known parameters

Discussion

To design this refrigeration cycle, we need to choose a safe and suitable refrigerant as our working fluid. We selected R-22 as our working fluid. Chlorodifluoromethane is a colorless gas better known as R-22. By constructing Figure 1, and labeling all the known and unknown values, we can determine how the refrigeration power cycle operates.

Our cycle operates as an open system and allows the transfer of energy throughout our system. The cycle consists of 4 processes including an evaporator, a compressor, a condenser, and an expansion valve. We began our design by using the given temperature ranges to determine our low and high temperatures. The ranges for our low temperature were -10°C and -20°C, while the range for our high temperature was 15°C- 25°C. We then used a temperature approach of 5°C-10°C to determine our low and high temperatures. T_{low} for our cycle is -26°C. T_{high} was found to be -32°C. These temperatures also form isobars. Isobars indicate constant pressure which are shown in our P-H diagram in figure 4. In our problem statement we were given a thermal load of 33 kW. Using the given safety factor of 1.3 will allow our system to achieve the desired cooling. Therefore, we must multiply the thermal load by the safety factor. This value was calculated to be 42.9 kW. Another term we call the thermal load is latent heat, which means there is a phase change present. We can use this value to calculate various parameters of our cycle.

To begin our refrigeration cycle, the working fluid (R-22) passes isobarically through an evaporator. Our refrigerant is on the saturated vapor line once it reaches state 1. The working fluid is compressed adiabatically where it reaches a temperature of 60°C and a pressure of 1.2 MPa. The working fluid then continues to an isobaric condenser where heat is rejected, and the working fluid has a pressure of 1.2 MPa and a new temperature T_3 (32°C). The working fluid is then sent through an adiabatic expansion valve, or throttling valve, where it drops to a new pressure of 0.2 MPa and a temperature, T_4 of (-26°C).

In an ideal vapor compression refrigeration cycle the compressor would be an isentropic process, however for our design we are considering our cycle to be an Actual refrigeration cycle. Therefore, we were tasked with finding two values for state 2. These two states have been labeled 2 and 2'. In the Ideal vapor compression cycle, the working fluid from state 1 to 2 follows a path of constant entropy, however for our actual cycle we will use our compressor efficiency to calculate the actual value of entropy at state 2 and depict that point on our graphs as well. These values for state 2 are shown in Table 1 and Figure 4. The compressor requires power input to increase the pressure of our gas. The evaporator's purpose is to remove heat from the interior of the refrigerator as it increases the heat of the refrigerant as it passes through the device. The condenser is used to reduce the heat of the refrigerant and the expansion valve controls the superheating of the refrigerant.

To calculate the mass flow rate of our working fluid we simply used a first law of thermodynamics analysis to manipulate the equation $\dot{Q}_L = \dot{m}\Delta H$. The value for $\dot{Q}_L$ or the

thermal load is 42.9kW. Therefore, after inputting all values for H, the mass flow rate is equal to 0.277 kg/s. Since we assume our cycle is a steady flow process, we can assume that the mass flow rate remains constant throughout the cycle. Work is supplied at the compressor. This value was calculated using the equation $\dot{W}_c = \dot{m}\Delta H$, where the mass flow rate is 0.277 kg/s, and the H values are 445 kJ/kg and 385 kJ/kg. The work added to the system is 16.6 kW. Heat rejected from the system was found using the equation $\dot{Q}_H = \dot{m}\Delta H$ and this value equals -59.5 kW. Using the Thermodynamics textbook found in our references, we were able to select an appropriate compressor efficiency of 75%. We used this efficiency to compute the actual entropy of state two. The actual entropy of our cycle is 465 kJ/kg. With this actual entropy we were able to extrapolate data from our P-H diagram to find other missing parameters such as temperature, enthalpy, and pressure. The coefficient of performance, COP, was found by dividing the thermal load by the compression work. This value is 2.58. The coefficient of performance tells us how effectively our refrigeration cycle transfers heat versus the amount of energy consumed. (Air, Adams)

Using our P-H diagram, we were able to determine all parameters at each state in the cycle. The pressure, temperature, enthalpy, and entropy of each process as well as the quality at each point were found using this diagram. The values for pressure at each state are as follows; P₁ is 0.2 MPa, P₂ is 1.2 MPa, P_{2'} is 1.2 MPa, P₃ is 1.2 MPa, and P₄ is 0.2 MPa. The temperatures of each state include T₁ at -26C, T₂ at 60 C, T_{2'} at 85 C, T₃ at 32 C, and T₄ at -26C. The enthalpies of each state are: H₁ equals 385 kg/kJ, H₂ equals 445 kg/kJ, H_{2'} equals 465 kg/kJ, H₃ equals 230 kg/kJ, and H₄ equals 230 kg/kJ. Also, the entropy of state 1 and 2 is 1.79 kJ/kg K, for state 2' is 1.85 kJ/kg K, for state 3 is 0.7 kJ/kgK, and for state 4 is 1.13 kJ/kgK. We were also able to find the quality, x, of each point as shown in table 2. The quality represents the mass fraction of vapor in a liquid/vapor mixture. At state 4, we can say that there is 26% vapor and 74% liquid based on the quality 0.26.

We used the P-H diagram to find our missing parameters by labeling each state point and the conditions given. An isobaric process is a process that takes place at constant pressure and is illustrated by two horizontal lines representing latent heat in Figure 4. Latent heat is simply heat being absorbed or given out by a substance as it changes its phase at constant temperature. From state 3 to 4 an isenthalpic process occurs. An Isenthalpic process is the irreversible adiabatic expansion in a throttling device. An isenthalpic process is one that proceeds without any change in enthalpy. There will usually be significant changes in pressure and temperature during the process as illustrated in figure 4.

An interesting observation we made was the difference in the actual and ideal refrigeration cycle. The entropy of state 2 actual is greater than the entropy of state 2 ideal. This is due to the heat added which caused a temperature increase. The compression work also plays a role in this increase because energy is being added to the system. Irreversibility and the transfers of energy increase the entropy.

Conclusion and Recommendations

In conclusion, the identify formulate, and solve methodology to successfully design our vapor compression refrigeration cycle. The refrigeration cycle we have designed the working fluid undergoes three-phase changes. These three phases are the vapor phase, liquid phase, and a mixture of liquid and vapor. The types of processes that occur within the cycle are isobaric, adiabatic, and isenthalpic. The compressor and expansion valve operate adiabatically. This causes the system at these streams to have no heat transfer. Based on the Second Law of Thermodynamics, we can also say that isentropic compression occurs in an ideal refrigeration cycle. However, we have designed an actual cycle and the entropies of state one and two are not equal. The heat exchangers are isobaric, which means there is constant pressure. Therefore, P1 is equivalent to P4 and P2 is equivalent to P3. We verified the heat rejected from the condenser by taking the sum of the evaporated heat and the compressed work, which should be equal to the amount of heat rejected. This equation is expressed as $42.9 \text{ kW} + 16.56 \text{ kW} = 59.5 \text{ kW}$ of rejected heat. Since this is a closed system, we know that the working fluid, R22, has a constant mass flow rate. The pressure-enthalpy (P-H) diagram was used to solve many of our missing parameters. Once we were able to find the pressures, temperatures, enthalpies, and entropies, we were able to calculate the mass flow rate, heat transfers, and work of the power cycle. The First Law of Thermodynamics, the Second Law of Thermodynamics, the coefficient of performance, and the compressor efficiency were used to calculate parameters. These calculations are used in the real world with applications of refrigeration systems. We were able to interpolate values from our diagrams and apply key equations that we have learned thus far in this course.

The screenshot shows a web browser window with a DocuSign interface. The top navigation bar includes 'Introduction to Nuc...', 'DocuSign', 'Google', and 'Reading li'. Below this, a purple status bar displays '25/26 Graded', '84.62 / 100 (85%) Average', and '5/26'. A user profile for 'Kennedy Dent' is visible. The main content area shows a document titled 'Introduction to Nuc...' with a toolbar containing icons for editing, text, and comments. A comment box on the right, titled 'Assignment Comments', contains the following text: 'Comments: references listed are not called out references not completely or consistently formatted missing callouts on some figures & tables missing captions on multiple figures & tables missing credits on borrowed figures COP is reasonable sound design process good choice of refrigerant'. The comment is dated 'Irvin Osborne-Lee, Dec 14 at 10:47am'. Below this, a response from 'Kennedy Dent' dated 'Dec 14 at 10:52am' reads: 'Yes sir. Thank you for the feedback'. A '0' comment icon is visible at the bottom right.

AVERAGE

I. PROJECT LETTER REPORT: Refrigeration Cycle Design

Memorandum

Date: September 17, 2021

To: Dr Irvin W. Osborne-Lee

From: Zenab Coulibaly-Diakite, Meibryth Salas, Jeffrey Sanders

Re: Project # 1 Analysis of a refrigeration cycle

INTRODUCTION

According to the requirements given, a refrigeration system needs to be designed in order to maintain the temperature from -30°C to -20°C , when the outer temperature will be in the range of 5°C to 10°C . The given storage unit will have a load of 33 kW. We need to choose a safe and appropriate refrigerant. With safe operation and care such as additional power transfers, the 1.3 safety feature will be used. The efficiency of the compressor should be between 60 and 80 percent. We are required to specify temperatures and pressures at the different states and indicate the permeable cycle in the temperature diagram of entropy (T-s). Also, the coefficient of performance value and the mass flow rate of the working fluid must be determined.

Refrigeration cycle:

A general refrigeration cycle has four major components which include 1) an evaporator 2) a condenser 3) a thermal expansion valve (TEV) and 4) a compressor (Zhao, L., Cai, et al., (2013)). The refrigerant remains piped between these four components, and it's contained in the refrigerant loop. The refrigerant is passed step by step through these four components. The refrigerant begins as a cool vapor and is entered into the first component which is the compressor. The gaseous refrigerant is entered into the compressor at a very low range of pressure and temperature. Then it is compressed with the help of a compressor as a result this cool gaseous refrigerant is turned to a hot and high-pressure vapor. Then this compressed gas enters the next component in the refrigeration cycle which is the condenser. The refrigerant enters the condenser as a superheated high pressure gas where it will be cooled down so that it turns from a gas into a liquid. This happens when the condenser removes heat from the superheated refrigerant vapor gas until it condenses it into a saturated liquid state. The refrigerant then leaves the condenser and enters the thermal expansion valve (TEV) as a regular temperature, saturated high-pressure liquid. The main job of the expansion valve is to create a pressure and temperature drop so that the refrigerant can evaporate more easily. The pressure drop causes some of the refrigerant to boil, creating a two-phase mixture of cold liquid and vapor. The refrigerant now enters the final component of the cycle, the

evaporator. In the evaporator, the refrigerant enters as a cold, low pressure liquid where it begins to boil and evaporate. As the refrigerant begins to evaporate it picks up the heat of the room and carries it away towards the condenser after the compressor where the refrigeration cycle will begin again.

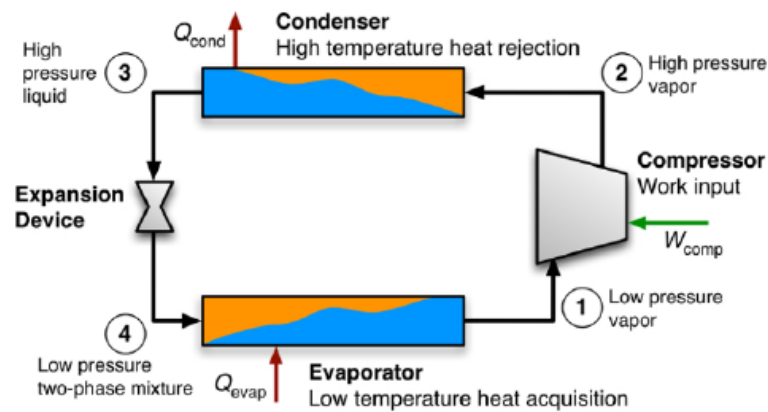


Figure 1: Diagram of vapor compression refrigeration cycle.

OBJECTIVES

- The main objective of this project was to design a refrigeration system to maintain the temperature in the ranges of 30°C to -20°C , when the outer temperature will be in the range of 5°C to 10°C .
- Find a suitable refrigerant for the assigned conditions.
- Determine the temperatures, pressures, entropies, and enthalpies at the different states of refrigeration cycle.
- Develop a temperature entropy (T-S) diagram or pressure enthalpy (P-H) diagram to illustrate the cycle with the vapor dome.
- Determine the coefficient of performance value and mass flow rate of working fluid.

RESULTS

The first action before anything else was to draw a schematic Diagram of our vapor compression refrigeration system. *Figure 1*, in the introduction section, represents it.

Our next step was to choose a refrigerant considering several factors such as cost, accessibility, environmental impacts. We picked R-134a.

The third objective is to determine the unknowns and calculate their values in the cycle. Those are the temperatures, enthalpies, entropies, and pressures at each different stages of the cycle. For that objective we will be using the P-H diagram of our chosen refrigerant R-134a, Figure 2.

Figure 2. Pressure Enthalpy for Refrigerant 134a

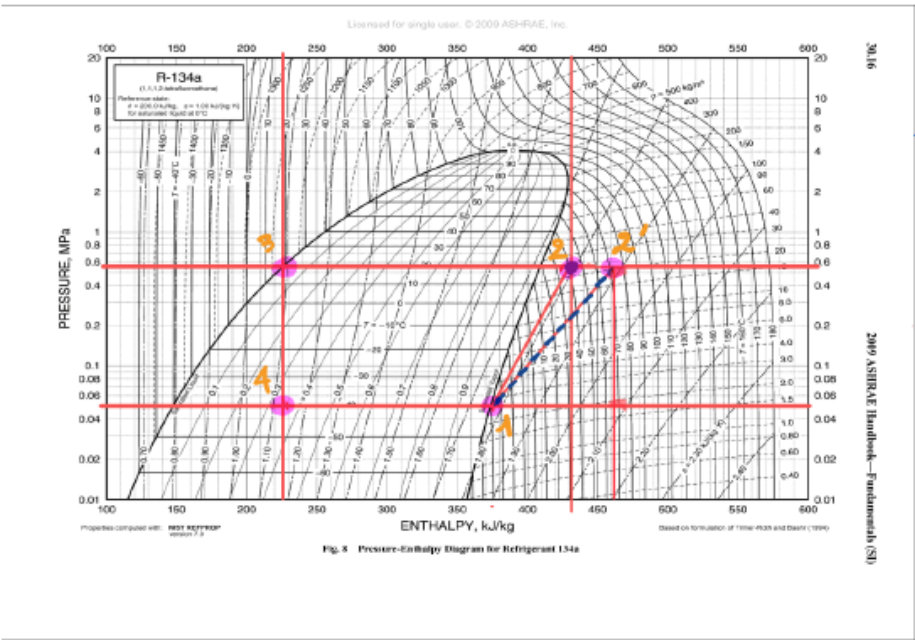


Figure 3. Temperature Entropy for Refrigerant 134a

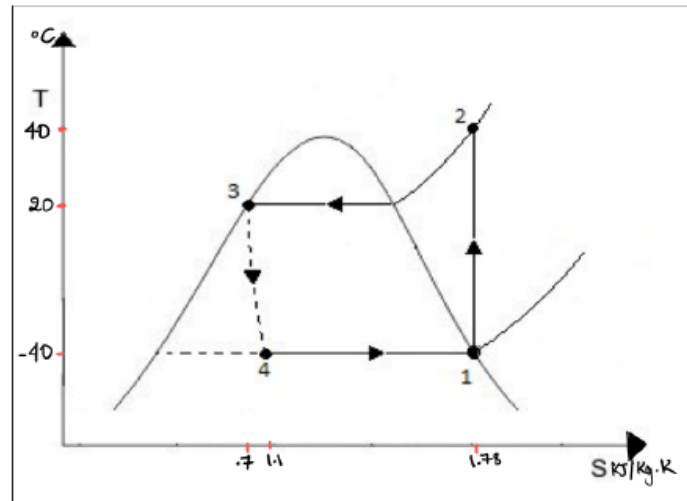


Table 1: Parameters of the cycle

	Phase 1	Phase 2	Phase 2'	Phase 3	Phase 4
Temperature T (°C)	-40	40	70	20	-40
Pressure, P (atm)	0.05	0.6	0.6	0.6	0.05
Enthalpy, H (kJ/kg)	375	430	460	225	225
Entropy, S (kJ/kg·K)	1.78	1.78	1.92	0.70	1.10

Next, the calculations necessary to find the coefficient of performance and the mass flow rate of the fluid.

Table 2: Key Equations

1-2: Constant S. Work done into the system by the Compressor	$w_{in} = \dot{m}(h_2 - h_1)$
2-3: Constant P. Heat released out of the system by the Condenser	$Q_{out} = \dot{m}(h_3 - h_2)$
3-4: Throttling in Expansion Valve	$h_3 = h_4, \Delta S = 0, \dot{w}_{net} = 0, \dot{Q}_{net} = 0$
4-1: Heat entering the Evaporator	$Q_{in} = \dot{m}(h_1 - h_4)$
Coefficient of Performance, COP	$COP = \frac{Q_{in}}{w_{in}}$
Isentropic Efficiency	$\eta_c = \frac{Ideal\ Work}{Actual\ Work} * 100\%$

Table 3 – Calculations

Mass Flow Rate of the Working Fluid, $\dot{m}$ $Q_{in} = \dot{m}(h_1 - h_4) = 33.0\text{ kW} \rightarrow \dot{m} = \frac{Q_{in}}{h_1 - h_4} = \frac{3\text{ kW}}{(375 - 225)\text{ kJ/kg}} = \frac{3}{150} * \frac{\text{kJ}}{\text{kg}} = 0.02\text{ kg/s}$
Heat rejected by Condenser, Q_{out} (negative because it is going out of the system) $Q_{out} = \dot{m}(h_3 - h_2) = 0.02\text{ kg/s} (225\text{ kJ/kg} - 430\text{ kJ/kg}) = -205\text{ kJ/s}$
Work done by the Compressor $W_{in} = \dot{m}(h_2 - h_1) = 0.02\text{ kg/s} (430\text{ kJ/kg} - 375\text{ kJ/kg}) = 55\text{ kJ/s}$
Coefficient of performance $COP = \frac{Q_{in}}{w_{in}} = \frac{\dot{m}(h_1 - h_4)}{\dot{m}(h_2 - h_1)} \rightarrow \frac{h_1 - h_4}{h_2 - h_1} = \frac{(375 - 225)\text{ kJ/kg}}{(430 - 375)\text{ kJ/kg}} = 2.73$
Isentropic Efficiency, η_c $\eta_c = \frac{h_2 - h_1}{h_{2'} - h_1} = \frac{430 - 375}{460 - 375} = 0.65 * 100\% = 65\%$

DISCUSSIONS

The refrigeration cycle is composed of several different components in which we listed in the introduction, in this project we discussed the possibility of the use of the working fluid R134a and how the refrigerant can be used throughout a refrigeration cycle. We were tasked to find the unknown values of this fluid and determine whether or not the refrigerant was an ideal working fluid for a refrigeration system.

Figure 1 is the refrigeration cycle illustrated to give a depiction on how and in what equipment the certain tasks take place and where the start of each phase exchange happens.

Figure 2 the Pressure enthalpy diagram shows is where we plotted our reference points for our refrigerant this is where the initial values of our graph are found that being the pressures and enthalpies of our fluid in which will be working through our cycle. The Phase changes are also depicted within this diagram.

Figure 3 The TS diagram has our liquid vapor region labeled which consisted of the temperatures -40 and 20 degrees Celsius. With a critical point which occurs at 40 degrees Celsius. It depicts specific entropy within the following phase changes on the X-axis and the route in which the cycle takes.

From Table 1 provided in the results section we determined the Phases 1-4 the cycle will take followed by the variables in which each phase will consist of, through the several operations that will take place during the cycle, which include the temperatures $T(^{\circ}\text{C})$, pressures $P(\text{atm})$, enthalpies $H(\text{kJ/kg})$ and entropies $S(\text{kJ/kg}\cdot\text{K})$. Throughout the cycle you can see depicted on the table the consistency of our refrigerant and that the results throughout the phases are constant.

Table 2 are the equations used to gather the information needed to evaluate our refrigerants properties to ensure the performance is adequate enough for viable use. We use equations to find the work done into the system of the compressor and the constant entropy, heat released by the condenser, the throttling expansion valve, heat entering the evaporator and the coefficient of performance to determine the use of the refrigerant can be seen as efficient.

Table 3 are the calculations which we determined from the equations shown in Table 2. The values we gathered in Table 3 determine whether or not our refrigerant (R134a) is an ideal

working fluid in a refrigeration cycle. Our calculations show that the major equipment inputs and outputs are all ideal values for a viable refrigeration system. COP tells us that our refrigerant has a moderately high energy efficiency (2.73).

CONCLUSION

In this project we were to find an adequate refrigerant which was viable and at the same time friendly towards the environment. During this project we were tasked with finding the unknown values of the specific parts of the refrigeration cycle according to a specified refrigerant and how that refrigerant acts within the system. Our group tested the usability of the refrigerant R134a, a refrigerant in which is used in many refrigeration systems. Through the findings depicted in the P-H and T-S diagrams we plotted our initial temperature points (in and out). With the initial values found through those diagrams we then used the two reference temperatures in the beginning Phases to begin our calculations. Through our findings we came to the conclusion that the working fluid R134a, is not only safe for the environment but it's more than ideal for a refrigeration system. In future works, with the understanding of the steps in testing different refrigerants, I believe that we will complete this project using several different options of refrigerants and then compare them with one another and analyze the different findings and choose out of the selected what will be the more ideal fluid in that respect. We will have a deeper understanding of how to read P-H and T-S diagrams and what plots are needed in the initial readings of the refrigerants. Overall this cycle was a success.

REFERENCES

- v Zhao, L., Cai, W., Ding, X., & Chang, W. (2013). Model-based optimization for vapor compression refrigeration cycle. *Energy*, 55, 392-402
- Evans, Paul. "Refrigeration Cycle." Feb. 2021, theengineeringmindset.com

The screenshot displays a Canvas LMS assessment interface. At the top, a purple header bar shows the student's name, Zenab Coulibaly-Diakite, and their overall grade of 84.62 / 100 (85%). Below this, a table indicates the current assessment status: 25/26 Graded, 84.62 / 100 (85%) Average, and 4/26 remaining. The main content area shows the assessment title, 'Assessment', and the grade out of 100, which is 87. To the right, the 'Assignment Comments' section provides feedback from the instructor, Irvin Osborne-Lee, dated Dec 14 at 11:05am. The comments include a list of observations: 'not all references listed are called out', 'some references missing', 'missing narrative on some sections (eg. around tables and figures)', 'incomplete captions and missing callouts on some figures & tables', 'missing credits on borrowed figures', 't-s diagram shows ideal cycle, not actual, and is not called out or discussed', 'COP is reasonable', 'good choice of refrigerant', and 'sound design process'.

Graded	Average	Remaining
25/26	84.62 / 100 (85%)	4/26

Assessment

Grade out of 100

87

Assignment Comments

Comments:

- not all references listed are called out
- some references missing
- missing narrative on some sections (eg. around tables and figures)
- incomplete captions and missing callouts on some figures & tables
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- t-s diagram shows ideal cycle, not actual, and is not called out or discussed
- COP is reasonable
- good choice of refrigerant
- sound design process

Irvin Osborne-Lee, Dec 14 at 11:05am

BELOW AVERAGE



FALL-2021-CHEG-3304P01-2210

Thermodynamic II

INSTRUCTOR: Dr. Osborne-Lee

Design of Refrigeration Cycle

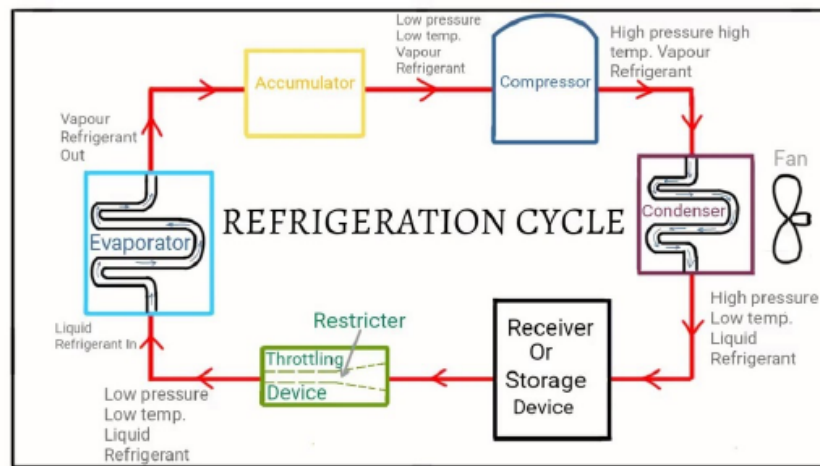
Team 7 Name: Nina Patthammavong

Vivian Patthammavong

Date: 09/17/2021

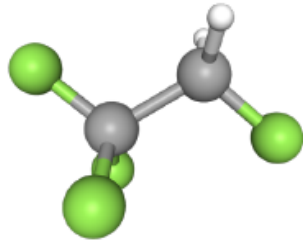
I. Introduction

Refrigeration cycles use in many mechanical systems and are commonly used in industrial facilities to create environments conducive to preservation and safe storage of products. This project will describe how a compression refrigeration system works, and the primary components used to develop the refrigeration cycle. These components are highly specialized to provide the desired effects. Four main parts complete the process, such as compressor, condenser, expansion valve, and evaporator.

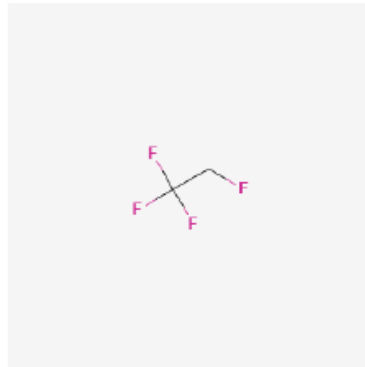


Additionally, the fridge must use a refrigerant. This substance is used to provide a cooling effect. And the cooling effect that undergoes phase transitions from fluid to gas and back to fluid. In this refrigeration cycle project, we will use R134a that widely used in today's times.

The structure of R134a



3D-image

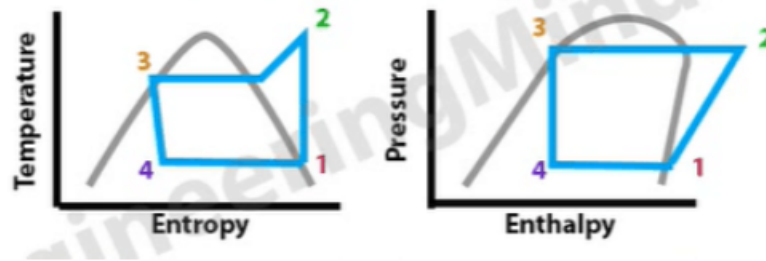


2D-image

R134a is also known as 1,1,1,2-tetrafluoroethane. The structure is CH_2FCF_3 that consists of two carbon atoms, two hydrogen, and four fluorine atoms. This refrigerant has no-toxic, non-flammable, and non-corrosive. Also, it has zero Ozone layer depleting properties and hence became popular as an ideal replacement for chlorofluorocarbons (CFC), hydrochlorofluorocarbons (HCFC), and dichlorodifluoromethane (R-12), which were known to harm the Ozone layer and global warming.

II. Objective

Our goal is to design a vapor-compression refrigeration cycle to absorb heat from cold to warm environments. This design bases upon the ideal vapor-compression refrigeration cycle. The components of the refrigeration system are the compressor, condenser, expansion valve, and evaporator. Additionally, to design the refrigeration system, the most important thing is we must determine the suitable size of refrigeration needed, such as mass flow rate, work input, pressure, coefficient of performance (COP), electric power input. We are also evaluating the P-H diagram or T-S diagram and selecting the refrigerant which will utilize



III. Calculation

A refrigeration system is to be designed to maintain the temperature in the range -50°C-40°C, while the outside temperature from 0°C-5°C. The total thermal load on the storage unit is given as 33 kW. Choose a safe and suitable refrigerant. Design the system using a safety factor of 1.3. The compressor efficiency could range from 60 to 80 percent.

Given: $T_{\text{low,min}} = -50^{\circ}\text{C}$

$T_{\text{low,max}} = -40^{\circ}\text{C}$

$T_{\text{high,min}} = 0^{\circ}\text{C}$

$T_{\text{high,max}} = 5^{\circ}\text{C}$

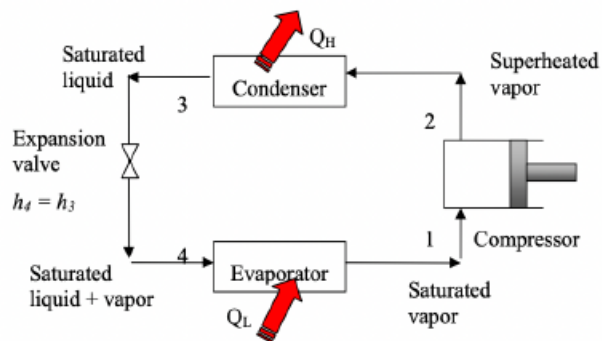
Safety factor of 1.3

Total thermal load on the storage unit $Q_{L \text{ or } in} = 33 \text{ kW} \times (1.3) = 42.9 \text{ kW}$

$$P_2 = P_3$$

$$P_1 = P_4$$

$$T_1 = T_4$$



- ❖ Based on the R-134a table properties of saturated liquid, saturated vapor, and superheated vapor.

Refrigerant 134a (1,1,1,2-Tetrafluoroethane) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pres- sure, MPa	Density, Volume, kg/m ³ m ³ /kg		Enthalpy, kJ/kg		Entropy, kJ/(kg·K)		Specific Heat c _p , kJ/(kg·K)		c _p /c _v	Velocity of Sound, m/s		Viscosity, μPa·s		Thermal Cond., mW/(m·K)		Surface Tension, Temp.,* mN/m °C
		Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor		Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	
-103.30*	0.00039	1591.1	35.4960	71.46	334.94	0.4126	1.9639	1.184	0.585	1.164	1120	126.8	2175.0	6.46	145.2	3.08	28.07 -103.30
-100	0.00056	1582.4	25.1930	75.36	336.85	0.4354	1.9456	1.184	0.593	1.162	1103	127.9	1893.0	6.60	143.2	3.34	27.50 -100
-90	0.00152	1555.8	9.7698	87.23	342.76	0.5020	1.8972	1.189	0.617	1.156	1052	131.0	1339.0	7.03	137.3	4.15	25.79 -90
-80	0.00367	1529.0	4.2682	99.16	348.83	0.5654	1.8580	1.198	0.642	1.151	1002	134.0	1018.0	7.46	131.5	4.95	24.10 -80
-70	0.00798	1501.9	2.0590	111.20	355.02	0.6262	1.8264	1.210	0.667	1.148	952	136.8	809.2	7.89	126.0	5.75	22.44 -70
-60	0.01591	1474.3	1.0790	123.36	361.31	0.6846	1.8010	1.223	0.692	1.146	903	139.4	663.1	8.30	120.7	6.56	20.80 -60
-50	0.02945	1446.3	0.60620	135.67	367.65	0.7410	1.7806	1.238	0.720	1.146	855	141.7	555.1	8.72	115.6	7.36	19.18 -50
-40	0.05121	1417.7	0.36108	148.14	374.00	0.7956	1.7643	1.255	0.749	1.148	807	143.6	472.2	9.12	110.6	8.17	17.60 -40

Refrigerant 134a Properties of Superheated Vapor

Pressure = 0.200 MPa Saturation temperature = -10.07°C						
f m/s	Temp.,* °C	Density, kg/m ³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s	Ts
	Saturated Liquid	1325.78	186.69	0.9506	672.8	Sa
	Vapor	10.01	392.71	1.7337	146.9	La
	-10	10.01	392.77	1.7339	147.0	
	0	9.54	401.21	1.7654	150.6	
	10	9.13	409.73	1.7961	154.0	
	20	8.76	418.25	1.8268	157.3	

State	1	2	3	4
Temperature (°C)	-50	5	0	-50
Pressure (MPa)	0.02945	0.29280	0.29280	0.02945
Enthalpy (KJ/Kg)	H ₁ = 367.65	H ₂ = 405.47	H ₃ = 200	H ₄ = 200
Properties of state	Saturated vapor, low pressure, low temperature	Super-heated High pressure, high temperature	Saturated liquid, high pressure, medium temperature.	Liquid/vapour mixture, low pressure, low temperature

- a) Determine the mass flow rate

$$Q_{L \text{ or } in} = \dot{m}(h_1 - h_4)$$

$$(33 \text{ kW}) \times (1.3) = \dot{m}(367.65 - 200)$$

$$\dot{m} = 0.2559 \text{ Kg/s}$$

- b) Determine work done on the compressor

$$\begin{aligned}\dot{W}_{in} &= \dot{m}(h_2 - h_1) \\ &= 0.2559 \times (405.47 - 367.65) \\ \dot{W}_{in} &= \mathbf{9.68 \text{ kW}}\end{aligned}$$

c) Determine the heat transfer in the condenser

$$\begin{aligned}Q_{H \text{ or out}} &= \dot{m}(h_2 - h_3) \\ &= (0.2559) \times (405.47 - 200) \\ Q_{H \text{ or out}} &= \mathbf{52.58 \text{ kW}}\end{aligned}$$

❖ Check the answer if it is correct. Rejected heat = Evaporated load + Compressor work

$$\begin{aligned}Q_{out} &= Q_{in} + \dot{W}_{in} \\ 52.58 \text{ kW} &= 42.9 \text{ kW} + 9.68 \text{ kW} \\ 52.58 \text{ kW} &= 52.58 \text{ kW}\end{aligned}$$

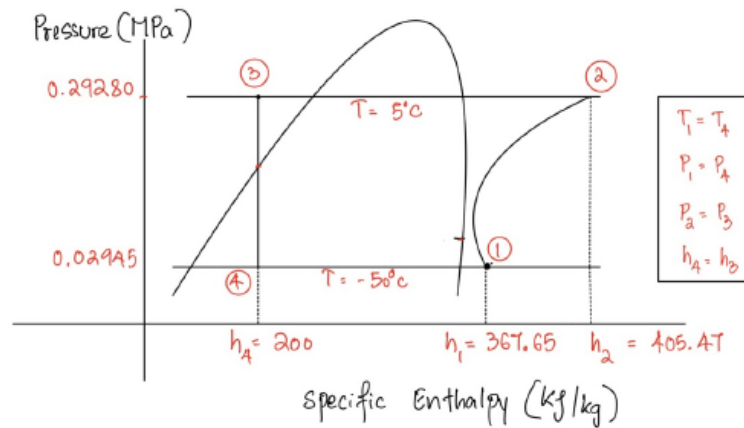
d) Determine the coefficient of Performance (COP) for the refrigeration

$$COP = \frac{Q_{in}}{\dot{W}_{in}} = \frac{42.9 \text{ kW}}{9.68 \text{ kW}} = 4.43$$

IV. Table of Results

Total Thermo Load (kW)	$Q_L = 42.9$
Mass Flow Rate (Kg/s)	$\dot{m} = 0.2559$
Work Done on the Compressor (kW)	$\dot{W}_{in} = 9.68 \text{ kW}$
Heat Transfer in the Condenser (kW)	$Q_H = 52.58$
The Coefficient of Performance	$COP = 4.43$

V. P-H Diagram



- Point 1 to 2: Refrigerant change in a compressor
- Point 2 to 3: Refrigerant change in a condenser
- Point 3 to 4: Refrigerant change through an expansion valve
- Point 4 to 1: Refrigerant change in an evaporator.

VI. Discussion

According to the result on the table, from state 1 to 2 is a reversible, adiabatic, or isentropic compression which saturated vapor of state 1 at low temperature $T = -50^\circ\text{C}$, and low pressure ($P_1 = 0.02945 \text{ MPa}$) is super-heated to state 2 at high temperature $T = 5^\circ\text{C}$ and high pressure $P_2 = 0.29280 \text{ MPa}$. From state 2 to 3 is reversible, constant pressure ($P_2 = P_3 = 0.29280 \text{ MPa}$) and condensed to a saturated liquid to state 2 at $T = 0^\circ\text{C}$. During this process, the working substance rejects most of energy ($Q_{\text{out}} = 52.58 \text{ Kw}$) to the condenser cooling water. From state 3 to 4 is an irreversible throttling process which the temperature and pressure decrease at constant enthalpy ($h_3 = h_4 = 200 \text{ KJ/Kg}$). The refrigerant enters the evaporator at state 4 in a low-quality saturated mixture. Finally, from state 4 to 1 process is a reversible and constant pressure

($P_4=P_1=0.02945$ MPa). Heat transfer ($Q_w=42.9$ Kw) in the refrigerant of two-phase mixture is evaporated to a saturated vapor at state 1.

VII. Conclusion

After research and design the refrigerant cycle, this project provides knowledges how to choose the right and safe refrigerant and learn how to obtain the pressure and the enthalpy using R-134a properties tables or graph. Understanding the processes of each state in detail from the lowest to the highest temperature and identifying the formula of how to solve the mass flow rate, the work done on the compressor, heat transfer in the condenser, the coefficient of performance (COP) for the refrigeration system are necessary for this project to draw a P-H diagram using those values from calculation. Therefore, this project is valuable to learn and understand refrigeration cycle better. It not only helps students to review the old material in thermodynamic I, but also prepare us to work as a team at the company in the future.

Reference

Otomi, Nihonbashi. "How to Draw a Refrigeration Cycle." *JSRAE*, 20 Mar. 2018, www.jsrae.or.jp/jsrae/stady/Eng%20saikuru.htm.

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84.62 / 100 (85%)
Average

14/26

← Vivian Patthammavong

74

Assignment Comments

Comments:

- references listed are not called out
- references not completely or consistently formatted
- use proper call out (by number or author/date)
- missing captions and callouts on some figures & tables
- missing credits on borrowed figures
- missing narrative on multiple sections
- missing callouts on some figures & tables
- missing phase diagram with actual data showing cycle
- good choice of refrigerant
- COP seems a bit high but may be reasonable in light of errors
- format from template not followed

Irvin Osborne-Lee, Dec 14 at 11:02am

CHEMICAL ENGINEERING THERMODYNAMICS II
FALL 2021

Title of Assignment: UPLOAD LETTER REPORT FOR PROJECT 2
Using ASPEN Simulation for Txy, Pxy Diagram Generation and
Activity Coefficient Model Selection

TOPICS COVERED IN PROJECT 2
(Project Activity & Letter Report Weight Category 50%)

Project 2 covered the following topics:

1. Literature search to find published VLE data for binary systems
2. Ideal solution behavior and departure from Raoult's Law
3. Activity coefficient models accounting for non-ideal solution behavior
4. Generation of phase diagrams (Txy and Pxy) using ASPEN.
5. Comparison of model simulations of phase behavior with real data obtained from the published literature
6. Selection of the best model based on visual observation of overlaid data and theory plots
7. Experience working in teams
8. Written communication

Using ASPEN Simulation for T-x-y, P-x-y Diagram Generation and Activity Coefficient Model Selections

This activity builds on what we have been learning in class about activity coefficients and how they can be modeled. It introduces you to chemical process simulation through use of built in property packages, which need to be specified in order to do a simulation with your particular set of components. A learning outcome will be that you will be able to calculate VLE data for a binary system and used it to model separation (and other operations) of a process stream using a chemical process simulation package from AspenTech, Inc. To help you become experienced users of ASPEN, you will use it to create the phase diagrams that you have been working much of this semester. Also, you will gain some experience with property method selection by comparing ASPEN simulation results with different choices of method.

So, this project occurs in three phases including the following activities: literature search in which you will select a binary system, acquire a table of published VLE data, and gain approval from instructor; use of ASPEN to generate Txy and Pxy diagrams for the system and conditions you had approved; and use of ASPEN to simulate your system using different property methods (such as Ideal Solution, Peng Robinson, etc.) and make comparison of simulation results with published VLE data; and reporting.

Instructional Objectives – At the end of this exercise, students will be able to accomplish the following.

- Use sources published information such as Perry's Handbook and online sources including the Internet search engines such as Google Scholar, and data base indexes such as Compendex.
- Select a binary system with useful VLE data.
- Reinforce knowledge of a simple flash drum separator
- Generate phase diagrams using the ASPEN simulator.
- Select a thermodynamics package to model a binary system.
- Compare simulation results to published data on binary system VLE

Because of the scope of information that must be searched, and the different skills required to complete this project, you are required to work in teams. Your instructor will allow you to form your team assignments. Do so by selecting the same team in Canvas as your team mates do (use the People link, and the Project2 tab, or send a message to your instructor with your teaming preference). When assigned, teaming will appear in Table 1.

An overview of the procedure you will use in making a simulation is outlined below.

Phase 1

- There are multiple sources of the data you will need. It will be best to use your team to "divide and conquer" the territory. You must find a set of data for VLE of a binary system that includes a table of P-x-y or T-x-y data. Each team will have a different binary system, so your selection is not final until approved by the instructor. Ideal binary systems are not allowed.
- Use the attached ASPEN Cookbook for VLE Calculation to practice generating T-x-y and P-x-y diagrams.

Phase 2

- Apply the technique learned in Phase 1 to use ASPEN for generating phase diagrams predicting VLE behavior, for various activity coefficient models.
- Compare the results of the ASPEN model predictions for your system to the actual data you obtained from your literature study in Phase 1. Find the model that best fits the data.

Phase 3

- Submit results via *eCourses*. All submissions will be via *eCourses*.
 - No cover page.
 - Deliverable is a letter report written in MSWord, with letter style formatting of address block; message body explaining assignment and attachments, along with a quick description of results; and signature block including all teammates who participated.

- Files attached as an appendix: (1) report containing table experimental data; figures based on ASPEN screenshots (with appropriate captions) or plotted data from ASPEN report files; plots showing comparisons of simulation results to actual data; findings, conclusions, and references; supporting literature, ASPEN simulation, and ASPEN report files.

NOTE: You will need a way to access ASPEN. **It is available for you to run from the Wilson 202 computer lab, which is the default access mode for this face-to-face course.** If you would like to access it remotely, you will need to use VDI or VPN. Contact technical support if you need remote access.

Aspen Cookbook for VLE Calculations

1. Select blank simulation, OK.
2. Select local PC, OK.
3. Select the units: Click on Data, Setup, Input data:, Output results:, then close window.
4. Click on Separators, click on Flash2, place in the middle of the canvas.
5. Click on Material STREAMS, connect the required streams on the Flash drum (red), Feed, Vapor, Liquid.
6. Rename the streams, select (left click) then right click, rename.
7. Data, Components, Specifications: type in names, e.g., Methanol, then propane, etc.
8. Data, Properties, Specifications, Base Method, select PENG-ROB or some other method.
Note that a brief description appears in the bottom pane when your mouse is over a given method.
9. Data, Setup, Report Options, Stream tab, select all items to be included in the report.
10. Select, right click on Feed stream, Input. Specify T, P, composition, flow rate and anything else you need.
11. Select, right click on Flash, Input. Specify the Flash Temperature and vapor fraction (change Pressure to Vapor fraction). Be sure that your temperature is below the critical point of the mixture or you will not get a flash calculation.
12. Data, Properties, Prop-sets, New → name it, find PHIMX, etc. and add as many properties to that prop-set that you need. Then click on the Qualifiers tab, select liquid in one column and vapor in the second column. You do not need to select a component.
13. Add the property set to the report: Data, Setup, Report options, Stream, Property Sets, find the name and add it.
14. Do the calculation. You need to do this even though you are not interested in the results. Run, Run, or N →.
15. You can now view the results of the calculation. Click on Check results in the Control Panel (blue folder with blue check mark).
16. If you want to generate Pxy or Txy diagrams: Tools, Analysis, Property, Binary, generate Pxy or Txy or Gibbs.
17. Select Analysis type: Pxy (or Txy)
18. Select temperature (or pressure).
19. Change the number of points or composition range, etc., if desired.
20. Click on Go.
21. To select a different property method (e.g., NRTL, etc.) go to step 8 and then re-run the flash calculation.
22. View the results.

Table 1. Teaming Assignments for Project 2

Team Set Project 2	Members
Team 1	Jazmain Carter Edgar Mendoza Dynasty Stephenson
Team 2	Shelton Amaram Kelby Smith Isaiah Waters
Team 3	Zenab Coulibaly-Diakite Yazmine Rincon Meibryth Salas Jeffrey Sanders
Team 4	Kayla freeman Janeria Perry Erron Williams
Team 5	Kalaya Anderson Kennedy Dent Kiara Graham
Team 6	Ariel Kinsey Alexis Rabb
Team 7	Byron Henderson Maya Spears Wesley Walsh
Team 8	Devin Lockett Kennedy Meeks
Team 9	Nina Patthammavong Vivian Patthammavong

**CHEMICAL ENGINEERING THERMODYNAMICS II
FALL 2021**

**SAMPLE WRITTEN REPORTS SUBMITTED AND
AND GRADING SCHEME FOR PROJECT 2**

ABOVE AVERAGE

Memorandum

Date: December 4, 2021

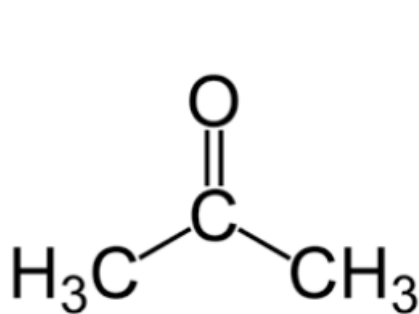
To: Dr. Irvin Osborne-Lee

From: Isaiah Waters, Shelton Amaram, Kelby Smith

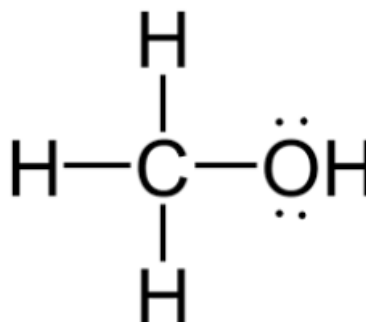
Re: Project #2 (ASPEN Simulation for T-x-y and $\ln \gamma$ vs. x diagrams)

Introduction

In this report, we were tasked to demonstrate our implementation of technical skills by using ASPEN+ to compare binary system activity coefficient models. These simulations were comparative to experimental data that was investigated from online. Numerous online data have been examined, and selecting the activity coefficient model that best reflected the data from our sources was the objective. Our project team resolved on choosing the Acetone/Methanol Binary VLE (Vapor-Liquid Equilibrium) system which does not follow Raoult's Law for binary systems. It is for this reason activity coefficient models are necessary to begin with, to account for deviations from ideal solution behavior of chemical species. Below are the structures of our two molecules.



Acetone (ketone)



Methanol (alcohol)

Objectives

- Choose binary VLE system of two chemical substances
- Research databases via Google Scholar and other reputable sources
- Use ASPEN PLUS to simulate VLE charts/data tables for different activity coefficients
- Compare simulated data to experimental data from literature

Results

The results of the assignment include a myriad of charts and plots that have been compared with literature. To make comparisons uncomplicated, plots were merged with the experimental data researched and tabulated through ASPEN Plus.

*The information below serves as a preface for the following graphs and data tables.

VLE Plots

Chosen System: Acetone/Methane Binary

All plots done at constant pressure 97.8 kPa ; mole fraction Acetone

- T-x-y plots (Compared with literature) @97.8 kPa
- Activity Coefficient vs. mole fraction
- Logarithmic Activity Coefficient vs. mole fraction (Compared with literature)

Activity Coefficient Models Implemented

- Redlich-Kwong-Soave
- Universal quasichemical Functional groups Activity Coefficient (UNIFAC)
- UNIQUAC (Universal Quasichemical)
- Peng-Robinson

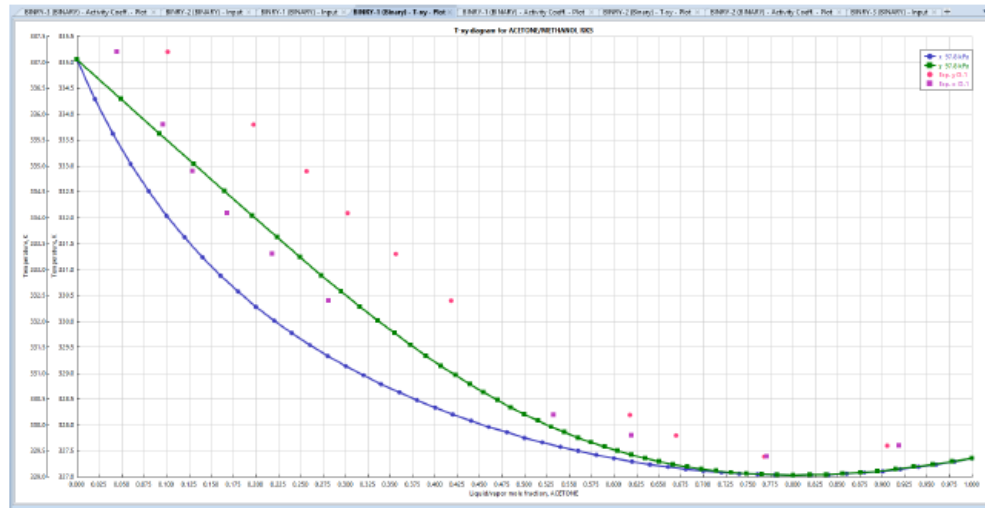


Figure 1: T-x-y diagram for ACETONE/METHANOL RKS-experimental data
This diagram depicts the Redlich-Kwong-Soave T-x-y graph formed through ASPEN when merged with the experimental data from the article.

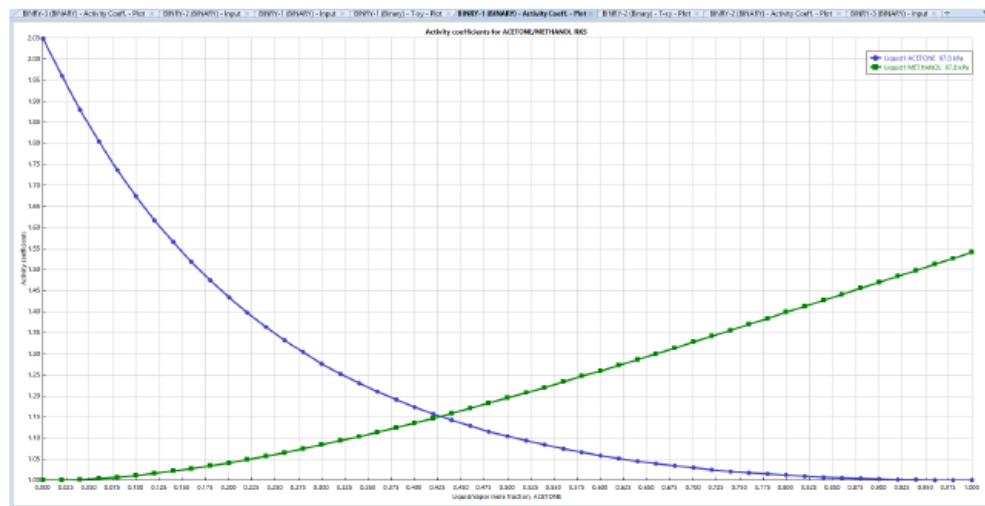


Figure 2: Activity coefficient diagram for ACETONE/METHANOL RKS
This diagram shows the Redlich-Kwong-Soave activity coefficient graph formed through ASPEN showing the γ vs x correlation for this binary mixture.

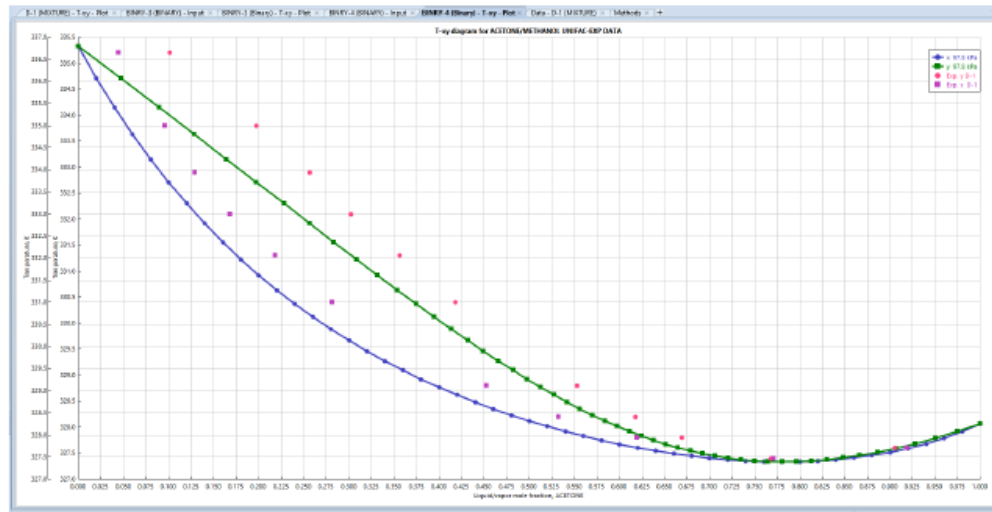


Figure 3: T-x-y diagram for ACETONE/METHANOL UNIFAC –experimental data
This diagram depicts the Unifac T-x-y graph formed through ASPEN when merged with the experimental data from the article.

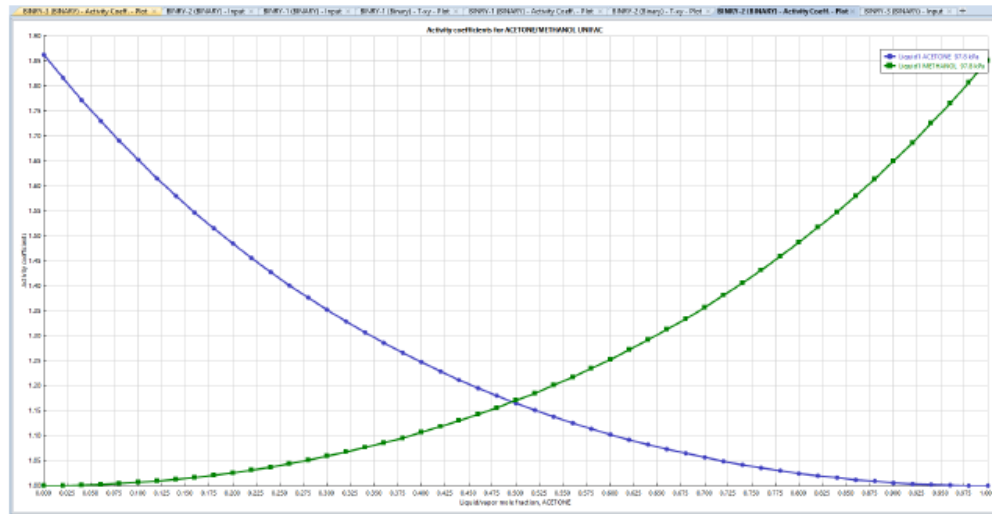


Figure 4: Activity coefficient diagram for ACETONE/METHANOL –UNIFAC
This diagram illustrates the Unifac activity coefficient graph formed through ASPEN showing the γ vs x correlation for the binary mixture.

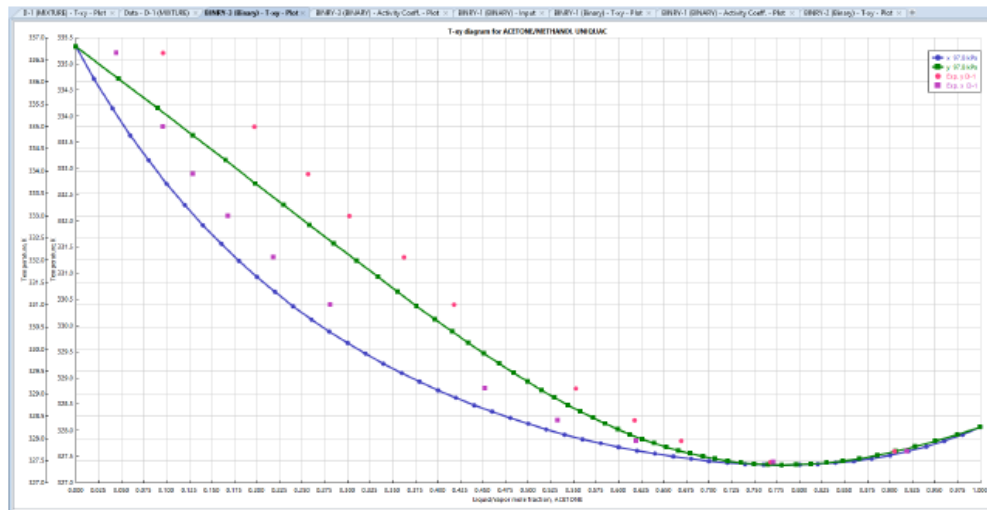


Figure 5: T-x-y diagram for ACETONE/METHANOL UNIQAC –experimental data

This diagram shows the Uniquac T-x-y graph formed through ASPEN when merged with the experimental data from the article.

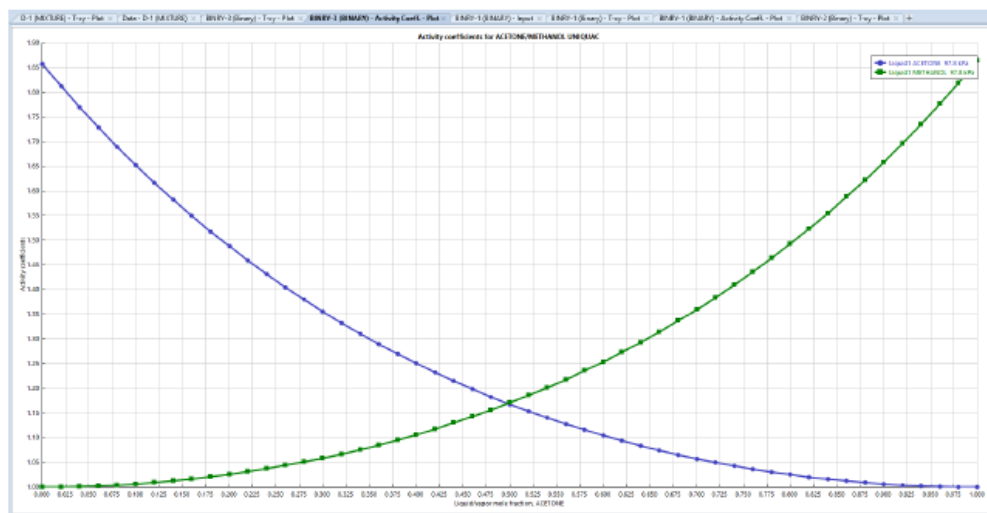
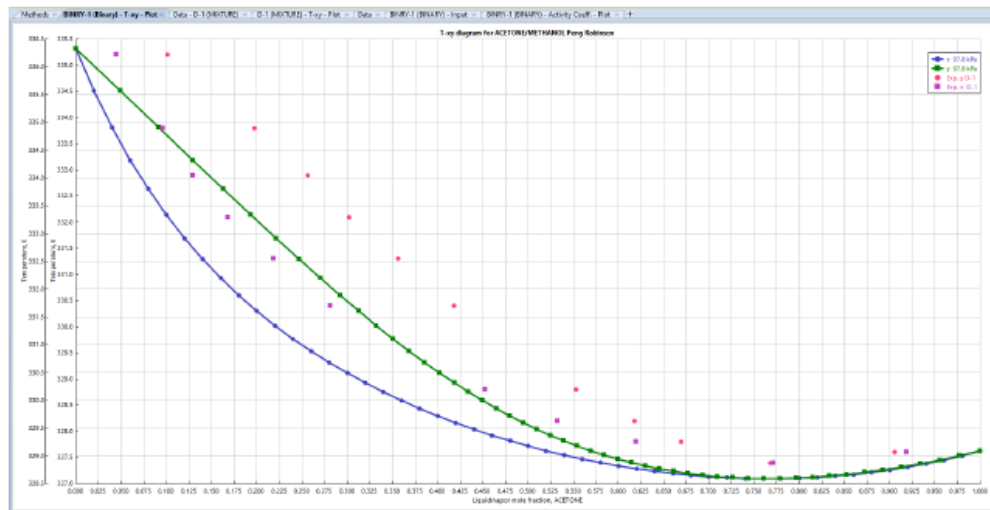


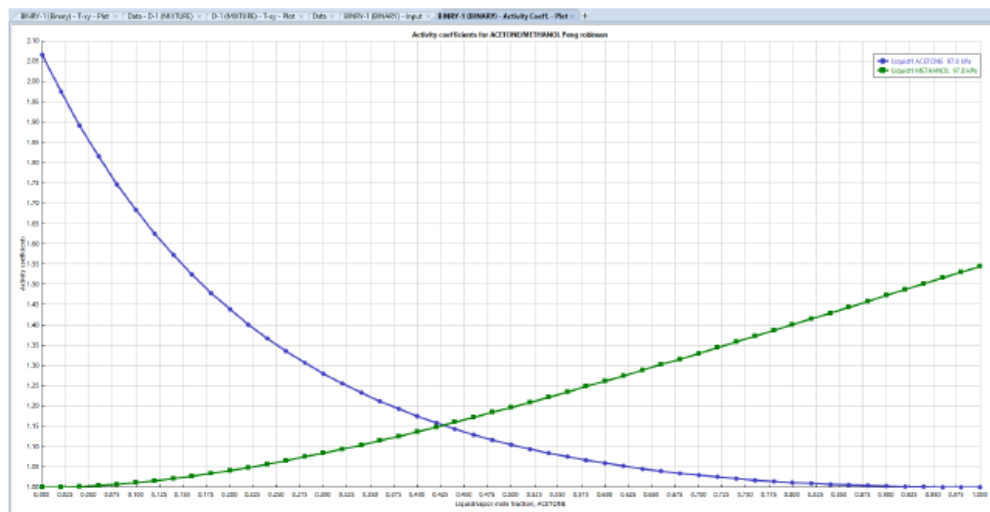
Figure 6: Activity coefficient diagram for ACETONE/METHANOL-UNIQAC

This diagram depicts the Uniquac activity coefficient graph formed through ASPEN showing the γ vs x correlation for this binary mixture.



**Figure 7: T-x-y diagram for ACETONE/METHANOL
Peng-Robinson—experimental data**

This diagram depicts the Peng-Robinson T-x-y graph formed through ASPEN when merged with the experimental data from the article.



**Figure 8: Activity coefficient diagram for ACETONE/METHANOL –Peng
Robinson**

This diagram depicts the Peng Robinson activity coefficient graph formed through ASPEN showing the γ vs x correlation for this binary mixture.

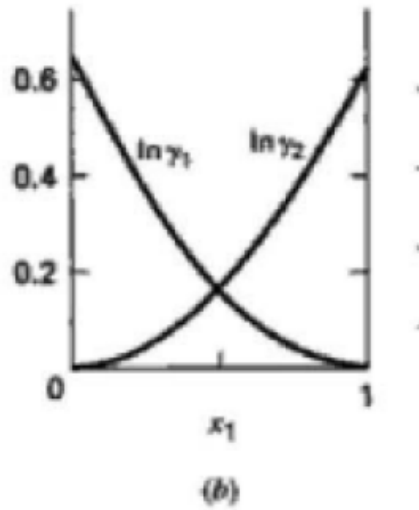


Figure 9: Activity Coefficient Graph for Acetone/Methanol Binary System from *Introduction to Chemical Engineering Thermodynamics, SVNA 7th Edition*

This plot from the class text serves as a reference for our generated and experimental activity coefficient graphs.

T/K	x_1	y_1	$\gamma_{1,NRTL}$	$\gamma_{1,UNIQUAC}$	γ_1^{exp}	γ_2^{exp}
327.6	0.9186	0.9049	0.9007	0.9072	1.0070	1.6996
327.4	0.7710	0.7676	0.7704	0.7763	1.0248	1.4887
327.8	0.6196	0.6693	0.6662	0.6669	1.0965	1.2542
328.2	0.5323	0.6177	0.6101	0.6073	1.1619	1.1594
328.8	0.4522	0.5526	0.5571	0.5512	1.1987	1.1295
330.4	0.2810	0.4182	0.4250	0.4129	1.3823	1.0470
331.3	0.2179	0.3564	0.3629	0.3491	1.4738	1.0260
332.1	0.1679	0.3024	0.3050	0.2906	1.5792	1.0117
332.9	0.1293	0.2566	0.2530	0.2388	1.6943	0.9972
333.8	0.0960	0.1973	0.2079	0.1882	1.7031	0.9999
335.2	0.0444	0.1009	0.0958	0.0963	1.8003	1.0015

Table 1: Experimental data for Acetone/Methanol Binary with Activity Coefficient parameters (γ)

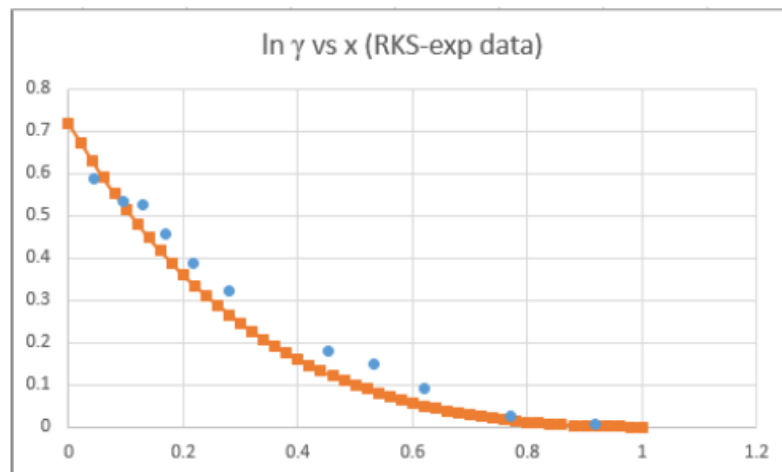


Figure 10: Activity Coefficient graphs for Redlich-Kwong-Soave and experimental data

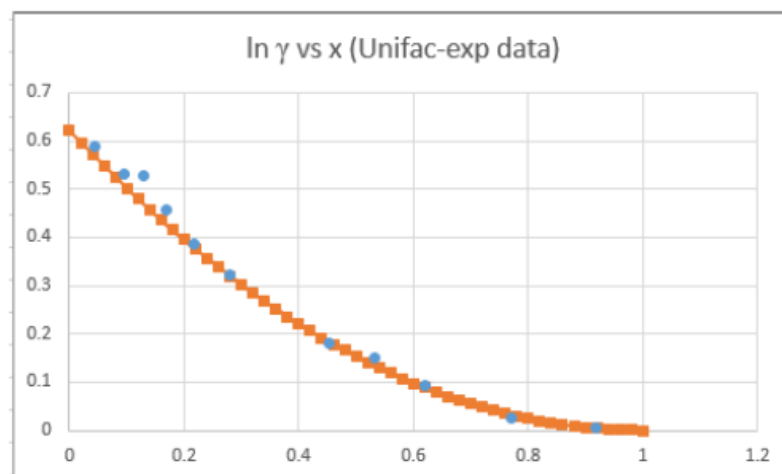


Figure 11: Activity Coefficient graphs for UNIFAC-experimental data

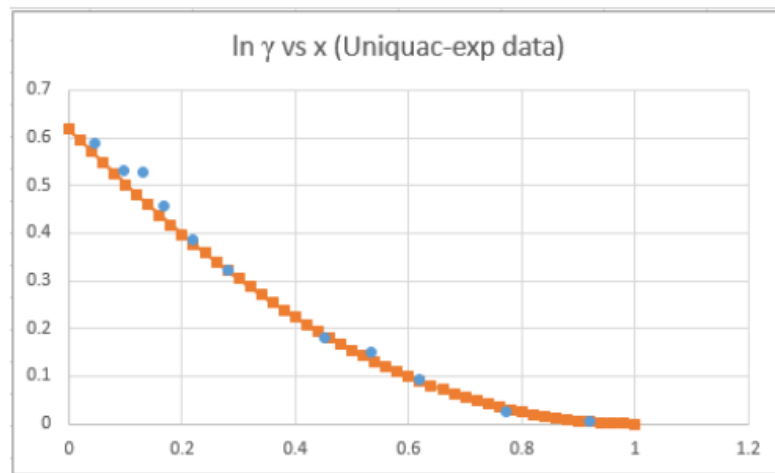


Figure 12: Activity Coefficient graphs for UNIQUAC—experimental data

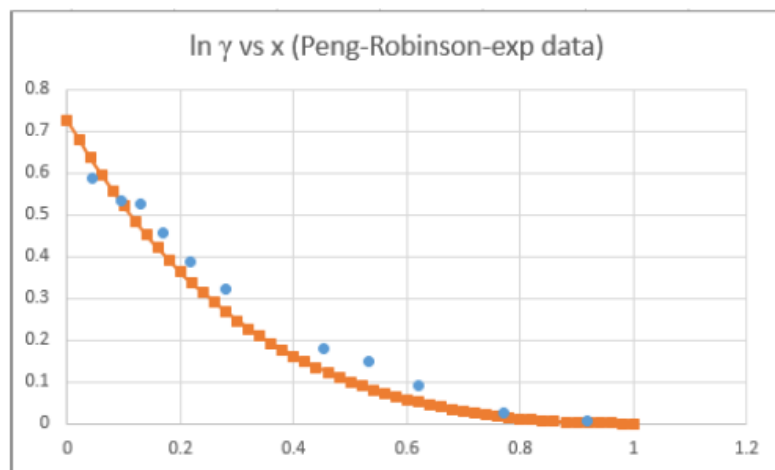


Figure 13: Activity Coefficient graphs for Peng-Robinson—experimental data

Discussion

For this assignment, the task was to conduct research on a binary VLE system, simulate ASPEN data plots for that system, and compare simulations with published data. The system chosen was the Acetone/Methanol vapor liquid equilibrium (VLE) system. Literature review indicates that this system does not follow Raoult's law. Because of their structures, the two chemical substances in question behave differently. Acetone $[(\text{CH}_3)_2\text{CO}]$ is a ketone whereas methanol (CH_3O) is an alcohol. When mixed, they do not form an ideal solution where all molecules behave similarly. For this reason Raoult's law does not hold. We must use activity coefficients (γ) to *modify* Raoult's law to correctly represent the VLE data.

Four different activity coefficient models were selected: Redlich-Kwong-Soave (RKS), Universal quasi-chemical Functional groups Activity Coefficient (UNIFAC), Universal Quasichemical (UNIQUAC), and Peng-Robinson (Peng-Rob). By selecting the different thermodynamic packages, ASPEN+ was able to generate T-x-y and activity coefficient diagrams from information stored in its databases. These plots were then merged with experimental data to compare their accuracies (Figures 1, 3, 5, 7). From these plots alone, it is possible to see how each of the simulations generally correspond with the actual data; however, we furthered our experiment by plotting logarithmic activity coefficient data through excel. This should give us a finer comparison between activity coefficient models.

Logarithmic activity coefficient data were accessible through multiple sources, including the class text (Figure 9). This graph served as a basis for what we should expect when tabulating data from online sources and simulated data. To plot the data in logarithmic form, we were inclined to use both ASPEN and Microsoft Excel. ASPEN only allowed activity coefficient (γ) data without logarithmic form. Taking the γ tables from each of the thermodynamic packages and placing them on Excel is what was necessary to move forward. Figures 2, 4, 6, and 8 show the diagrams of γ vs. x; the tables were derived from each of the simulations. To get activity coefficient to compare the simulations with, we used a table from an article publication. This is shown in Table 1 above. In Excel, the graphs of $\ln \gamma$ vs. x were superimposed where each thermodynamic model (i.e. RKS, UNIFAC, etc.) was layered with the data from literature. This

is apparent in Figures 10-13. With these diagrams, we can accurately compare the behaviors of simulated versus published data.

Each of the graphs follow a similar pattern, but *UNIFAC and UNIQUAC are the lines of best fit*. When looking at the plots, it also seems that these two activity coefficients are identical with each other. Research shows that UNIFAC and UNIQUAC behave the same for mixtures of unsubdivided molecules.

Conclusions and Recommendations

After completing the task, we acquainted ourselves with ASPEN+ and successfully implemented activity coefficient models to compare different binary systems with their corresponding t-x-y diagrams. In order to find out which method correlated most, we merged the experimental data obtained from online publications onto the simulated data. It was concluded that both the UNIFAC and UNIQUAC modules proved most consistent with outside sources. From all this information being known, it is determined that the binary system for Acetone/Methanol works very well under non-ideal conditions when looking for different thermodynamic models to make a graph out of. One system that could be further explored is the solid-liquid equilibrium system for this mixture due to its usefulness in designing industrial separation and purification operations.

References:

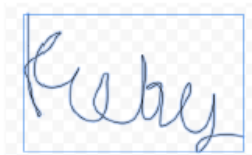
"Results: 1 - 200F6604." *ACS Publications. Most Trusted. Most Cited. Most Read*,
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<https://www.sciencedirect.com/science/article/pii/037838129402586P>.

Smith, J., et al. "Chapter 12/Section 1." *Introduction to Chemical Engineering Thermodynamics*, McGraw-Hill Higher Education, Boston, 2005, p. 445.

Signature box:

A handwritten signature in blue ink, appearing to read "Kelby", enclosed within a blue rectangular box.

Kelby Smith

A handwritten signature in black ink, appearing to read "Shelton", written in a cursive style.

Shelton Amaram

A handwritten signature in black ink, appearing to read "Isiah Waters", written in a cursive style.

Isaiah Waters

AVERAGE

Kayla Freeman
Erron Williams
Janeria Perry

Memorandum

To : Dr. Osborne-Lee

From: Janeria Perry, Kayla Freeman, Erron Williams

Date: Dec. 1. 2021

Subject: ASPEN Simulation Model for Propyl- Acetate/ Methanol

Introduction: The objective of this memorandum is to correlate experimental data of the binary system of Propyl-Acetate(1) + Methanol (2) to an ASPEN simulated model that portrays the liquid-vapor equilibrium on a T-xy diagram using a activity coefficient model. While performing the Aspen model simulation of the TXY diagram of our binary mixture we decided to use three different activity coefficient models. Each model was simulated at a constant pressure of 0.6MPa. The first model we decided to use was the Peng Robinson equation of state model. From our published experimental data, we discovered that the Peng Robinson EOS usually works well with polar components, which in this case is Methanol. We also used the SRK activity coefficient model because we knew the equation was the same for the Peng- Robinson model but we wanted to see how the graph would vary with different parameter functions. The last activity coefficient model we used was the UNIFAC method. We used the UNIFAC method because we learned that this method uses the various functional groups that are present in the liquid mixture to calculate the activity coefficients. In this case the different functional groups that were present were an acidic ester from the propyl acetate and a primary alcohol from the methanol.

The experimental data of Propyl-Acetate was determined by using an ebulliometer to determine the boiling points of the solution by measuring the temperatures of vapor-liquid equilibrium isobarically at 0.6MPa.

Objectives:

- -Examine useful experimental data for a binary system that does not follow Rault's Law
- -Generate T-xy and/or P-xy diagrams of the data using ASPEN simulator
- -Generate Aspen simulations of the chosen binary system using different property methods
- -Compare the simulation results to the published experimental data

Key Concepts:

- 1) **T-xy Diagram** : Txy Diagrams display the liquid (x) and vapor (y) mole fractions that correspond with temperature values of the pure components for a binary system that is isobaric.
- 2) **P-xy Diagram**: represent the molar liquid and vapor compositions on a VLE diagram in correspondence with pressure values; which is used for an isothermal system
- 3) **Activity Coefficient Model**: shows the ratio of the chemical activity of any substance to its molar concentrations. These models can be used to determine the magnitude of deviation within a binary system in reference to ideal gas behavior (ex. SRK, Peng Robinson, Van Laar.. etc.)
- 4) **(VLE)Vapor-Liquid Equilibrium** - the state of coexistence of liquid and vapor phases
- 5) **Raoult's Law**- a law that states that the partial pressure of each component in an ideal solution of liquids is equal to the pure component of ideal gas/vapor multiplied by its mole fraction. This law can only be used for ideal Mixtures.
- 6) **Modified Raoult's Law**- This law is used for non-ideal solutions that deviate from ideal solution behavior
- 7) **Fugacity** - a thermodynamic property that measures the tendency of a gas to expand or escape. Fugacity can also measure the reactivity of a gas within a solution.
- 8) **Binary System** - a chemical compound containing two different elements
- 9) **Isobaric** - a thermodynamic process in which the pressure is constant.
- 10) **Isothermal**- a thermodynamic process in which temperature is constant

Equations:

- (PR) Peng Robinson Equation-
$$P = \frac{RT}{V-b} - \frac{a(T)}{(V+\epsilon b)(V+\sigma b)}$$
- (SRK) Soave- Redlich- Kwong -
$$P = \frac{RT}{V-b} - \frac{a(T)}{(V+\epsilon b)(V+\sigma b)}$$
 - PR & SRK share the same equation but differ with parameter function of a(T), as well as different values for ϵ and σ .

- Raoult's Law - $y_i = \frac{x_i p_i^{sat}}{P_t}$
- Antoine's Equation - $\ln_{10} P^{sat} = A - \frac{B}{T+C}$
- Modified Raoult's law - $\gamma_i P = x_i \gamma_i P_i^{sat}$
- Unifac - $\ln^i \gamma = \ln^i \gamma^c + \ln^i \gamma^R$

Key:

P- Pressure

x_i - Vapor Phase property (of species i)

R- Gas Constant

P_i^{sat} - Saturated Pressure

V- Molar Volume

T- Absolute Temperature

γ_i - Liquid Phase Property (of species i)

A,B,C - Parameters for Antoine's equation (can be found on data table)

Results:

Table 1-1 Error Calculations of Peng Robinson, SRK, and Unifac Activity coefficients

PG			SRK			UNIFAC		
X1	Error% (y)	Error% T	X1	Error%(y)	Error % T	X1	Error%(y)	Error% T
0.04	30.463	0.572	0.04	35.656	0.450	0.04	9.267	0.213
0.28	37.555	0.709	0.28	37.629	0.558	0.28	4.077	0.703
0.4	24.485	0.483	0.4	23.512	0.326	0.4	4.465	0.875
0.44	17.711	0.308	0.44	16.566	0.152	0.44	2.997	0.875
0.5	13.658	0.129	0.5	12.302	0.024	0.5	6.202	0.995
0.64	3.919	0.656	0.64	5.290	0.785	0.64	4.470	1.020
0.72	10.637	1.101	0.72	11.873	1.202	0.72	4.497	1.026
0.78	13.677	1.301	0.78	14.763	1.372	0.78	4.966	1.085
0.88	15.121	1.239	0.88	15.841	1.237	0.88	4.052	1.128
0.9	15.429	1.209	0.9	16.049	1.188	0.9	2.418	1.021

Table 1.1 Calculation of error within the y component and (T) temperature
- E. Williams

T-XY Diagram Propyl-Acetate/ Methanol using Peng- Robinson EOS at 0.6MPa

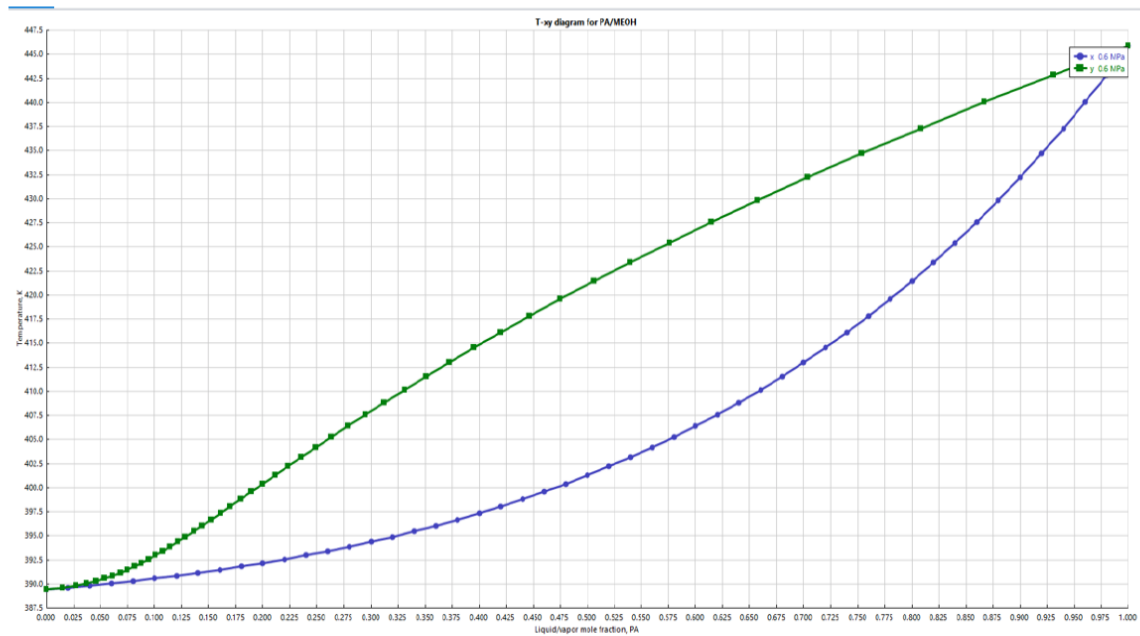


Figure 1.1 T-xy Diagram for *Propyl-Acetate Methanol*; this diagram was created using ASPEN Plus, using the Peng-Robinson method at 0.6MPa
- K.Freeman

T-XY Diagram comparing the Experimental data to the Simulated Data of Propyl-Acetate/ Methanol using Peng- Robinson EOS at 0.6MPa

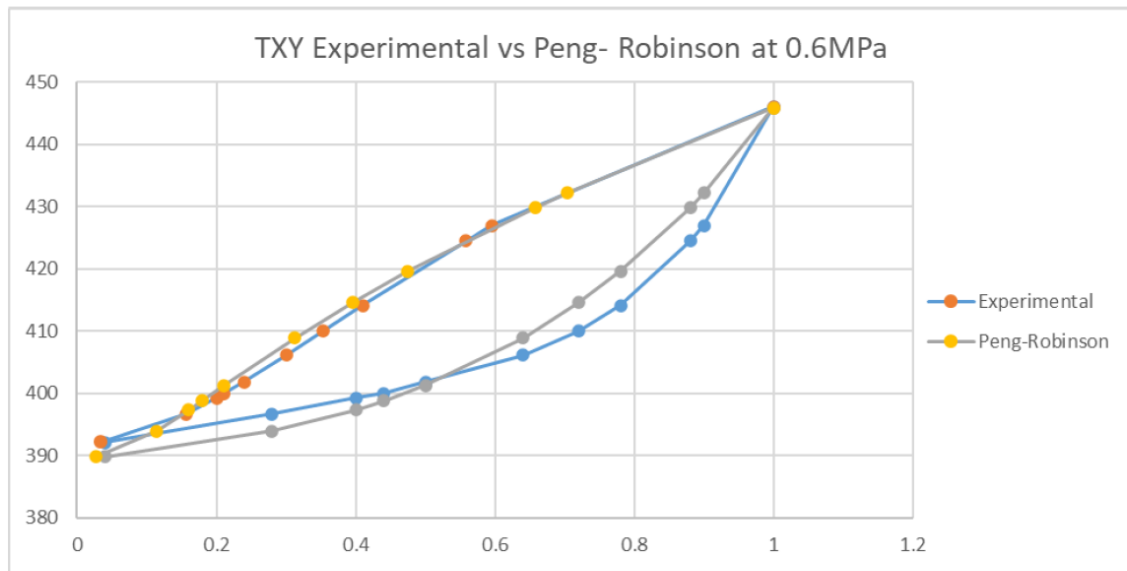


Figure 2.1 T-xy Diagram comparing the experimental data to the simulated Peng- Robinson data for *Propyl-Acetate Methanol*; this diagram was created using Excel. - K.Freeman

T-XY Diagram Propyl-Acetate/ Methanol using SRK EOS at 0.6MPa

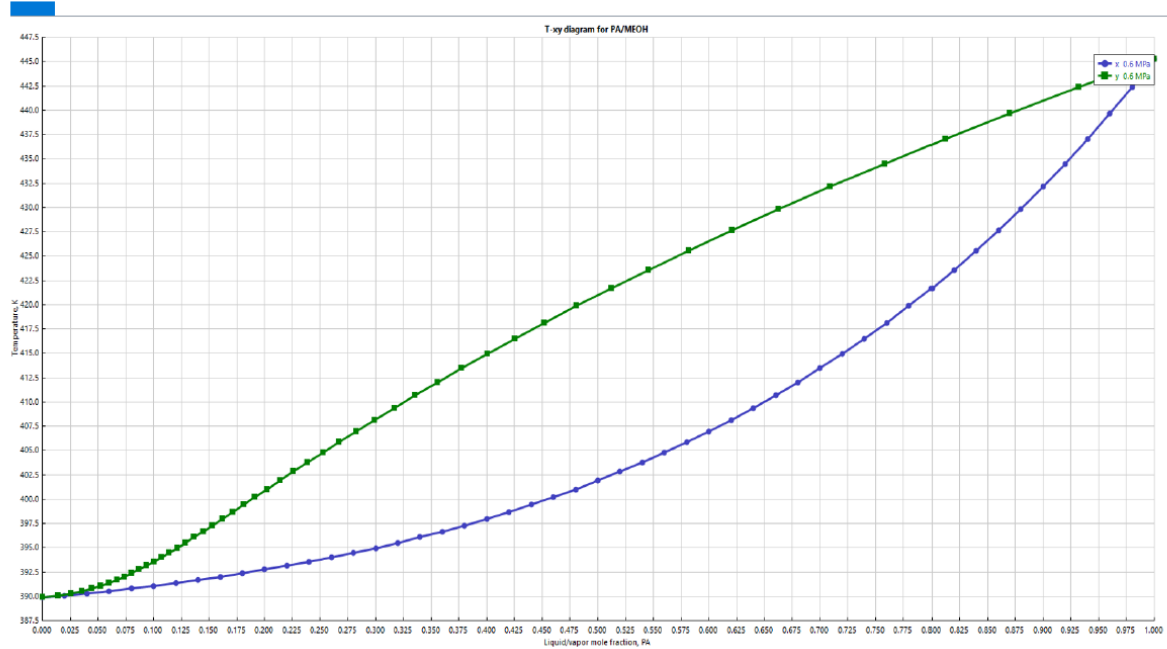


Figure 1.2 T-xy Diagram for *Propyl-Acetate Methanol*; this diagram was created by ASPEN Plus using the SRK EOS method. - K.Freeman

T-XY Diagram comparing the Experimental data to the Simulated Data of Propyl-Acetate/ Methanol using Peng- Robinson EOS at 0.6MPa

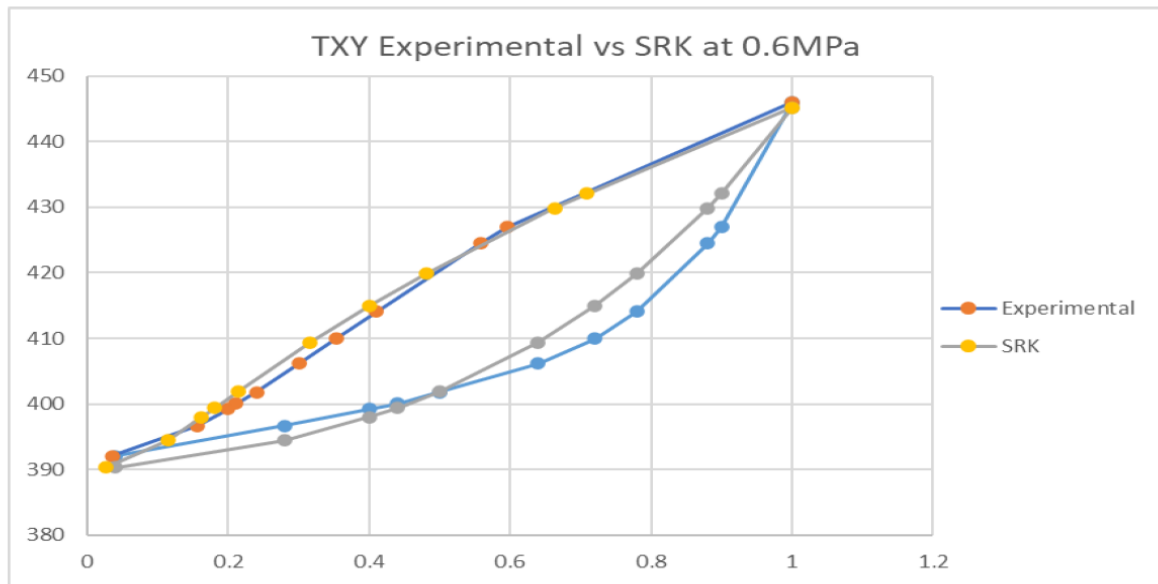


Figure 2.2T-xy Diagram comparing the experimental data to the simulated SRK data for Propyl-Acetate Methanol; this diagram was created using Excel. - K.Freeman

T-XY Diagram Propyl-Acetate/ Methanol using SRK EOS at 0.6MPa

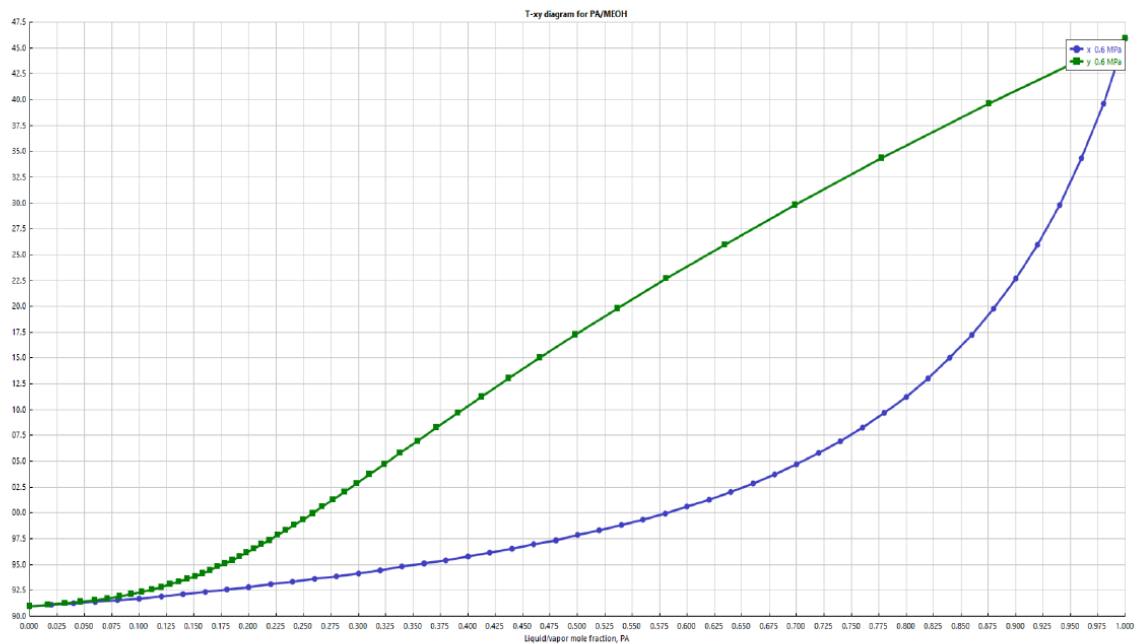


Figure 1.3 T-xy Diagram for *Propyl-Acetate Methanol*; this diagram was created using the UNIFAC ASPEN Plus model. - K.Freeman

T-XY Diagram comparing the Experimental data to the Simulated Data of Propyl-Acetate/ Methanol using the UNIFAC Method at 0.6MPa

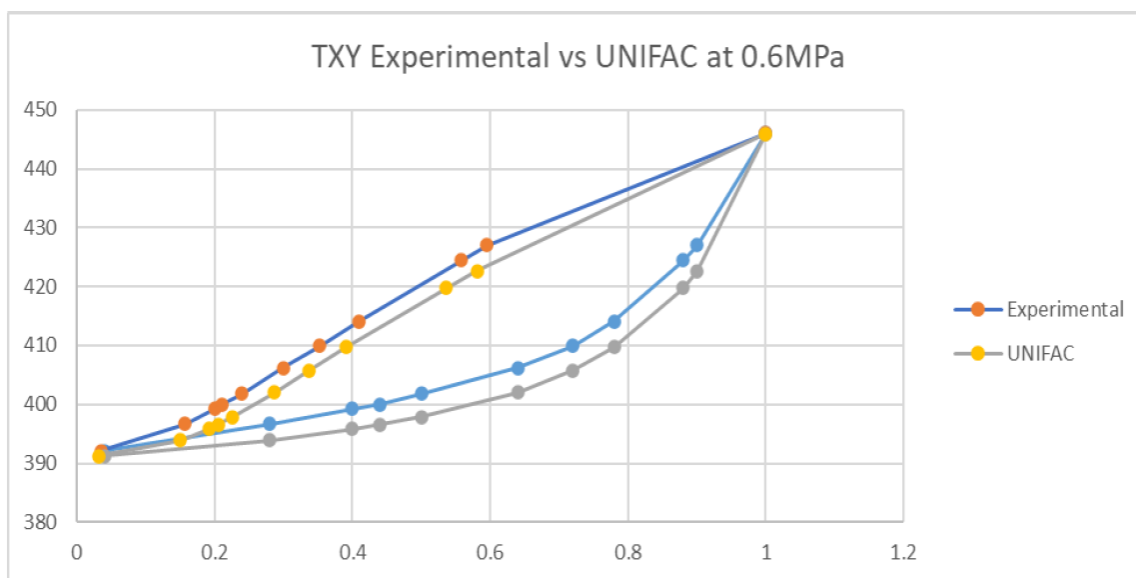


Figure 2.3 T-xy Diagram comparing the experimental data to the simulated SRK data for *Propyl-Acetate/Methanol*; this diagram was created using Excel. - K.Freeman

Activity Coefficients Diagram Simulated in Aspen of Propyl-Acetate/ Methanol using the UNIFAC Method at 0.6MPa

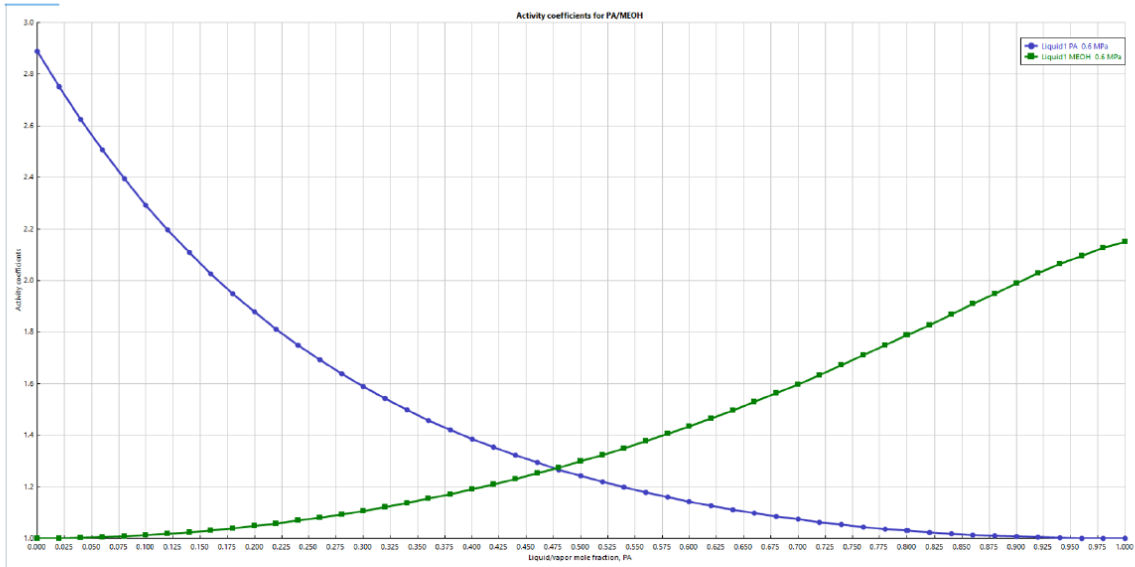


Figure 3.1 Activity Coefficient diagram for *Propyl-Acetate Methanol*: this diagram was created using the activity coefficient model of UNIFAC in ASPEN Plus. - K.Freeman

Activity Coefficients Diagram Simulated in Aspen of Propyl-Acetate/ Methanol using the Peng-Robinson Method at 0.6MPa

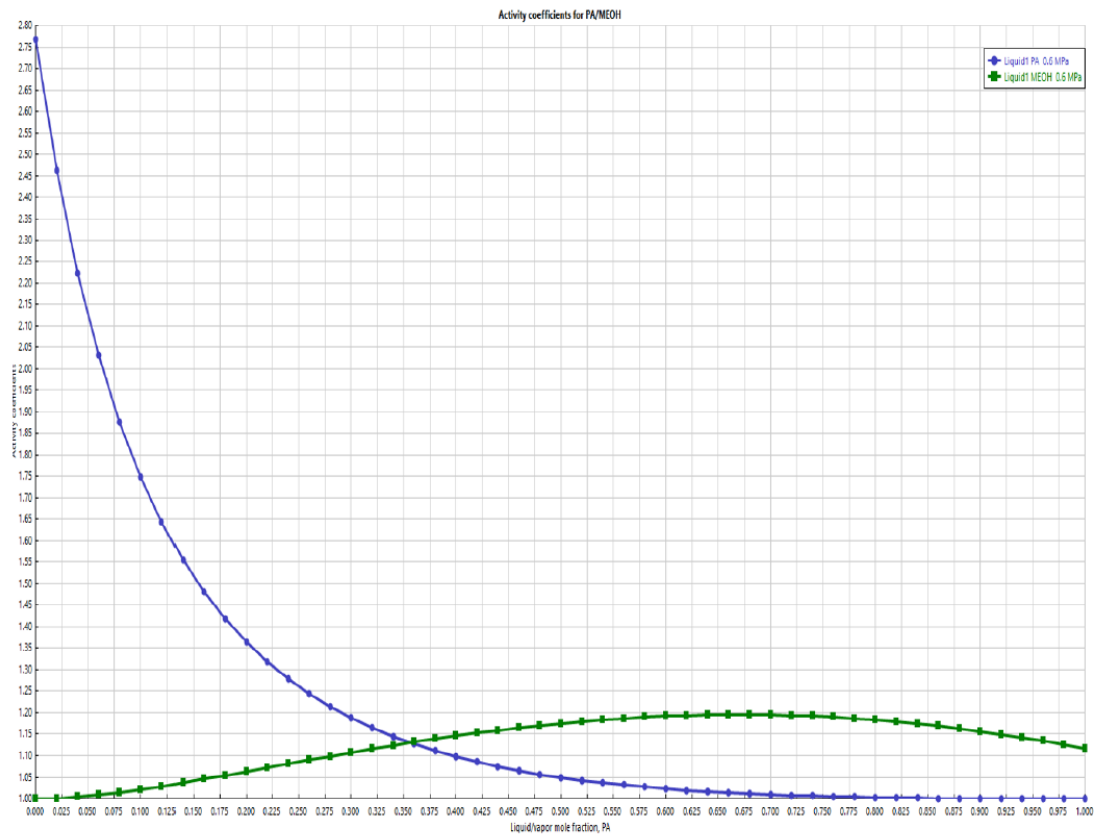


Figure 3.2 Activity Coefficient diagram for *Propyl-Acetate Methanol*: this diagram was created using the activity coefficient model of Peng Robinson in ASPEN Plus. - K.Freeman

Activity Coefficients Diagram Simulated in Aspen of Propyl-Acetate/ Methanol using the SRK Method at 0.6MPa

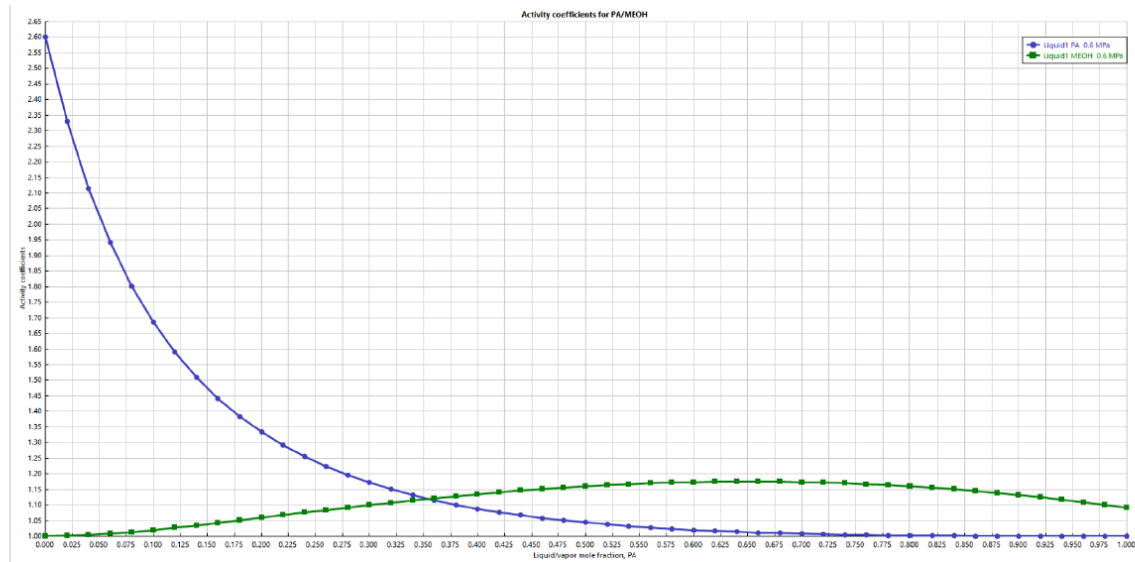


Figure 3.3 Activity Coefficient diagram for *Propyl-Acetate/Methanol*; this diagram was created using the activity coefficient model of SRK in ASPEN Plus. - K.Freeman

T-XY Diagram of experimental data of Propyl-Acetate (1) + Methanol (2) at 0.6MPa

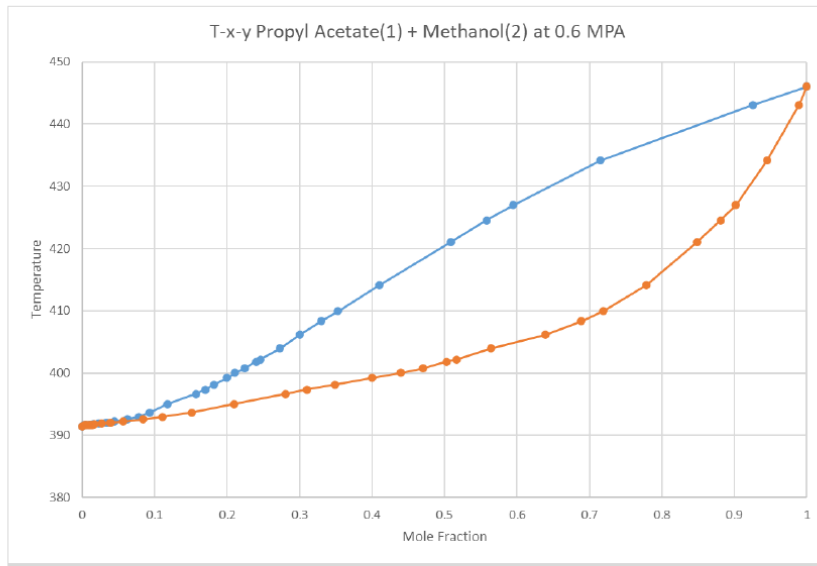


Figure 4.1 TXY Diagram of experimental data of Propyl Acetate(1) + Methanol (2) at 0.6 MPa this diagram was made in excel. - K.Freeman

Discussion: Looking at the ASPEN Results for the Peng-Robinson(PR) and Soave- Redlich-Kwong(SRK) equations of state we can see that the Error for Vapor Composition (y) Decreases as the composition of Propyl Acetate Increases. From this we can determine that Cubic Equations of State aren't very accurate for predicting the polar behavior of Methanol Vapor in these conditions. Our graphs help us understand this as the Liquid and Vapor curves are almost indistinguishable from $x_1=0-0.05$ on all of our ASPEN Models. The Average Error for the points used for the table above for PR and SRK were 18.3% and 18.9% respectively. What we can conclude from this is that while these graphs give us a good visual of how our binary system behaves in Vapor Liquid equilibrium, It is not reliable enough if precise calculations are needed. Our UNIFAC model showed a similar trend to the Cubic EOS as the error of the vapor curve decreased and the composition of Propyl Acetate increased. However The UNIFAC Method only had an Average Error of 4.7% which is about 4 times more accurate then the other two methods. This is likely due to the fact that the UNIFAC method is based on estimating the activity coefficients of a mixture rather than parameters such as Pressure, Volume and Temperature like an EOS. Using this Knowledge we can look at the activity coefficient graphs and see that trends for Propyl Acetate are similar with the SRK Model being a bit closer to the UNIFAC. However looking at the activity coefficient plots for Methanol we can see that the PR Model

does not follow the other curves as x_1 trends towards 1. With our understanding of the Gibbs/Duhem Equation $\frac{G^E}{RT} =$

$\sum_i x_i \ln \gamma_i$ Since our activity constant for Methanol has less of an effect on thermodynamic data of the system as its presence decreases, the increasing error of the PR Methanol activity coefficients had a more negligible effect as the trend increased. This also may explain why $x_1=0.4, 0.44, 0.5$ were the only mole fractions that PR had a higher Error as the inaccuracy of the Methanol calculations were more relevant at these values.

Conclusion: This report consists of three chosen activity coefficients models that were simulated using ASPEN plus. We generated a TXY diagram of the experimental data for Propyl Acetate/Methanol and excel spreadsheets and excel functions to show the variations of VLE diagrams of each activity coefficient in reference to the experimental data. The activity coefficient models that were chosen are the SRK equation, Peng Robinson equation, and the UNIFAC method. The VLE diagram that was chosen to determine the nature and compositions of the liquid and vapor mole fractions of this binary system was the T-xy diagram. The T-xy diagram provided a more convenient option for observing the relation of phase compositions at varying temperatures with a constant pressure value of 0.6Mpa. This pressure value demonstrated that in each model the binary system will form azeotropes (because there are points in which $y_i = x_i$) and concur that Propyl-Acetate/Methanol cannot be completely separated by distillation at this pressure.

To effectively interpret the data from each diagram, the activity coefficient models were carefully chosen in order to fit the parameters that correspond to the experimental data for Propyl-Acetate/ Methanol. Due to the fact we created a TXY diagram we need to hold a pressure constant. We decided to hold pressure constant at 0.6MPa to best correlate with our experimental data. Furthermore, the modified Raoult's law would be needed in order to conduct a better analysis of the VLE behavior. The modified Raoult's law is commonly used for binary systems at low pressure; and the experimental data of this binary system was held at a low pressure which made the VLE analysis feasible.

The Aspen simulated TXY diagrams represent the activity coefficient models for vapor/liquid equilibrium of Propyl-Acetate/Methanol at 0.6Mpa. The T-xy diagrams that were generated using ASPEN appear to complement the experimental data. The TXY diagrams that were generated in Aspen are not an exact replica of the TXY experimental diagram because an ebulliometer was used to record and distinguish the equilibrium of Propyl-Acetate/Methanol. The activity coefficient model diagrams will differ from the experimental diagrams because of the degree of uncertainty placed on the ebulliometer, the parameters and their different functions of the parameters from the EOS models(Peng-Rob and SRK).

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BELOW AVERAGE

Memorandum

Date: December 1, 2021

To: Dr. Osborne-Lee

From : Maya Spears, Byron Henderson, and Wesley Walsh

Re : Project #2: Aspen Simulation of T-x-y Diagrams and Activity Coefficient Models

Introduction

Raoult's Law is a Vapor/Liquid Equilibrium model where ideal solutions and ideal gas behavior are assumed. The formula for this simplification is shown below¹:

$$y_i P = x_i P_i^{\text{sat}} \quad (i = 1, 2, \dots, N) \quad (13.16)$$

where x_i is a liquid-phase mole fraction, y_i is a vapor-phase mole fraction, and P_i^{sat} is the vapor pressure of pure species i at the temperature of the system. The product $y_i P$ is the *partial pressure* of species i in the vapor phase. Note that the only thermodynamic function to survive here is the vapor pressure of pure-species i , suggesting its primary importance in VLE calculations.

However, sometimes components will deviate from ideal gas behavior and Raoult's Law.

Another law has to come into play and take this deviation into account. The law that takes this into account is the Modified Raoult's Law, which is shown below:

$$y_i P = x_i \gamma_i P_i^{\text{sat}} \quad (i = 1, 2, \dots, N) \quad (13.19)$$

For this project, we had to choose a non-ideal mixture that deviates from Raoult's Law. The mixture we decided to go with for this project was a Benzene-Methanol mixture. We chose this mixture because it has a positive deviation from Raoult's Law and is not an ideal solution. After getting our mixture approved by our professor, we were tasked with calculating VLE data for a binary system and using different models within various simulations in Aspen. This project consists of three phases; first we select a binary system and use published VLE data, next we use Aspen to generate our T-x-y diagrams for our system, and finally we use Aspen to simulate different property methods and compare those simulations to our real data.

¹ Smith, Joseph M., et al. "Chapter 13: THERMODYNAMIC FORMULATIONS FOR VAPOR/ LIQUID EQUILIBRIUM." *Introduction to Chemical Engineering Thermodynamics*, McGraw-Hill Education, Dubuque, 2021.

Objectives

- Find a binary system
- Ensure binary system is not ideal and deviates from Raoult's
- Compare T-x-y diagrams that use different activity coefficient models generated within Aspen.
- Select the best activity coefficient model that fits within our real binary system data.

Results

After getting the Benzene + Methanol mixture approved by our professor, the first thing we did was plot our real data onto an Excel sheet. This can be seen viewed as Figure 1 in our appendix1''11233'. Figure 1 includes the x-y, gamma, and natural log of gamma points, as well as T-x-y, gamma vs x, natural log of gamma vs x plot. We used these Benzene + Methanol plots from the Excel sheet to compare them to our Aspen simulations. After careful comparison and analysis of the plots, we decided the best activity coefficient model for our mixture would be the Wilson model.

Discussion

To start our project, we had to first find a binary system. The particular system we chose could not be ideal and had to be approved by our professor to ensure no two groups would pick the same system. After our professor approved Benzene + Methanol as our binary system, we were able to begin our work. First, we had to utilize Aspen so we could simulate T-x-y plots using different activity coefficient models to compare to our original data. After deliberating on which models to choose, we decided to select Wilson, Vanlaar, and Grayson. We originally chose 4 activity coefficient models with our fourth one being UNIQUAC. However, after simulating the diagrams within Aspen, we realized that UNIQUAC and Wilson looked identical to each other, so we decided to pick one and chose Wilson.

To plot the data points in Aspen, we specifically utilized Aspen Plus V9. Upon opening the program, we created a blank simulation and entered Benzene and Methanol as our components. After this step, we selected which method we would like to use for the T-x-y plot. The first method we chose was WILSON-2 and we had to select a specific source within the program so it could pull the necessary information about our components. Finally, the program could generate our T-x-y plot and we were able to capture a picture of this diagram. We repeated these same steps for both the VANL-2 and GRAYSON-2 methods in Aspen.

After generating the T-x-y plots in Aspen, we then used the data points from data from our source to plot real experimental data to compare to the T-x-y diagrams created in Aspen. The first diagram we attempted to plot our real data on was the Vanlaar T-x-y chart. However, the windows of the Vanlaar diagram did not fit the numbers in our experimental data, so we could not plot it. This immediately let us know that the Vanlaar activity coefficient model would not be the best fit for our system and we were down to two models. After Vanlaar, we plotted the experimental data onto the Wilson and Grayson diagrams. Upon examining the diagrams with

both data points, we then deliberated on which model best fit our mixture. The activity coefficient model we elected to choose was the Wilson model.

Figure 3 in the appendix shows our T-x-y diagram for the Wilson activity coefficient model along with our experimental data plotted for comparison. Based off of our real data, which is the purple and orange lines shown on the diagram, the Wilson activity coefficient model was the one that best matched with our original Benzene-Methanol data. The other diagrams had similar shapes, however none of the points matched as closely as Wilson. The other graphs will be available to see in the appendix, labeled as Figures 2 and 4 respectively.

After we chose Wilson as the activity coefficient model, we chose to generate a plot for the natural log of gamma vs X in Aspen with the Wilson model. After Aspen generated this diagram, we plotted our points for the natural log of gamma and X to compare the two. We also chose to create this plot for the other models for this particular type of diagram, but we did not plot our points on there since we already chose Wilson as the activity coefficient model that best fit our mixture. After putting our points on the Wilson diagram, we saw that once again our plots followed a similar trend to the Wilson model and further solidified our decision to select Wilson as the best fit model.

Conclusion

To summarize, we feel that this project was a success. This project introduced us to Aspen, and as time went on, we were able to successfully navigate Aspen and become more familiar with the program. In regard to the objectives of our project, the binary system that we chose within the given parameters was Benzene-Methanol. After picking our binary system, we plotted our VLE data in T-x-y and activity coefficient diagrams in order to compare it to the different simulations used within Aspen. After doing trial and error with different property methods, we were able to determine that Wilson was the activity coefficient method that matched the closest to our T-x-y binary system data.

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**CHEMICAL ENGINEERING THERMODYNAMICS II
FALL 2021**

**Title of Assignment: UPLOAD VIDEO PRESENTATION FOR
PROJECT 1 – Refrigeration Cycle Design Project**

**TOPICS COVERED IN PROJECT 1
(Video Articulation of Concepts Weight Category 25%)**

Project 1 covered the following topics:

1. Review of the 1st and 2nd laws of thermodynamics
2. Introduction of refrigeration cycle with application of thermodynamic principles
 - a. Cycles and state properties
 - b. Isothermal, isobaric, reversible, and irreversible processes
 - c. Use of thermodynamic tables
 - d. Real vs. ideal gas behavior
3. Concept of efficiency: compressor efficiency, cycle efficiency and coefficient of performance
4. Phase diagrams (p-H and T-S diagrams) and their use in representing and analyzing a refrigeration cycle
5. Application of 2nd law and concept of approach temperature in selecting condenser & evaporator operating pressure
6. Refrigerant selection based on operating pressure/temperature and global warming potential (GWP)
7. Experience working in teams
8. Oral communication

**CHEMICAL ENGINEERING THERMODYNAMICS II
FALL 2021**

**SAMPLE ORAL REPORTS SUBMITTED AND
AND GRADING SCHEME FOR PROJECT 1**

ABOVE AVERAGE

Thermodynamics Project 1 Video Link
 Dr. Osborne-Lee
 CHEG 3304
 Kayla Freeman & Janeria Perry
 Video Link: <https://youtu.be/0I3VnvUWfbA>

Project 1 Team 6 Video Grading

Wednesday, October 20, 2021 6:59 AM

CHEG 3304 **Che Thermo II**
 Oral Report [Video Articulation]

Project 1 Refrigeration Cycle Design
 September 17, 2021

Rubric for Grading Video Presentations for Project 1

Criteria (Weights)	4 Expert	3 Proficient	2 Apprentice	1 Novice
Content (30)	Shows a full understanding of the topic. Thoroughly explains and includes readings from the texts, terminology, key questions & answers, and outside research.	Shows a good understanding of the topic. Explains and includes readings from the texts, terminology, key questions & answers, and outside research.	Shows a good understanding of parts of the topic. Explains and includes a small bit of readings from the texts, terminology, key questions & answers, and outside research.	Does not seem to show an understanding of the topic. Little to no explanation; little to no readings from the texts, terminology, key questions & answers, and outside research.
Use of Terms (15) Vocabulary, Pronunciation, Spelling	Uses vocabulary appropriate for the audience and does so correctly. Extends audience vocabulary by defining words that might be new to most of the audience.	Uses vocabulary appropriate for the audience, with some familiarity. Includes some words that may be new to most of the audience and mostly defines them.	Uses vocabulary appropriate for the audience, but is somewhat unfamiliar with some. Does not include any vocabulary that might be new to audience.	Uses several (5 or more) words or phrases that are not understood by the audience, or by the presenter.
Expertise (20) Comprehension of Concepts, Ability to Explain	Student is able to accurately answer almost all questions posed on the topic, such as meaning of terms and importance results.	Student is able to accurately answer most questions posed on the topic, such as meaning of terms and importance results.	Student is able to accurately answer a few questions posed on the topic, such as meaning of terms and importance results.	Student is unable to accurately answer almost all questions posed on the topic, such as meaning of terms and importance results.
Articulation (10) Clarity of Speech, fluency, posture, eye contact	Speaks clearly and distinctly consistently. Stands or sits erect, looks relaxed and confident. Establishes eye contact during the presentation.	Speaks clearly and distinctly most of the time. Stands or sits erect. Establishes eye contact during the presentation.	Speaks clearly and distinctly much of the time. Sometimes stands or sits erect. Establishes some eye contact.	Mumbles or cannot be understood. Slouches and/or does not look at people during the presentation.
Readiness (10) Level of Preparedness	Student is completely prepared and has obviously rehearsed.	Student seems pretty prepared but might have needed a bit more rehearsal.	Student is somewhat prepared, but rehearsal is clearly lacking.	Student does not seem at all prepared to present.
Teaming (10) Effective interaction of teammates	Excellent	Good	Fair	Poor
Timeliness (5) Punctuality, Use of Time	Presentation began on time and is the correct length.	Presentation began a bit late and/or is nearly the correct length.	Presentation began late or was not the correct length.	Presentation began late and was not the correct length.

Total Score: _____

Comments:

Team 6

- Well balanced team presentation
- Both were confident and fluent
- Both demonstrated excellent knowledge
- Excellent presentation

Freeman
Perry

Refrigeration Cycle Design

- Compressor**
 - Through an isentropic process vapor is compressed, and a superheated vapor is produced.
- Condenser**
 - Superheated vapor is condensed a liquid is formed, and there is liquid heat.
- Thermal Expansion Valve**
 - Saturated liquid is expanded through an isenthalpic process, saturated liquid and vapor is produced.
- Evaporator**
 - At constant temperature and pressure heat is absorbed, saturated liquid is evaporated, and saturated vapor is produced.

CHEG3304 Project 1 KaylaFreeman JaneriaPerry

Results

Calculations:

Given: $T_1 = 20^\circ\text{C}$
 $T_2 = 10^\circ\text{C}$
 $T_3 = 40^\circ\text{C}$
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AVERAGE

Link to our Project 1 Video Presentation

Thermo2Project1 iCloud Drive

<https://www.icloud.com/iclouddrive/04cRifA3zjHcV3UzF9CIRFD-A#Thermo2Project1>

Isaiah Waters, Shelton Amaram, Kelby Smith

Project 1 Team 5 Video Grading

Wednesday, October 20, 2021 6:59 AM

CHEG 3304 CHE Thermo II
Oral Report (Video Articulation)

Project 1 Refrigeration Cycle Design
September 17, 2021

Rubric for Grading Video Presentations for Project 1

Criteria (Weight)	4 Expert	3 Proficient	2 Apprentice	1 Novice
Content (30)	Shows a full understanding of the topic. Thoroughly explains and includes readings from the texts, terminology, key questions & answers, and outside research.	Shows a good understanding of the topic. Explains and includes readings from the texts, terminology, key questions & answers, and outside research.	Shows a good understanding of parts of the topic. Explains and includes a bit of readings from the texts, terminology, key questions & answers, and outside research.	Does not seem to show an understanding of the topic. Little to no explanation; little to no readings from the texts, terminology, key questions & answers, and outside research.
Use of Terms (15) Vocabulary, Pronunciation, Spelling	Uses vocabulary appropriate for the audience and does so correctly. Defines any audience vocabulary by defining it in a way that might be new to most of the audience.	Uses vocabulary appropriate for the audience, with some familiarity. Includes some words that may be new to most of the audience and mostly defines them.	Uses vocabulary appropriate for the audience, but is somewhat unfamiliar with some. Does not include any vocabulary that might be new to audience.	Uses several (5 or more) words or phrases that are not understood by the audience, or by the presenter.
Expertise (20) Comprehension of Concepts, Ability to Explain	Student is able to accurately answer almost all questions posed on the topic, such as meaning of terms and importance results.	Student is able to accurately answer most questions posed on the topic, such as meaning of terms and importance results.	Student is able to accurately answer some questions posed on the topic, such as meaning of terms and importance results.	Student is unable to accurately answer almost all questions posed on the topic, such as meaning of terms and importance results.
Articulation (10) Clarity of Speech, Fluency, posture, eye contact	Speaks clearly and distinctly consistently. Stands or sits erect, looks relaxed and confident. Establishes eye good contact during the presentation.	Speaks clearly and distinctly most of the time. Stands or sits erect. Establishes eye contact during the presentation.	Speaks clearly and distinctly much of the time. Sometimes stands or sits erect. Establishes some eye contact.	Mumbles or cannot be understood. Slouches and/or does not look at people during the presentation.
Readiness (10) Level of Preparedness	Student is completely prepared and has obviously rehearsed.	Student seems pretty prepared but might have needed a bit more rehearsal.	Student is somewhat prepared, but rehearsal is clearly lacking.	Student does not seem at all prepared to present.
Teaming (10) Effective interaction of teammates	Excellent	Good	Fair	Poor
Timeliness (5) Punctuality, Use of Time	Presentation began on time and is the correct length.	Presentation began a bit late and/or is nearly the correct length.	Presentation began late or was not the correct length.	Presentation began late and was not the correct length.

Total Score: _____

Comments:

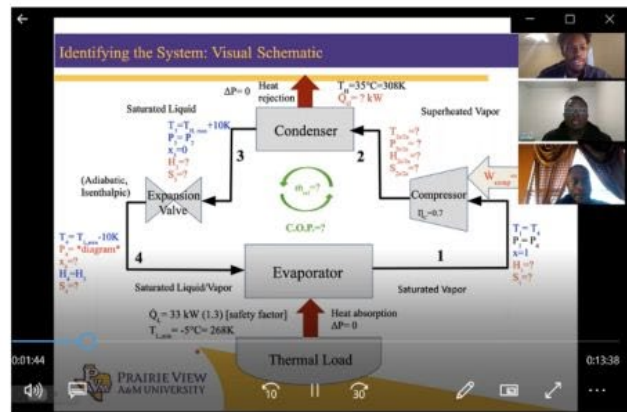
Team 5

- Good use of 3-step method for problem solving
- Cycle well represented on PH diagram
- Quality of 0.4 does not match location on PH diagram for state 4 ($x \approx 0.34$)
- Proper use of efficiency
- Too many sig digs
- Video continuity problem (technical difficulty)

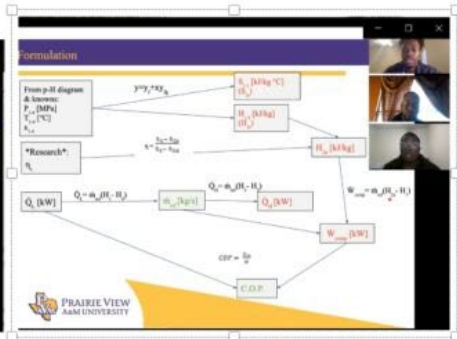
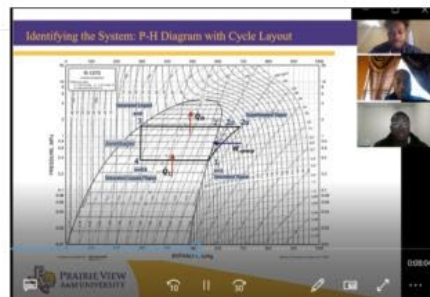
Waters - contributed most

Amaram - contributed much

Smith - contributed much less (1 min total screen time)



W
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A



BELOW AVERAGE

Group 9 Project link
 Zenab Coulibaly-Diakite
 Meibruth Salas
 Jeffrey Sanders
 Link for Video Recording
 passcode-6vBY6=qw
https://pvpanther.zoom.us/rec/play/EVmUVJO5yg5K-8NZaxdhy2qCWHO3dDoE5kLnfg9zbnLBHMRlPhXWpWV4BVYSqesKouQaZBqF7aW6AiW.4cDzVLLMsdI2I_KW?continueMode=true&_x_zm_rtaid=K397YMK7Rd-vY897X-KPsA.1632018461173.753537e12379a6582be56200b9d38129&_x_zm_rhtaid=330

Project 1 Team 9 Video Grading

Wednesday, October 20, 2021 6:59 AM

CHEG 3304 **CHE Thermo II**
 Oral Report (Video Articulation)

Project 1 Refrigeration Cycle Design
 September 17, 2021

Rubric for Grading Video Presentations for Project 1

Criteria (Weight)	4 Expert	3 Proficient	2 Apprentice	1 Novice
Content (30)	Shows a full understanding of the topic. Thoroughly explains and includes readings from the texts, terminology, key questions & answers, and outside research. ✓	Shows a good understanding of the topic. Explains and includes readings from the texts, terminology, key questions & answers, and outside research.	Shows a good understanding of parts of the topic. Explains and includes a small bit of readings from the texts, terminology, key questions & answers, and outside research.	Does not seem to show an understanding of the topic. Little to no explanation; little to no readings from the texts, terminology, key questions & answers, and outside research.
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Teaming (10) Effective interaction of teammates	Excellent	Good ✓	Fair	Poor
Timeliness (5) Punctuality, Use of Time	Presentation began on time and is the correct length. ✓	Presentation began a bit late and/or is nearly the correct length.	Presentation began late or was not the correct length.	Presentation began late and was not the correct length.

Total Score: _____

Comments:

Team 9

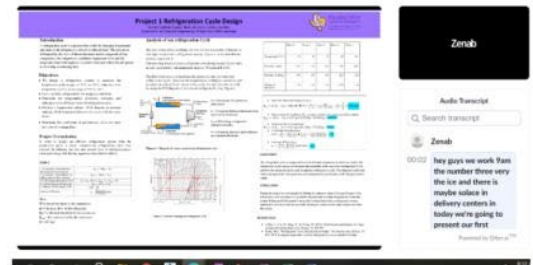
- Used poster style presentation template
- Coulibaly-Diakite
- Did not appear (face not shown) in video
- Contributed most

Salas

- Did not appear (face not shown) in video
- Volume very low

Sanders

- Did not appear (face not shown) in video
- Seemed to be reading a script



CHEMICAL ENGINEERING THERMODYNAMICS II FALL 2021

**Title of Assignment: UPLOAD ORAL PRESENTATION REPORT FOR
PROJECT 2 – Using ASPEN Simulation for Txy, Pxy Diagram
Generation and Activity Coefficient Model Selection**

**TOPICS COVERED IN PROJECT 2
(Video Articulation of Concepts Weight Category 25%)**

Project 2 covered the following topics:

1. Literature search to find published VLE data for binary systems
2. Ideal solution behavior and departure from Raoult's Law
3. Activity coefficient models accounting for non-ideal solution behavior
4. Generation of phase diagrams (Txy and Pxy) using ASPEN.
5. Comparison of model simulations of phase behavior with real data obtained from the published literature
6. Selection of the best model based on visual observation of overlaid data and theory plots
7. Experience working in teams
8. Oral communication

**CHEMICAL ENGINEERING THERMODYNAMICS II
FALL 2021**

**SAMPLE ORAL REPORTS SUBMITTED AND
AND GRADING SCHEME FOR PROJECT 2**

ABOVE AVERAGE

Group 4 Project link

Kayla Freeman

Janeria Perry

Erron Williams

Topic: thermo 2 project presentation

Date: Dec 5, 2021 12:00 PM Pacific Time (US and Canada)

Meeting Recording:

https://pvpanther.zoom.us/rec/share/g8_dCb2nbui8hl7Ss7EhGbt12dq1ds2RNniNu4_ZUag5jJ69Xf9cGNFCbzEZKdqh.Pa7maToTBCZldm-

CHEG 3304 ChE Thermo II
Oral Report (Video Articulation)

Project 2 VLE Simulation & Activity Coefficient Selection
November 19, 2021

Rubric for Grading Video Presentations for Project 2				
Criteria (Weight)	4 Expert	3 Proficient	2 Apprentice	1 Novice
Content (30)	100 Shows a full understanding of the topic. Thoroughly explains and includes readings from the texts, terminology, key questions & answers, and outside research.	88 Shows a good understanding of the topic. Explains and includes readings from the texts, terminology, key questions & answers, and outside research.	75 Shows a good understanding of parts of the topic. Explains and includes a small bit of readings from the texts, terminology, key questions & answers, and outside research.	60 Does not seem to show an understanding of the topic. Little to no explanation; little to no readings from the texts, terminology, key questions & answers, and outside research.
Use of Terms (15) Vocabulary, Pronunciation, Spelling	Uses vocabulary appropriate for the audience and does so correctly. Extends audience vocabulary by defining words that might be new to most of the audience.	Uses vocabulary appropriate for the audience, with some familiarity. Includes some words that may be new to most of the audience and mostly defines them.	Uses vocabulary appropriate for the audience, but is somewhat unfamiliar with some. Does not include any vocabulary that might be new to audience.	Uses several (5 or more) words or phrases that are not understood by the audience, or by the presenter.
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Total Score: 96

Comments:

Team 5

- All are confident and demonstrate knowledge
- Team benefitted from their research in knowledge of how their binary system behaves and is usually modeled

Kiara Graham

- Introduction and background

Kennedy Dent

- Objectives
- Identify, formulate and solve
- Discussed use of activity coefficient model to fit literature data

Kalaya Anderson

- Described steps taken to get results and how the data look when presented
- Explained ideal solution model and how modified Raoult's Law is different
- Nice theoretical background given!

AVERAGE

https://drive.google.com/file/d/1TjR9eE8CdZWFFdQQAwDQMK05OmfWYbq/view?usp=drive_w eb

CHEG 3304 ChE Thermo II
Oral Report (Video Articulation)

Project 2 VLE Simulation & Activity Coefficient Selection
November 19, 2021

Rubric for Grading Video Presentations for Project 2

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Team 1 (7:15)

- Good team dynamics shown
- Method of analysis does not include direct overlay of plot of model prediction versus published actual behavior, but rather relied on side by side observation of shape of curve of plotted data

Jazmaine Carter

- Introduction

Dynasty Stephenson

- Discussed the method taken and the steps to model the data in Aspen

Edgar Mendoza

- Discussed objectives

88

Total Score: _____

Comments:

BELOW AVERAGE

Team 9: Nina Patthammavong

Vivian Patthammavong

• Zoom Link:

<https://protect-us.mimecast.com/s/5JDYJCjRN7ouRq1EXcRV8PK?domain=pypanther.zoom.us>

Passcode: rcwqg6.

CHEG 3304 **ChE Thermo II**
Oral Report (Video Articulation)

Project 2 VLE Simulation & Activity Coefficient Selection
November 19, 2021

Rubric for Grading Video Presentations for Project 2

Criteria (Weight)	4 Expert	3 Proficient	2 Apprentice	1 Novice
Content (30)	Shows a full understanding of the topic. Thoroughly explains and includes readings from the texts, terminology, key questions & answers, and outside research.	Shows a good understanding of the topic. Explains and includes readings from the texts, terminology, key questions & answers, and outside research.	Shows a good understanding of parts of the topic. Explains and includes a small bit of readings from the texts, terminology, key questions & answers, and outside research.	Does not seem to show an understanding of the topic. Little to no explanation; little to no readings from the texts, terminology, key questions & answers, and outside research.
Use of Terms (15) Vocabulary, Pronunciation, Spelling	Uses vocabulary appropriate for the audience and does so correctly. Extends audience vocabulary by defining words that might be new to most of the audience.	Uses vocabulary appropriate for the audience, with some familiarity. Includes some words that may be new to most of the audience and mostly defines them.	Uses vocabulary appropriate for the audience, but is somewhat unfamiliar with some. Does not include any vocabulary that might be new to audience.	Uses several (5 or more) words or phrases that are not understood by the audience, or by the presenter.
Expertise (20) Comprehension of Concepts, Ability to Explain	Student is able to accurately answer almost all questions posed on the topic, such as meaning of terms and importance results.	Student is able to accurately answer most questions posed on the topic, such as meaning of terms and importance results.	Student is able to accurately answer a few questions posed on the topic, such as meaning of terms and importance results.	Student is unable to accurately answer almost all questions posed on the topic, such as meaning of terms and importance results.
Articulation (10) Clarity of Speech, fluency, posture, eye contact	Speaks clearly and distinctly consistently. Stands or sits erect, looks relaxed and confident. Establishes eye good contact during the presentation.	Speaks clearly and distinctly most of the time. Stands or sits erect. Establishes eye contact during the presentation.	Speaks clearly and distinctly much of the time. Sometimes stands or sits erect. Establishes some eye contact.	Mumbles or cannot be understood. Slouches and/or does not look at people during the presentation.
Readiness (10) Level of Preparedness	Student is completely prepared and has obviously rehearsed.	Student seems pretty prepared but might have needed a bit more rehearsal.	Student is somewhat prepared, but rehearsal is clearly lacking.	Student does not seem at all prepared to present.
Teaming (10) Effective interaction of teammates	Excellent	Good	Fair	Poor
Timeliness (5) Punctuality, Use of Time	Presentation began on time and is the correct length.	Presentation began a bit late and/or is nearly the correct length.	Presentation began late or was not the correct length.	Presentation began late and was not the correct length.

Team 9 (7:33)

- Published data obtained does not include data in the dilute x1 or dilute x2 region of the Pxy diagram
- Did not find best fitting model or discuss how it would be done
- Did not overlay model results with published data

Vivian Patthammavong

- Introduction, including explanation of VLE
- Showed and discussed molecular structure of methanol and water

Nina Patthammavong

- Discuss Pxy diagram, using NRTL model to create plot in Aspen
- Reading the slide
- Table of data presented is very difficult to read due to small font
- Says that using the simulator is more accurate than using real data (!!), because of gap in dilute region.

Total Score: 70

**CHEMICAL ENGINEERING THERMODYNAMICS II
FALL 2021**

Title of Assignment Category: QUIZZES, NOTES AND EXERCISES

**LIST OF ASSIGNMENTS IN THIS CATEGORY
(Quizzes, Notes and Exercise Weight Category 15%)**

Samples of assignments with quiz grade are presented from those listed here.

1. Upload Certificate of Completion of Academic Integrity Assignment
2. Thermo II Syllabus Quiz (Take in Canvas)
3. Upload Thermodynamic Concepts Inventory (TCI) Quiz
4. Upload Confidential Team Member Evaluation for Project 1 (Individual Assignment)
5. Upload Quiz (Part A from Practice Test)
6. Upload Quiz on VLE Terms & Concepts
7. Upload Confidential Team Member Evaluation for Project 2 (Individual Assignment)

CHEMICAL ENGINEERING THERMODYNAMICS II
FALL 2021

SAMPLE ASSIGNMENTS WITH QUIZ GRADE

Samples of notes are presented from those listed here.

1. Upload Bullet Point Notes on BPR & BPN
2. Upload Bullet Point Notes (BPN) Explanation
3. Upload Bullet Point Notes (BPN) of Kelley's Review
4. Upload BPN for Chapter 3 Sections 3.4-3.7
5. Upload BPN for Viewing of 2 Videos on Cubic Equations & Corresponding States
6. Upload Bullet Point Notes on Chapter 13 in textbook (8e) on VLE
7. Upload BPN for Viewing of Screencast on Cubic Equations of State by Dr. Patton-Luks
8. Upload Notes from Early Consultation Meeting with Instructor (for Project 1)

CHEMICAL ENGINEERING THERMODYNAMICS II
FALL 2021

SAMPLE NOTES ASSIGNMENTS

Upload Bullet Point Notes on BPR & BPN
Due: Aug 26, 2021 at 11:59pm - CHEG3304P01-2210-18342

25/26 Graded 100 / 100 (100%) 2/26
Average

← ✓ Kalaya Anderson →

Page 1 of 2

Bullet Point Notes on BPR + BPN Kalaya Anderson

1) Bullet Point Reading (BPR) / Bullet Point Notes (BPN)

Actions to take

- conduct before learning session (1-7 days)
- read info. thoroughly
- encapsulate important info > 5 words
- skip lines for organization

Purpose

- ensure retention of material
- assist in focusing aspect
- mastering paraphrasing
- straightforward format = supporting retention
- decreasing study time
- increase student's comprehension level

TIPS to help a student

- begin work promptly once assigned
- maintain organization throughout BPN
- review continuously = ensure adequate comprehension
- keep all BPNs together
- BPN time: 8-10 min
1 hour learning

2) Understanding How the 4.0 guaranteed plan works

4.0 Plan Thoughts / Benefits

- detailed Management Plan => 4.0 Plan
- Improved GPA due to plan
- Easier to achieve 4.0
- motivation on graduate school enrollment
- Starting assignments directly when assigned
- Career planning = unique to success
- based on student's opinion / feedback
- opportunities for leadership development

Submitted: Aug 26, 2021 at 7:29pm

Student Viewed Document: Oct 19, 2021 at 12:16pm

Submitted Files: (click to load)

KaLaya Anderson BPN Notes on BPR + BPN (1).pdf

Assessment

Grade out of 100

100

Assignment Comments

<= 5 words, not >= 3

Irvin Osborne-Lee, Oct 19, 2021 at 12:13pm

0

Add a Comment

Submit

Reassign Assignment

Download Submission Comments

- Important to students: 8 hr z_z
- BPN contributed to successful understanding
- Importance of Guaranteed 4.0 Plan = key
- Some students found BPN unimportant

Upload Bullet Point Notes (BPN) of Kelley's Review

 Published

 Edit



Read the first 16 pages of Kelley's Review of Thermodynamics (available at this course site) while taking bullet point notes. To complete this assignment, upload your BPN for this bullet point reading (BPR) assignment.

Points 100

Submitting a file upload

Due	For	Available from	Until
Sep 1, 2021 at 11:59am	Everyone	Aug 25, 2021 at 12am	Sep 2, 2021 at 11:59pm

 Rubric

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Kelly's Review of Thermo (BPN)

Wesley Walsh
due: 9/1

I. Macroscopic description of thermodynamic systems

thermo. system def: any body of matter or radiation large enough to be described by macroscopic parameters w/o reference to individual (atomic or subatomic) constituents.

- complete specification requires knowledge of a system's contents AND boundary

↳ boundaries MAY be permeable

isolated system → NO exchange of energy or mass

closed system → exchange energy but NOT mass

open system → exchange energy and mass

- thermodynamic parameters

intensive: independent of mass

extensive: dependent on mass

- central problem of thermo → What is the equilibrium condition now that "x" external condition is different?

- equation of state relates parameters in an equilibrium state

II. Reversible and Irreversible Transformations

- reversible → changes to system can be undone; uncommon; useful for theory; adiabatic

- irreversible → changes to system can't be undone; more common due to rapid changes

III. Laws of Thermodynamics

0th Law - if two systems are separately in equilibrium w/ a third, then they must also be in equilibrium with each other.

↳ transitive

- ask about 0th law + isotherms

1st Law -

- adaptation of law of conservation to suit thermodynamics
- internal energy (U); state function
- work (W); change in (U) NOT due to heat
- heat (Q); change in (U) NOT due to work
- $\Delta U = Q + W$
- work done (rev.) adiabatic → $\delta W = -P dV$

2nd Law -

- heat flows hot → cold
- no engine perf. efficient
- basis for ENTROPY
- entropy increases always due to either system OR surroundings

3rd Law -

- entropy approaches zero as temp. approaches zero
- not possible to optimize a system to reach $T = 0$ K

IV. Thermodynamic Potentials

- $du = T ds + \sum_i P_i dx_i$
- $ds = \frac{1}{T} du + \sum_i \frac{Q_i}{T} dx_i$
- enthalpy → $H = U + PV$

Upload BPN for Chapter 3 Sections 3.4-3.7

 Published

 Edit



Read the first 16 pages of Kelley's Review of Thermodynamics (available at this course site) while taking bullet point notes. To complete this assignment, upload your BPN for this bullet point reading (BPR) assignment.

Do bullet point reading for this material from Thermo I, which appears in chapter 3. Attached are sections 3.4-3.7 for this purpose.

 [svna8 ch3 section 4-7.pdf](#) 

Upload your BPN here.

Points 100

Submitting a file upload

File Types pdf, doc, txt, ppt, docx, pptx, xlw, xls, and jpg

Due	For	Available from	Until
Sep 30, 2021 at 11:59am	Everyone	Aug 25, 2021 at 12am	Oct 2, 2021 at 11:59pm

 Rubric

Chapter 3: 3.4-3.7

virial equations of state: $PV = a + bP + cP^2 + \dots$

$PV = a(1 + B'P + C'P^2 + D'P^3 + \dots)$, $B', C', \dots$ are constants

Ideal Gas Temp: $(PV)^* = a = f(T)$

Universal Gas Constant: $(PV)^* = a = RT$

$(PV)^*_T = R \times 273.16 \text{ K}$
 $T_K = 273.16 \frac{(PV)^*_T}{(PV)^*}$

$$R = \frac{(PV)^*_T}{273.16 \text{ K}}$$

$$R = \frac{22711.8 \text{ bar} \cdot \text{cm}^3 \cdot \text{mol}^{-1}}{273.16 \text{ K}} = 83.14 \frac{\text{bar} \cdot \text{cm}^3}{\text{mol} \cdot \text{K}}$$

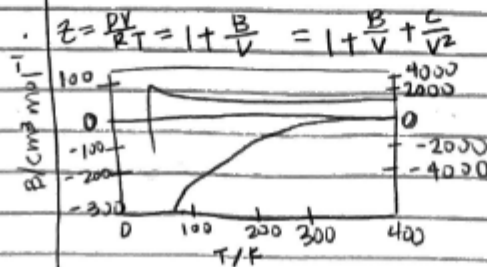
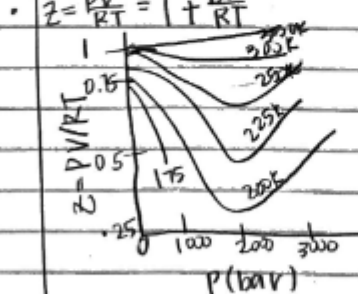
2 Forms of Virial Equation: $Z = \frac{PV}{RT} = \frac{V}{V_{ig}}$

$Z = 1 + B'P + C'P^2 + D'P^3 + \dots$

$$Z = 1 + \frac{B}{V} + \frac{C}{V^2} + \frac{D}{V^3} + \dots$$

$$B' = \frac{B}{RT} \quad C' = \frac{C - \frac{B^2}{RT}}{(RT)^2} \quad D' = \frac{D - 3B^2 + 2B^3}{(RT)^3}$$

application of virial eq: $\left(\frac{\partial Z}{\partial P}\right)_T = B' + 2C'P + 3D'P^2 + \dots$, $\left(\frac{\partial Z}{\partial P}\right)_{T,P=0} = B'$

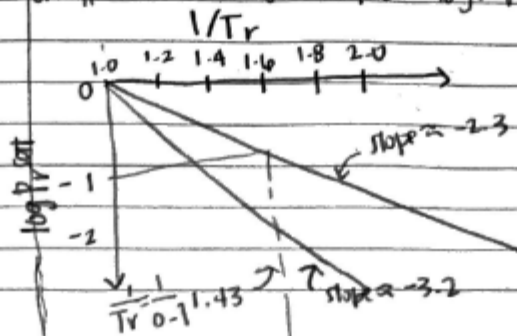


cubic equations of state • Van der Waals Equation: $P = \frac{RT}{V-b} - \frac{a}{V^2}$
 • generic cubic equation: $P = \frac{RT}{V-b} - \frac{a(T)}{V(V+b)} \Rightarrow P = \frac{RT}{V-b} - \frac{a(T)}{(V+eb)(V+ob)}$

determination of equation-of-state parameters • $\left(\frac{\partial P}{\partial V}\right)_{T,cr} = 0$ $\left(\frac{\partial^2 P}{\partial V^2}\right)_{T,cr} = 0$
 $b = \Omega \frac{RT_c}{P_c}$ and $a(T_c) = \psi \frac{R^2 T_c^2}{P_c}$
 • $a(T) = \psi \alpha(T_r, \omega) \frac{R^2 T_c^2}{P_c}$

roots of generic cubic equation • $B \equiv \frac{bP}{RT}$ $q \equiv \frac{a(T)}{bRT}$
 $z = 1 + B - qB \frac{z}{(z+eB)(z+oB)}$
 $z = B + (z+eB)(z+oB) \frac{(1+B-z)}{qB}$
 $B = \Omega \frac{P_r}{T_r}$ $q = \frac{\psi \alpha(T_r, \omega)}{\Omega T_r}$

corresponding states; acentric factor • all fluids, @ same T_r & P_r , have about same compressibility factor, & all deviate from ideal-gas behavior @ about same degree
 • $\frac{d \log P_r^{sat}}{d(1/T_r)} = f \Rightarrow \log P_r^{sat}(SF) - \log P_r^{sat}$
 • acentric factor: $\omega \equiv -1.0 - \log(P_r^{sat})_{T_r=0.7}$



Generalized
correlation for
gases

• Pitzer Correlations for Compressibility Factor: $z = z^0 + w z^1$

• $\frac{T_c}{K} = \frac{43.6}{1 + \frac{21.8}{2.014T}} \quad (\text{for } H_2)$

• $\frac{P_c}{\text{bar}} = \frac{20.5}{1 + \frac{44.2}{2.014T}} \quad (\text{for } H_2)$

Upload BPN for Viewing of 2 Videos on Cubic Equations & Corresponding States [Ⓐ]

✓ Published

✎ Edit

⋮

Complete the viewing of the two videos with links given below.

- Zoom Class Meeting Recording - Cubic Equations & Corresponding States by Dr. Osborne-Lee - Access Passcode: FS=[^]vf=5
 - https://pvpantther.zoom.us/rec/share/f2ceva3lg6H8CIUhBmf7suFD6ubdRgByYhExhbdoJ8Cnyti-LMDUdFugFeMbbnI.HuIAry_f9BnqKULz [Ⓐ]
- Instructional Video on Generalized Correlations By Dr. Patton-Luks (No Passcode Needed)
 - <https://www.youtube.com/watch?v=sfOMRzecx1Y> [Ⓐ]



Upload bullet point notes here. One set should cover both videos, since the Osborne-Lee lecture discusses the Patton-Luks lecture material.

Points 100

Submitting a file upload

File Types pdf, doc, txt, ppt, docx, pptx, xlw, xls, and jpg

Due	For	Available from	Until
Oct 1, 2021 at 11:59am	Everyone	Aug 25, 2021 at 12am	Oct 3, 2021 at 11:59pm

+ Rubric

Lecture BPN notes

- departure function = residual function

- P_i = zer correlation

- $Z = Z^0 + wZ'$

- $Z^0 = f(T_r, P_r)$

- w = substance constant - acentric factor

- $Z' = f(T_r, P_r)$

- $w > 0.02$ is significant

- Ammonia $w = 0.25$

- $Z = 0.85 + (0.25)(0.18) = 0.9$

- accuracy of reading charts limited

- $P = \frac{RT}{V-b} - \frac{a}{V^2}$

- $PV^3 - (Pb + RT)V^2 - aV + ab = 0$

- $\bar{a}x^3 + \bar{b}x^2 + \bar{c}x + \bar{d} = 0$

$$i \quad \tilde{a} = P$$

$$\cdot \tilde{b} = -(Pb + RT)$$

$$\cdot \tilde{c} = -a$$

$$\tilde{d} = ab$$

• Tabulate & formulate V

Module 13A Generalized correlation BPN

$$\cdot T_r = \text{reduced temperature} = T/T_c$$

$$\cdot P_r = \text{reduced pressure} = P/P_c$$

$$\cdot H_c \text{ and } H_e$$

$$\cdot T_r = T/(T_c + 8K)$$

$$\cdot P_r = P/(P_c + 8 \text{ atm})$$

• Compressibility graphs

• P_r vs Z , lines T_r

$$\cdot \frac{H^R}{RT_c} = \frac{(H^R)^0}{RT_c} + w \frac{(H^R)^1}{RT_c}$$

$$\cdot \frac{S^R}{R} = \frac{(S^R)^0}{R} + w \frac{(S^R)^1}{R}$$

• H^R = residual enthalpy

• S^R = residual entropy

$$H_2 - H_1 = -H_{T_1, p_1}^R + \left[\Delta H_{T_1, T_2}^{IG} + \Delta H_{p_2, p_1}^{IG} \right] + H_{T_2, p_2}^R$$

$$H_2 - H_1 = -H_{T_1, p_1}^R + \Delta H_{T_1, T_2}^{IG} + H_{T_2, p_2}^R$$

$$S_2 - S_1 = -S_{T_1, T_2}^R + \left[\Delta S_{T_1, T_2}^{IG} + \Delta S_{p_1, p_2}^{IG} \right] + S_{T_2, p_2}^R$$

$$\Delta H^{IG} = \int_{T_1}^{T_2} C_p dT$$

$$\Delta S^{IG} = \int_{T_1}^{T_2} \frac{C_p}{T} dT - R \ln \left(\frac{p_2}{p_1} \right)$$

Samples of Exercises are presented from those listed here.

1. Upload Exercise 1 – Review of Thermo 1
2. Upload Exercise Pxy Plots at 3 Temperatures with Flash and Activity Coefficient Plotting
3. Upload Preliminary Calculations for Project 1 – Identify and Formulate
4. Upload Exercise on Deriving Maxwell Relations from UHAG Generating Functions
5. Upload Exercise on Partial and Maxwell Relations
6. Upload Exercise on calculating Z for Project 1 Working Fluid (Teams)
7. Upload Exercise (Part B – Problem 1 from Practice Test)
8. Upload Exercise (Part B – Problem 2 from Practice Test)
9. Upload Exercise on Understanding Phase Diagrams (Individual)
10. Upload Exercise on Estimating Tank Pressure and residual Volume
11. Upload Exercise on Calculating Z Values from Data, EOS, and TCS for Project 1 Working Fluid (Teams) – Part A&B
12. Upload Exercise on Calculating Z Values from Data, EOS, and TCS for Project 1 Working Fluid (Teams) – Part B&C

CHEMICAL ENGINEERING THERMODYNAMICS II
FALL 2021

SAMPLE EXERCISE ASSIGNMENTS

Upload Exercise 1 - Review of Thermo 1

 Published

 Edit



Complete the problems in this exercise as part of your review of Thermo I.

 [200821- cheg3053 review of thermo 1.pdf](#) 

Points 100

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Due	For	Available from	Until
Aug 29, 2021 at 11:50pm	Everyone	Aug 23, 2021 at 12am	Aug 30, 2021 at 11:59pm

 Rubric

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Exercise 1 - Review Problems

1. What pressure in torr is equivalent to standard atmospheric pressure?

Answer: 760 torr

2. What height of water @ 25°C in standard gravitational field is equivalent to standard atmospheric pressure?

$P = \rho g h$ @ standard atmospheric pressure = 1 atm

$$1 \text{ Pa} = 1 \frac{\text{kg}}{\text{m} \cdot \text{s}^2} \quad 1 \text{ atm} = 101325 \text{ Pa}$$

$$g = 9.81 \text{ m/s}^2$$

$$\rho \text{ of water @ } 25^\circ\text{C} = 997.07 \frac{\text{kg}}{\text{m}^3}$$

$$P = \rho g h$$

$$101325 \text{ Pa} = 997.07 \frac{\text{kg}}{\text{m}^3} \left(9.81 \frac{\text{m}}{\text{s}^2} \right) \cdot h$$

$$101325 \frac{\text{kg}}{\text{m} \cdot \text{s}^2} = 997.07 \frac{\text{kg}}{\text{m}^3} \left(9.81 \frac{\text{m}}{\text{s}^2} \right) \cdot h$$

Answer: $h = 10.359 \text{ m} \approx \boxed{h = 10.36 \text{ m}}$

3. A) $P(V-b) = RT$ here, b is a constant & $0 < b < V$

$$P = \frac{RT}{V-b}$$

$$dW = -P dV$$

$$W = - \int_{V_i}^{V_f} (P dV)$$

$$= - \int_{V_i}^{V_f} \frac{RT}{V-b} dV$$

$$= -RT \ln(V-b) \Big|_{V_i}^{V_f}$$

$$= -RT (\ln(V_f - b) - \ln(V_i - b))$$

$$= -RT \ln \left(\frac{(V_f - b)}{(V_i - b)} \right)$$

Answer: $\boxed{W = RT \ln \left(\frac{(V_i - b)}{(V_f - b)} \right)}$

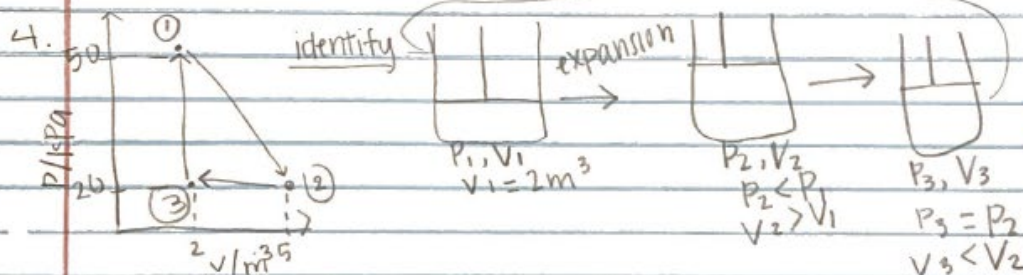
→ Back

3. B) $PV = nRT$

$$P = \frac{RT}{V}$$

$$\begin{aligned} W &= - \int_{V_i}^{V_f} (P dV) \\ &= - \int_{V_i}^{V_f} \frac{RT}{V} dV \\ &= -RT \ln(V) \Big|_{V_i}^{V_f} \\ &= -RT (\ln(V_f) - \ln(V_i)) \\ &= -RT \ln \left(\frac{V_f}{V_i} \right) \\ &= RT \ln \left(\frac{V_i}{V_f} \right) \end{aligned}$$

Answer: Ideal gas produces less work



Goal: $W_{12} = ?$, $W_{23} = ?$, $W_{31} = ?$, $W_{\text{total}} = W_{12} + W_{23} + W_{31} = ?$

Formulate: $W = - \int_{V_i}^{V_f} P dV$

Solve: $W_{12} = - \int_{V_1}^{V_2} P dV = - \int_{V_1}^{V_2} (70 - 10V) dV$

$$\begin{aligned} P &= aV + b \\ P &= 70 - 10V \\ &= - \left[70(V_2 - V_1) - \frac{10}{2} (V_2^2 - V_1^2) \right] \\ &= - \left[70(5 - 2) - 5(5^2 - 2^2) \right] \\ &= -105 \text{ kJ} \therefore \text{work done by the system} = \boxed{W_{12} = 105 \text{ kJ}} \end{aligned}$$

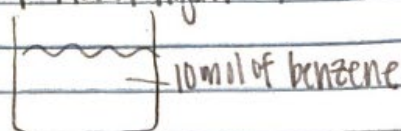
$$\begin{aligned} W_{23} &= - \int_{P_2}^{P_3} P dV = - P \int_{V_2}^{V_3} dV \\ &= - P_2 (V_3 - V_2) \\ &= P_2 (V_2 - V_3) \\ &= 20(5 - 2) \\ &= 60 \text{ kJ} \therefore \text{work done by system is } \boxed{W_{23} = -60 \text{ kJ}} \end{aligned}$$

$W_{31} = 0$ bc constant volume

$$\begin{aligned} W_{\text{TOTAL}} &= W_{12} + W_{23} + W_{31} \therefore \boxed{W_{\text{total}} = 45 \text{ kJ}} \\ &= 105 \text{ kJ} - 60 \text{ kJ} + 0 \text{ kJ} \end{aligned}$$

5. The 1st law of thermodynamics for a closed system is written different in some books because depending on whether work is done by or on the system, the sign changes from (+) to (-) or vice versa

6. Identify: • assume no heat exchange • work done by paddle wheel = 10256 J
 • 10 mol of benzene • temp. rise of liquid = 4°C
 • $C_p = 133.1 \text{ J} \cdot \text{mol}^{-1} \cdot ^\circ\text{C}^{-1}$



Formulate: $\Delta H = n C_p \Delta T$

Solve: $10256 \text{ J} = 10 \text{ mol} \cdot C_p \cdot 4^\circ\text{C}$

$$C_p = 156.4 \text{ J/mol} \cdot ^\circ\text{C}$$

∴ All work is not converted into heat ∴ there will be always heat loss of system from surrounding

7. Identify:

ideal gas	evacuated
no heat	no temp

 • $Q = ?$ • $\Delta U = ?$ • $P_f = ?$
 • $W = ?$ • $T_f = ?$

Formulate: ideal gas law: $PV = nRT$
 total $V_t = V_1 + V_2$

Solve: $W = 0$

$Q = 0$ bc perfectly insulated.

$$\Delta U = 0$$

$$\Delta U = C_v (T_f - T_i)$$

$$\Delta U = 0 \Rightarrow T_f = T_i$$

$T_i = \text{initial temperature}$

$$P_i V_i = P_f V_f$$

$$P_f = \frac{P_i V_i}{V_f}$$

$$P_i V_i = nRT_i$$

$$P_f = \frac{nRT_i}{V_f}$$

→ Back

8. Identify:

$$\boxed{\text{engine}} \left\{ \begin{array}{l} T_1 = 250^\circ\text{C} + 273 = 523\text{K} \\ T_2 = 25^\circ\text{C} + 273 = 298\text{K} \\ \text{work done: } W_{\text{net}} = 0.45\text{kJ} \end{array} \right.$$

Formulate: $\eta_{\text{th}} = \frac{\text{work output}}{\text{heat supplied}} \times 100$ & $\eta_{\text{rev}} = \frac{T_1 - T_2}{T_1} \times 100$

Solve: $\eta_{\text{th}} = \frac{0.45}{1} \times 100 = 45\%$

$$\eta_{\text{rev}} = \frac{523 - 298}{523} \times 100 = 43.02\%$$

Since no engine can be more efficient than a reversible engine, the claim is false.

9. Refrigerator: heat transfers from inside the refrigerator into the room. From the 2nd law of thermodynamics I know heat transfer can not do this. So, 100% of the work can not be converted into energy, there will always be some amount of energy that escapes as heat which warms the room. ∴
Window AC: The window AC takes hot air out & brings in cool air. The hot air is released outside so then you are left w/ cold air inside. This validates the 2nd law of thermodynamics because the heat transfer is from hot to cold. This means that the window AC cools the room.

10. Identify: $\boxed{280^\circ\text{C}} \xrightarrow{100\text{kJ}} \boxed{5^\circ\text{C}} \quad \Delta S_{\text{total}} = ?$ $280^\circ\text{C} = 553\text{K}$
 $5^\circ\text{C} = 278\text{K}$

Formulate: $\Delta S = \frac{Q}{T}$, $\Delta S_{\text{total}} = (\Delta S_H + \Delta S_L)$

Solve: $\Delta S_H = \frac{-100\text{kJ}}{553\text{K}} = -0.181\frac{\text{kJ}}{\text{K}}$ $\Delta S_L = \frac{100\text{kJ}}{278\text{K}} = 0.360\frac{\text{kJ}}{\text{K}}$

$$\begin{aligned} \Delta S_{\text{total}} &= \Delta S_H + \Delta S_L \\ &= -0.181\frac{\text{kJ}}{\text{K}} + 0.360\frac{\text{kJ}}{\text{K}} \\ &= \boxed{0.179\frac{\text{kJ}}{\text{K}}} \end{aligned}$$

11. A.) 1st law: $\Delta Q = \Delta U + \Delta W$

2nd law: $\Delta S = \Delta Q / T$

$$\Delta S = \frac{\Delta U}{T} + \frac{\Delta W}{T}$$

$$= \frac{C_v \Delta T}{T} + \frac{P \Delta V}{T}$$

@ constant volume, $dV = 0 \therefore \Delta S = \frac{C_v \Delta T}{T}$

B.) 1st law: $\Delta Q = \Delta U + \Delta W = \Delta U + P \Delta V$

enthalpy: $\Delta H = \Delta U + d(PV) \Rightarrow \Delta H = \Delta Q - P \Delta V + P \Delta V + V \Delta P = \Delta Q + V \Delta P$

@ constant pressure, $dP = 0$

$dQ = dH = C_p \Delta T$

$\therefore$ 2nd law: $\Delta S = \frac{\Delta Q}{T} \Rightarrow \Delta S = \frac{C_p \Delta T}{T}$

12. Consider an ideal gas for which $(C_v = \frac{5}{2}R, C_p = \frac{7}{2}R)$. The initial state is 1 bar & 20°C

A.) 1 kmol is heated @ constant volume to 80°C. Calculate $\Delta U, \Delta H, \Delta S, Q, \Delta W$

$T_2 = 80^\circ\text{C}$ $\Delta U = C_v \Delta T$

$$= \frac{5}{2}R \times (80 - 20)$$

$$= \frac{5}{2} \times 8.314 (80 - 20) \times 1000$$

$\Delta U = 1247.10 \text{ kJ}$

$\Delta H = C_p \Delta T$

$$= \frac{7}{2} (8.314) (80 - 20) \times 1000$$

$\Delta H = 1745.94 \text{ kJ}$

$\Delta S = \int_{T_1}^{T_2} C_p \frac{dT}{T} - R \ln\left(\frac{P_2}{P_1}\right)$

$\Delta S_{\text{total}} = 1000 \times \left[\frac{7}{2} \ln\left(\frac{80 + 273}{20 + 273}\right) - 8.314 \ln\left(\frac{P_2}{1 \text{ bar}}\right) \right]$

$P_1 V = nRT$ $\frac{P_1}{P_2} = \frac{T_1}{T_2} \Rightarrow \frac{1 \text{ bar}}{P_2} = \frac{293 \text{ K}}{353 \text{ K}}$

$P_2 = 1.205 \text{ bar}$

$\Delta S_{\text{total}} = 1000 \times \left[\frac{7}{2} \ln\left(\frac{353}{293}\right) - 8.314 \ln\left(\frac{1.205}{1}\right) \right]$

$\Delta S_{\text{total}} = -8916.28 \frac{\text{J}}{\text{K}}$

Back

14. $\beta T = kP = 1 - (b/v)$ where b is a constant. Find the equation of state of the gas, if $PV/RT = 1$ @ $P=0$.

- ideal gas $PV = RT$

$$dV = \left(\frac{\partial V}{\partial T}\right)_P dT + \left(\frac{\partial V}{\partial P}\right)_T dP$$

$$\frac{dV}{V} = \beta dT - k dP$$

$$\frac{dV}{V} = \frac{dT}{T} \left(1 - \frac{b}{v}\right) - \frac{dP}{P} \left(1 - \frac{b}{v}\right)$$

$$\frac{1}{V} \frac{dV}{\left(1 - \frac{b}{v}\right)} = \frac{dT}{T} - \frac{dP}{P}$$

$$\frac{dV}{v-b} = \frac{dT}{T} - \frac{dP}{P}$$

$$\ln(v-b) = \ln T - \ln P$$

$$\ln(v-b) = \ln\left(\frac{T}{P}\right)$$

$$(v-b) = \frac{T}{P}$$

$$\boxed{T = P(v-b)}$$

15. the eq. of state for liquids is $\frac{V_0 - V}{V_0} = \frac{AP}{B+P}$. Demonstrate that $A \leq 1$

$$\frac{V_0 - V}{V_0} = 1 - \frac{V}{V_0}$$

$$\therefore 1 - \frac{V}{V_0} \leq 1$$

$$\text{now, } \frac{AP}{B+P} \geq 1$$

$$\frac{1}{A} \left[\frac{B}{P} + 1 \right] \geq 1$$

since $\left(\frac{B}{P} + 1\right)$ is greater than 1 so, this means $\boxed{A \leq 1}$

Upload Exercise Pxy Plots at 3 Temperatures with Flash and Activity Coefficient Plotting [⚡]

Published

Edit

Complete the exercise started on Monday 15 November. Upload yours here.

 [211115 cheg 3304 pxy plots at 3 pressures for pentane toluene binary.doc](#) 

Points 100

Submitting a file upload

File Types pdf, doc, txt, ppt, docx, pptx, xlw, and xls

Due	For	Available from	Until
Nov 16, 2021 at 11:50pm	Everyone	Nov 10, 2021 at 12am	Nov 17, 2021 at 11:59pm

+ Rubric

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You may collaborate on this problem and may coach each other.
Each must submit their own unique individual work.

VLE data for the binary system *n*-pentane (1) and toluene (2) are shown in the graph below for three different temperatures. Use the inverse lever arm rule (ILAR) to determine the quality of the vapor-liquid mixture at 20°C and 200 torr for an overall composition of 37.5% *n*-pentane. Repeat for 30°C and 40°C. What is the trend? At what pressure will L/V 1 for a 50/50 mixture at 40°C?

*P(x,y) follow Raoult's law if the bubble curve is linear

ILAR for 20°C line:

$$\frac{.375 - .34375}{.9375 - .34375} = .052$$

ILAR for 30°C line:

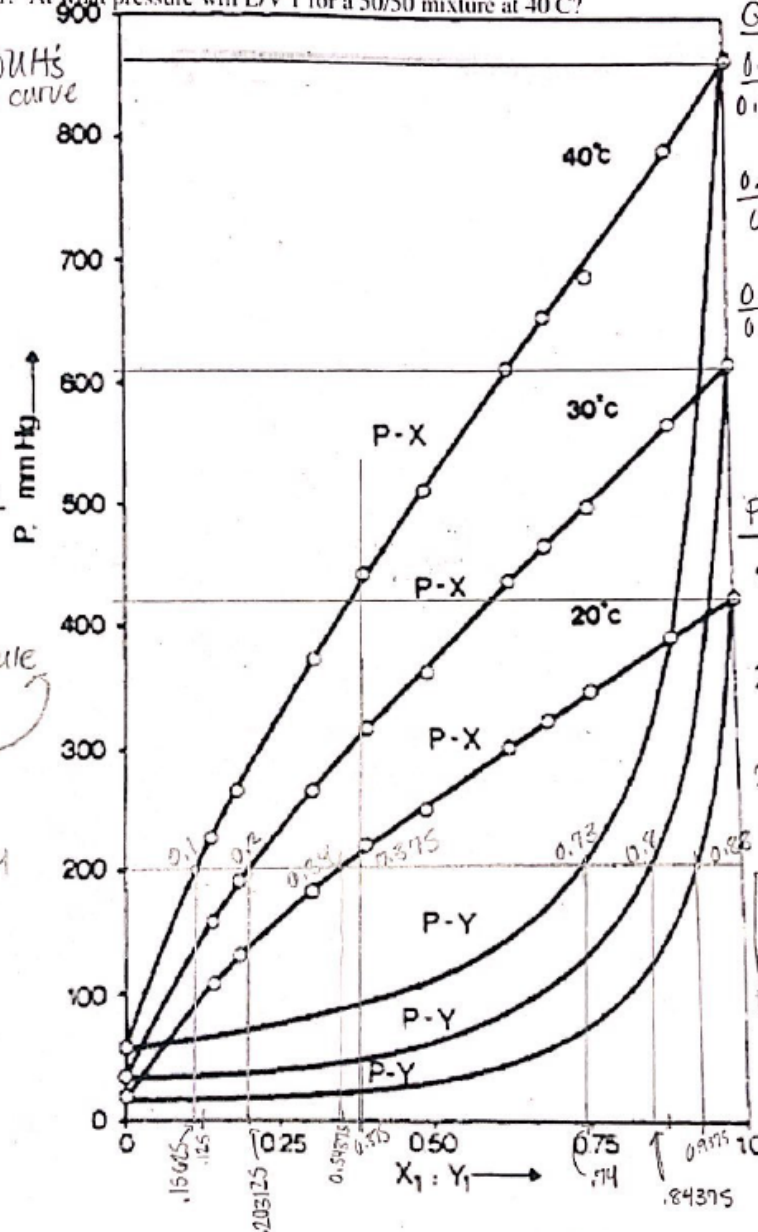
$$\frac{.5 - .31}{.99 - .31} = .0279$$

starting @ 1cm

ILAR for 40°C line:

$$\frac{3.95 - 1.15}{7.75 - 1.15} = .424$$

starting @ 0cm



Quality

$$\frac{0.375 - 0.34}{0.84 - 0.34} (20^\circ\text{C})$$

$$= 0.06$$

$$\frac{0.375 - 0.2}{0.80 - 0.2} (30^\circ\text{C})$$

$$= 0.29$$

$$\frac{0.375 - 0.1}{0.73 - 0.1} (40^\circ\text{C})$$

$$= 0.44$$

P(torr) L/V

$$0.50 - 0.17$$

$$0.77 - 0.17$$

$$= 0.55$$

$$0.5 - 0.19$$

$$0.79 - 0.19$$

$$= 0.52$$

$$0.5 - 0.2$$

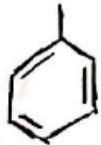
$$0.8 - 0.2$$

$$= 0.5$$

@ 272 mmHg

you'll get 50/50 mixture

Toluene n-pentane



To see if the lines follow modified Raoult's law

$$y_i P = x_i P_i^{\text{sat}}$$

To find P_i^{sat} of Pentane-n
- Using Antoine's Eq. $T = 20^\circ\text{C}$

$$\ln P_i^{\text{sat}} = A - \frac{B}{T+C}$$

$$\ln P_1^{\text{sat}} = (13.7667) - \frac{2451.88}{20 + 232.014}$$

$$\ln P_1^{\text{sat}} = 4.638 \Rightarrow P_1^{\text{sat}} = 56.69 \text{ kPa} \times 7.5 \frac{\text{torr}}{\text{kPa}}$$

$$\text{given } x_1 = 0.375, P = 200 \text{ torr} \Rightarrow P_1^{\text{sat}} = 425 \text{ torr}$$

- Using Antoine's Eq. $T = 30^\circ\text{C}$

$$\ln P_2^{\text{sat}} = A - \frac{B}{T+C} = 13.7667 - \frac{2451.88}{30 + 232.014}$$

$$\ln P_2^{\text{sat}} = 4.409 \Rightarrow P_2^{\text{sat}} = 82.18 \text{ kPa} \times 7.5 \frac{\text{torr}}{\text{kPa}}$$

$$\Rightarrow P_2^{\text{sat}} = 616 \text{ torr}$$

Using Antoine's Eq. $T = 40^\circ\text{C}$

$$\ln P_3^{\text{sat}} = A - \frac{B}{T+C} = 13.7667 - \frac{2451.88}{40 + 232.014}$$

$$\ln P_3^{\text{sat}} = 4.763 \Rightarrow P_3^{\text{sat}} = 115.92 \text{ kPa} \times 7.5 \frac{\text{torr}}{\text{kPa}}$$

$$\Rightarrow P_3^{\text{sat}} = 869.4 \text{ torr}$$

$$P = 200 \text{ torr} = 200 \text{ mmHg}$$

$$y_i P = x_i P_i^{\text{sat}}$$

$$P = 200 \text{ torr} = 200 \text{ mmHg}$$

$$x_1 = 0.34, y_1 = 0.88$$

$$(0.88) 200 \text{ torr} = (0.34)(425) \gamma$$

$$\gamma_1 = \frac{0.88(200)}{(0.34)(425)} = 1.22$$

$$P = 200 \text{ torr}$$

$$x_1 = 0.2, y_1 = 0.8$$

$$\gamma_2 = \frac{(0.8) 200}{(0.2)(616)} = 1.3$$

$$P = 200 \text{ torr}$$

$$x_1 = 0.1, y_3 = 0.73$$

$$\gamma_3 = \frac{(0.73) 200}{(0.1)(869)} = 1.7$$

@ 20°C

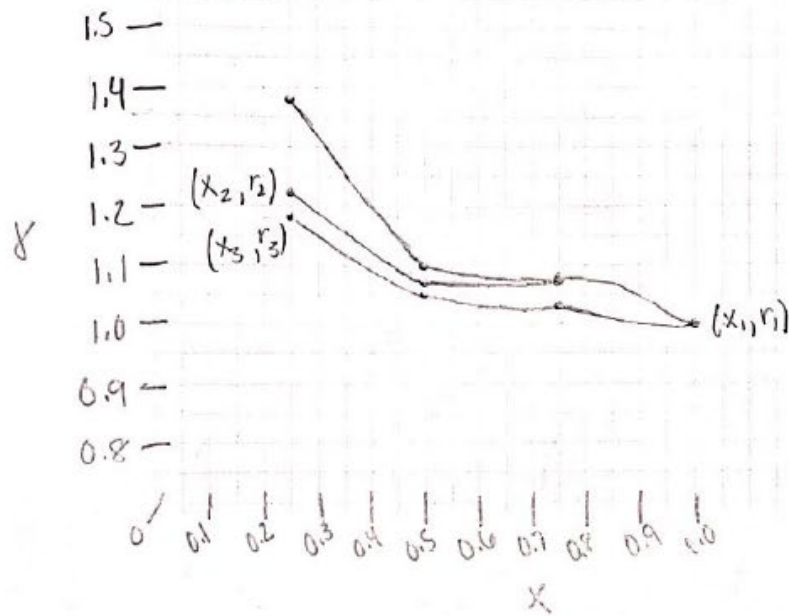
x_1	y_1	P_{torr}	P_1^{sat} (torr)	γ_1
0			425	
0.25	0.87	175		1.39
0.50	0.97	250		1.10
0.75	0.98	350		1.07
1	1	425		1

@ 30°C

x_2	y_2	P_{torr}	P_2^{sat} (torr)	γ_2
0			616	
0.25	0.86	225		1.24
0.50	0.95	280		1.08
0.75	0.99	402		1.07
1	1	616		1

@ 40°C

x_3	y_3	P_{torr}	P_3^{sat} (torr)	γ_3
0			869	
0.25	0.82	315		1.19
0.50	0.93	500		1.06
0.75	0.97	695		1.03
1	1	869		1



x - γ graph

Upload Exercise on Calculating Z for Project 1 Working Fluid (Teams)

 Published

 Edit



This exercise is given as a practice problem in class for the Monday 20 September class meeting. Upload here your completed calculation of the compressibility factor for your working fluid between each of the 4 stages in your refrigeration cycle. This is a team assignment.

 [210920 cheg3304 p02 exercise - refrigerants how much fudge \(z\).doc](#) 

Points 100

Submitting a file upload

File Types pdf, doc, rtf, and docx

Due	For	Available from	Until
Sep 22, 2021	Everyone	Sep 15, 2021 at 12am	Sep 24, 2021 at 11:59pm

 Rubric

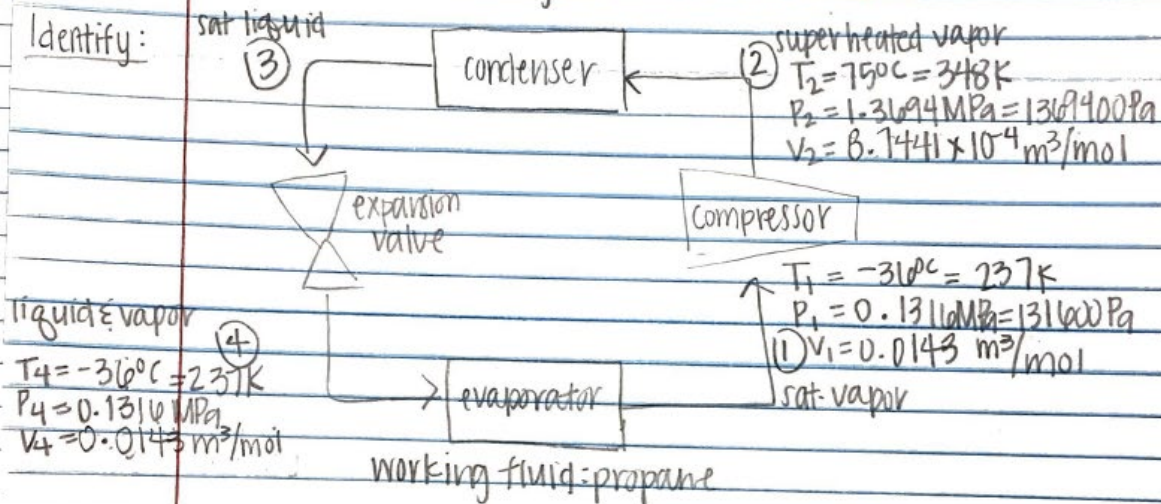
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Team 3: Kiara Graham
Dynasty Stephenson
Erren Williams

Exercise on Calculating Z Values from Data

Identify:



Formulate:

$$z = \frac{V_{\text{actual}}}{V_{\text{ideal}}}$$

$$z = \frac{PV}{RT}$$

$$z = z^0 + w z^1$$

$$\text{Van der Waals: } P = \frac{RT}{V-b} - \frac{a}{V^2}$$

$$z = \frac{V}{V-b} - \frac{a}{RTV}$$

$$z = \frac{P_2}{P_1}$$

$$T_R = \frac{T}{T_c}$$

$$P_R = \frac{P}{P_c}$$

$$PV = RT$$

$$P = \frac{RT}{V}$$

Solve:

A.) state 1: $z = \frac{(131600\text{Pa})(0.0143\text{m}^3/\text{mol})}{(8.314 \frac{\text{m}^3 \cdot \text{Pa}}{\text{mol} \cdot \text{K}})(237\text{K})} = 0.955 \approx \boxed{0.96}$

state 2: $z = \frac{(1369400\text{Pa})(8.7441 \times 10^{-4}\text{m}^3/\text{mol})}{(8.314 \frac{\text{m}^3 \cdot \text{Pa}}{\text{mol} \cdot \text{K}})(348\text{K})} = \boxed{0.41}$

state 1:

B.) $P = \frac{RT}{V-b} - \frac{a}{V^2}$ $a = 8.779 \frac{\text{L}^2 \cdot \text{bar}}{\text{mol}^2}$ $b = 0.08445 \frac{\text{L}}{\text{mol}}$

$V_1 = 0.0143 \frac{\text{m}^3}{\text{mol}} \quad 1\text{L}$ $R = 0.08206 \frac{\text{L} \cdot \text{atm}}{\text{K} \cdot \text{mol}} \quad 1.01325\text{bar}$

$\frac{\text{mol}}{0.001\text{m}^3}$ $R = 0.08315 \frac{\text{L} \cdot \text{bar}}{\text{K} \cdot \text{mol}}$

$V_1 = 14.3 \text{L/mol}$

Back

$$P = \frac{RT}{V-b} - \frac{a}{V^2}$$

$$P = \frac{(0.08315 \frac{\text{L} \cdot \text{bar}}{\text{K} \cdot \text{mol}})(237\text{K})}{(14.3 \text{ L/mol}) - (0.08445 \text{ L/mol})} - \frac{8.779 \frac{\text{L}^2 \cdot \text{bar}}{\text{mol}^2}}{(14.3 \text{ L/mol})^2}$$

$$P = 1.343 \text{ bar} \bigg| \frac{0.1 \text{ MPa}}{1 \text{ bar}} = 0.1343 \text{ MPa}$$

$$P = \frac{RT}{V}$$

$$P = \frac{(8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}})(237\text{K})}{0.0143 \text{ m}^3/\text{mol}} = 0.137791 \text{ MPa}$$

$$Z = \frac{P_{\text{actual}}}{P_{\text{ideal}}} = \frac{0.1343 \text{ MPa}}{0.137791 \text{ MPa}} = \boxed{0.97}$$

$$\text{State 2: } V = \frac{8.7441 \times 10^{-4} \text{ m}^3}{\text{mol}} \bigg| \frac{1 \text{ L}}{0.001 \text{ m}^3} = 0.87441 \text{ L/mol}$$

$$P = \frac{(0.08315 \frac{\text{L} \cdot \text{bar}}{\text{K} \cdot \text{mol}})(348\text{K})}{(0.87441 \text{ L/mol}) - (0.08445 \text{ L/mol})} - \frac{(8.779 \frac{\text{L}^2 \cdot \text{bar}}{\text{mol}^2})}{(0.87441 \text{ L/mol})^2}$$

$$P = 25.148 \text{ bar} \bigg| \frac{0.1 \text{ MPa}}{1 \text{ bar}} = 2.515 \text{ MPa}$$

$$P = \frac{RT}{V}$$

$$P = \frac{(8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}})(348\text{K})}{8.7441 \times 10^{-4} \text{ m}^3/\text{mol}} = 3.311 \text{ MPa}$$

$$Z = \frac{P_{\text{actual}}}{P_{\text{ideal}}} = \frac{2.515 \text{ MPa}}{3.311 \text{ MPa}} = \boxed{0.76}$$

Upload Exercise (Part B - Problem 2 from Practice Test)



✓ Published

Edit



This is part of a practice test given in class Wednesday 3 November. Upload Part A here.

Points 100

Submitting a file upload

File Types pdf, doc, rtf, and docx

Due	For	Available from	Until
Nov 3, 2021	Everyone	Nov 3, 2021 at 12am	Nov 4, 2021 at 11:59pm

+ Rubric

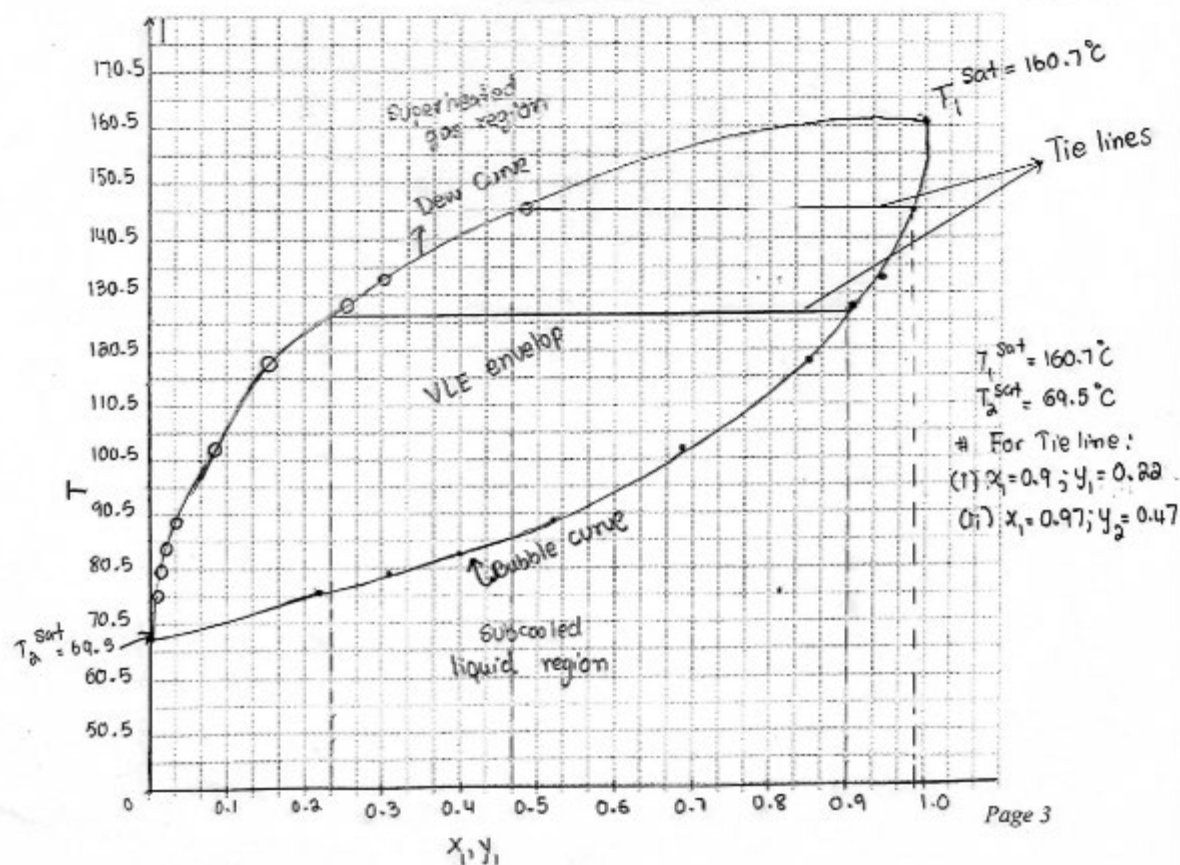
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November 3, 2021

- Plot the data points to create a phase diagram showing mixture behavior (a T - x - y diagram).
- Label the important features on the diagram, including the pure component saturation temperature values of each component; the boiling and condensation curves (bubble and dew curves); regions for different phase types; and equilibrium tie lines.

Temperature ($^{\circ}\text{C}$)	Ethylene Glycol in Liquid x_1	Ethylene Glycol in Vapor y_1
69.5	0	0
76.1	.23	.003
78.9	.31	.003
83.1	.40	.010
89.5	.54	.020
103.1	.73	.06
118.4	.85	.13
128	.90	.22
134.7	.93	.30
145.0	.97	.47
160.7	1	1



**CHEMICAL ENGINEERING THERMODYNAMICS II
FALL 2021**

Title of Assignment Category: DISCUSSION

**LIST OF ASSIGNMENTS IN THIS CATEGORY
(Discussion Weight Category 10%)**

Samples of Discussion assignments are presented from those listed here.

1. Discuss Bullet Point Reading (BPR) & Bullet Point Notes (BPN) from the Guaranteed 4.0 Plan
2. Discussion Recap - The Laws of Thermodynamics
3. Discussion Week 2 - Reversible vs. Irreversible, Intensive vs. Extensive, State vs. Path
4. Discussion Week 3_ P-H (versus the T-S) diagrams
5. Discussion Topic_ Theorem of Corresponding States (Chapter 3)

Discussion Forum Grading Rubric

	25	20	15	5-0
1. Relevance of Post	Posting thoroughly answers the discussion prompts and demonstrates understanding of material with well-developed ideas. Posting integrates assigned content and makes strong connections to practice.	Posting addresses most of the prompts and shows mild understanding of material with well-developed ideas. Posting references assigned content and may not make connections to practice.	Posting fails to address all components of the prompt. Makes short or irrelevant remarks. Posting lacks connection to practice	No posting.
2. Quality of Post	Post accurate and meaningful material to the community; attempts to motivate the group discussion; present creative approaches to topic	Post mostly accurate and/or somewhat meaningful material to the community; attempts to present relevant viewpoints for consideration by others	Post inaccurate and/or not-so-meaningful material to the community; minimal effort is made to participate	No posting.
3. Quality of Response	Appropriate comments: thoughtful, reflective, and respectful of other's postings.	Appropriate comments and responds respectfully to other's postings.	Responds, but with minimum effort. (e.g. "I agree with Alicia")	No response to another student's posting.
4. Mechanics (No file attachment uploads except where stipulated in assignment statement)	Writing is free of grammatical, spelling, or punctuation errors. No unsolicited file uploads.	Writing includes few grammatical, spelling, or punctuation errors. No unsolicited file uploads.	Writing includes more than a few grammatical, spelling, or punctuation errors. One or more unsolicited file uploads.	No posting or, writing contains many grammatical, spelling or punctuation errors.

Some typical feedback:

In the future, please remember to:

- Study before your post!
 - Do assigned readings, screencast viewings, and
 - Review available office hour recordings on the topic
- Cover all the points raised in the assignment statement
- Don't copy from sources verbatim, but instead to write in your own words (paraphrase)
- Respond to a colleague's post with comments that are constructive
 - Encourage the good
 - Suggest ideas for improvement
- You can respond to more than one colleague's post
- Check the assignment carefully, reading the assignment statement very carefully
- Be sure to post on the correct topic!

Total: _____ / 100 points

CHEMICAL ENGINEERING THERMODYNAMICS II
FALL 2021

DISCUSSION TOPIC 1

1. Discuss Bullet Point Reading (BPR) & Bullet Point Notes (BPN) from the Guaranteed 4.0 Plan

Published
Edit
...

This is a graded discussion: 100 points possible due Aug 26, 2021

Discuss Bullet Point Reading (BPR) & Bullet Point Notes (BPN) from the Guaranteed 4.0 Plan 40 52

Discuss the nature of (1) bullet point reading and (2) bullet point notes, saying what each is and the difference in the terms, plus the merits of each. Suggest how it can be used to enhance learning in this course.

For full credit you must post (50 points) AND comment (50 points) on another student's post. Your comment should point out strengths and areas for improvement. See grading rubric available at this site.

[Discussion Forum Post - Grading Rubric by JWOL.pdf](#)

- 

<https://ecourses.pvamu.edu/courses/13615/users/2584>
 Aug 24, 2021
- Bullet point reading is a step-by-step approach used to make learning what you have read more effective and simple. It should be done 1-7 days before class. To do bullet point reading, you should read section by section and stop when you see an important idea. Summarize what you have read in 3-5 words. Bullet point notes is also a step-by-step approach to make note-taking easier to understand what you have learned in class. This should be done immediately after class and for every hour spent in lecture, it should take no more than 10 minutes of bullet notes. The difference between bullet point reading and bullet point note-taking is that: bullet point reading should be done before class to ensure a preview of material about to be taught. On the other hand, bullet point notes should be done after class to help identify our level of understanding. The merit of bullet point reading is that it helps you organize the information you read in your own words also it is storing the information you read in your long-term memory. The merit of bullet point notes is that, when it is time to review your notes, it will become a faster and easier process because you have clear explanations of what you have learned. Bullet point reading can enhance learning in this course by becoming familiar with concepts before they are taught in class and your brain does not have to work as hard. Bullet point notes can enhance learning in this course by reinforcing what has been taught in class. By doing this, studying for quizzes and exams becomes easier because it does not take as much time. By using both of these techniques, you can ultimately help you get a 4.0 GPA.
-
- 

<https://ecourses.pvamu.edu/courses/13615/users/11080>
 Aug 24, 2021
- Hello Kiara,
- I agree with all the points you highlighted in your post. Your explanation was concise and comprehensive.
-
- 

<https://ecourses.pvamu.edu/courses/13615/users/4633>
 Aug 24, 2021
- Hey Kiara, Great Job Highlighting the Differences Between BPR and BPN and how each can help us absorb information. You covered all the necessary information maybe just try breaking up this paragraph next time.
-
- 

<https://ecourses.pvamu.edu/courses/13615/users/4108>
 Aug 24, 2021

This was a really great explanation Kiara. You were detailed about the BPN and BPR also you stated the differences with the advantages.

[← Reply](#)

○



[Zenab Coulibaly-Diakite](#)

<https://ecourses.pvamu.edu/courses/13615/users/11080/>

Aug 24, 2021

*Bullet Point Reading: allow the student to read the material easier, brain-friendly. The student sees an already organized hierarchy. The big concepts of the materials are highlighted. To be done 1-7 days before the class.

*Bullet Point Notes: It is how a student organizes or takes his notes in his own words during the lectures to be able to bullet point read later on.

*How can those too enhance learning in this course?

- study method that is brain-friendly
- less needed study time
- bettering comprehension

[← Reply](#)

○



[Kiara Graham](#)

<https://ecourses.pvamu.edu/courses/13615/users/2584/>

Aug 24, 2021

Great response! I didn't see anything about how they are merits of each other. Other than that, it was a good response.

[← Reply](#)

○



[Edgar Mendoza](#)

<https://ecourses.pvamu.edu/courses/13615/users/4205/>

Aug 26, 2021

hello Zenab, I would add that BPR requires us to continue reading until we reach an important idea and BPN should be done immediately after lectures. But I liked how you identified "Big concepts of materials" and the material being "Brain-friendly". Those 2 things resonated with me.

[← Reply](#)

○



[Erron Williams](#)

<https://ecourses.pvamu.edu/courses/13615/users/4639/>

Aug 24, 2021

For Bullet Point Reading you should summarize important points in 3-5 words on a separate sheet of paper and it should be done 1-7 days before class. BPR helps you pay attention by putting info in your own words in a concise format. Bullet Point Notes should also be 3-5 words on a separate piece of paper however, they need to be done immediately after class so that they can reinforce what was just taught in the lecture. For every hour of lecture, there should be 10 minutes of notes so you should have 30 minutes of Notes at the end of the week for a 3-hour course. BPR can be used to make sure that we are familiar with the material and help us form questions prior to class. BPN can be useful by helping us retain the concepts taught in class so that we can successfully complete our homework and tests.

[← Reply](#)

○



[Yazmine Rincon](#)

<https://ecourses.pvamu.edu/courses/13615/users/10784/>

Aug 24, 2021

Hello Erron!

Excellent job in highlighting when we should start BPR and BPN, and why it is important. I like how you also reinforced in your last statement of how it can be beneficial to us as students. I believe that is a crucial sentence to outline because that is how it will help us retain the material taught in class.

[← Reply](#)

○

1/5/22, 8:02 AM

Topic: Discuss Bullet Point Reading (BPR) & Bullet Point Notes (BPN) from the Guaranteed 4.0 Plan



<https://ecourses.pvamu.edu/courses/13615/users/7718>

<https://ecourses.pvamu.edu/courses/13615/users/7718>

Aug 25, 2021

Hi Erron

I also agree with you about the meaning and the differences between BPR and BPN. Both methods are really useful in learning or reviewing the material in class. Also, it is essential to help students prepare for the exam.

[Reply](#)

O



<https://ecourses.pvamu.edu/courses/13615/users/10784>

<https://ecourses.pvamu.edu/courses/13615/users/10784>

Aug 24, 2021

Bullet Point Reading and Bullet Point Notes are methods used to reinforce what we have learned during lecture. Bullet Point Reading should be a summarization of points in 3 to 5 words and should be done within 1 to 7 days whereas Bullet Point Notes is paraphrasing information that you have retained. Basically to create an understanding between the material and the student. By utilizing BPN and BPR, we will be able to identify and outline the importance and become familiar with the concepts. These methods are feasible to create as they are effective in note taking and has proven to make a student successful in class.

Edited by [Yazmine Rincon](https://ecourses.pvamu.edu/courses/13615/users/10784) <https://ecourses.pvamu.edu/courses/13615/users/10784> on Aug 24, 2021 at 8:05pm

[Reply](#)

O



<https://ecourses.pvamu.edu/courses/13615/users/8134>

<https://ecourses.pvamu.edu/courses/13615/users/8134>

Aug 25, 2021

Hi Yazmine,

I also agree with you that this is a creative and effective way to study the material. It definitely helps with being successful in the class and understanding the course better.

[Reply](#)

O



<https://ecourses.pvamu.edu/courses/13615/users/4108>

<https://ecourses.pvamu.edu/courses/13615/users/4108>

Aug 24, 2021

Bullet point reading is a method that helps students gain background knowledge of the material prior to the lecture. Typically students take down 3-5 words when reading chapter(s) or sections of key points that will help them remember the topic in class. This also helps with stating points for class discussions and journals/essays. The advantage of following the BPR steps is that you will know about the information that is about to be taught in class days before the class. On the other hand, there is BPN, (bullet point notes), which is notes that are written during the lecture or right after the lecture. This method should help the student reinforce the material they have learned during the lecture. This also shows how well the student understands the information that they were being taught. Some students that may have did the BPR will just elaborate more on the information they had before the class to after the lecture. The advantage of BPN is key points will be remembered. The difference between BPR and BPN is BPR is learning new information before class and going into a lecture with knowledge. The BPN is going into a lecture taking down major points or key details that will show how well you understood the lecture after class.

[Reply](#)

O



<https://ecourses.pvamu.edu/courses/13615/users/8204>

<https://ecourses.pvamu.edu/courses/13615/users/8204>

Aug 25, 2021

hello Kennedy

You do a great job highlighting the difference between BPN and BPR and the meaning of each of them. Also, I agree with you that a note-taking method will help you prepare before the lecture and review critical concepts after a class. you include all necessary information for us to know how much is essential to do BPN and BPR

[Reply](#)

CHEMICAL ENGINEERING THERMODYNAMICS II
FALL 2021

DISCUSSION TOPIC 2

2. Discussion Recap - The Laws of Thermodynamics

Published Edit ...

This is a graded discussion: 100 points possible due Aug 27, 2021 at 2pm

Discussion Recap - The Laws of Thermodynamics 49 50

Summarize the laws of thermodynamics, saying what each means and giving an illustration (in words not by drawing). Reply to the post of at least one other student. The grading rubric is shown in the document linked below.

[Discussion Forum Post - Grading Rubric by IWOL.pdf](#)

← Reply

- 
<https://ecourses.pvamu.edu/courses/13615/users/4179/>
 Alexis Rabb
 Aug 25, 2021

The 0th Law of Thermodynamics states that thermal equilibrium is transitive.

Ex: When you leave a cup of hot tea and cold tea on the table all day, both cups will attain thermal equilibrium with the temperature of the room.

The 1st Law of Thermodynamics states that energy is conserved but can be transformed.

Ex. A ball 10 meters high has only potential energy, and right before the ball hits the ground, it has very little potential energy and mostly kinetic energy. The potential energy decreases while the kinetic energy increases.

The 2nd Law of Thermodynamics states that the entropy of an isolated system that isn't in equilibrium will increase with time, eventually reaching a maximum value at equilibrium.

Ex: When putting an ice pack at 20 degrees Fahrenheit on a fevered forehead that's 101 degrees Fahrenheit, the ice pack and forehead will eventually reach the same temperature.

The 3rd Law of Thermodynamics states that entropy (disorder) vanishes at absolute zero ($T=0K$).

Ex: Vapor is the gaseous state of water at high temperatures, while entropy is increasing.

← Reply 🗨️
- 
<https://ecourses.pvamu.edu/courses/13615/users/2584/>
 Kiara Graham
 Aug 26, 2021

I like the examples you used.

← Reply 🗨️
- 
<https://ecourses.pvamu.edu/courses/13615/users/11080/>
 Zenab Coulibaly-Diakite
 Aug 26, 2021

Hello Alexis,

Your explanation is clear and very easy to grasp.

← Reply 🗨️
- 
<https://ecourses.pvamu.edu/courses/13615/users/2584/>
 Kiara Graham
 Aug 26, 2021

The 0th law of thermodynamics summarizes that thermal equilibrium is transitive. This means that if two thermodynamic systems are each in thermal equilibrium with the third system; then they are in thermal equilibrium with each other. An illustration of this is if you had two glasses of water, one with hot water and the other with cold, you then leave them out on the table for a few hours then they will obtain the temperature of the room.

The 1st law of thermodynamics can be summarized as energy is conserved but can be transformed. This means that energy can neither be created nor destroyed, only altered in form. An illustration of this is a light bulb transforms electrical energy into light energy.

The 2nd law of thermodynamics can be summarized as energy degrades when transformed. This means that the second law establishes the concept of entropy as a physical property of a thermodynamic system. An illustration of this is if you place a hot object in contact with a cold object. Heat flows from hot to cold, never spontaneously from cold to hot.

Lastly, the 3rd law of thermodynamics can be summarized as entropy (disorder) vanishes at absolute zero. This means that the entropy of a system approaches a constant value as its temperature approaches absolute zero. An illustration of this would be vapors of water are the gaseous forms of water at high temperatures.

← Reply ↩



<https://ecourses.pvamu.edu/courses/13615/users/10784/>

<https://ecourses.pvamu.edu/courses/13615/users/10784/>

Aug 26, 2021

Hello Kiara,

great examples! Truly, I was able to comprehend the information a lot better because the examples you provided are things that we come across on a daily basis. Especially the transfer of heat in the 0th law of thermodynamics. Heat travels from hot objects to cold objects, leading to thermal equilibrium.

← Reply ↩



<https://ecourses.pvamu.edu/courses/13615/users/10784/>

<https://ecourses.pvamu.edu/courses/13615/users/10784/>

Aug 26, 2021

The 0th Law: If two systems are found to be in equilibrium with a third system, then they are in thermal equilibrium to each other

If A is in equilibrium with B, and B is in equilibrium with C, then A and C are in thermal equilibrium

The 1st Law: Energy can not be created nor destroyed. It can only change forms

$$\Delta E = Q - W$$

The increase in the energy of a chocolate chip cookie in an oven is equal to the amount of heat transferred to it

The 2nd Law: In all spontaneous system, entropy can either increase or stay the same however it can not decrease

When freshly baked hot cookies are in contact with a cold plate, heat flows from the hot baked cookies to the cold plate and never the opposite.

The 3rd Law: If the temperature were to reach absolute zero, then entropy nears to zero

All modes of motion stop (no vibration, no rotation nor no translation)

← Reply ↩



<https://ecourses.pvamu.edu/courses/13615/users/4173/>

<https://ecourses.pvamu.edu/courses/13615/users/4173/>

Aug 26, 2021

The examples you used were easy to follow, also, the equation you added helped be visualize the law in a different way

← Reply ↩



<https://ecourses.pvamu.edu/courses/13615/users/11080/>

<https://ecourses.pvamu.edu/courses/13615/users/11080/>

Aug 26, 2021

*0th Law: Equilibrium is transmissible => if two systems are in thermal equilibrium with a third system, they are also in thermal equilibrium with each other. Ex: a cup of cold water and a hot cup of tea both are in the same room, after some time, they will both have the same temperature as the room.

*1st Law: In a closed system, energy can neither be created nor destroyed, it can only be transformed. ex: a system of swing, the energy goes from Potential energy to be kinetic energy, to potential energy, etc

*2nd Law: entropy or disorder of a system is always increasing. ex: Heat will flow from a hot cup of coffee to its surroundings because the more it is dispersed the more it is disordered.

*3rd Law: There is no entropy at absolute zero (temperature), that is the point where every substance is solid.

← Reply



[Ariel Kinsey](https://ecourses.pvamu.edu/courses/13615/users/8134/)

<https://ecourses.pvamu.edu/courses/13615/users/8134/>

Aug 26, 2021

These examples are great, and can be seen in everyday practices which is fascinating as well.

← Reply



[Ariel Kinsey](https://ecourses.pvamu.edu/courses/13615/users/8134/)

<https://ecourses.pvamu.edu/courses/13615/users/8134/>

Aug 26, 2021

There are four different laws of thermodynamics; the 0th, 1st, 2nd and 3rd law.

- The 0th law states that the thermal equilibrium is transitive.
- 1st law states that the energy is conserved but it can also be transformed.
- 2nd law states that the energy degrades as it is transformed.
- Lastly the 3rd law states that the entropy vanishes at absolute zero.

The 0th law can be described as two or more systems at thermal equilibrium that is connected to another system, the third system will be at thermal equilibrium too. For example, if you place two cups of water at different temperatures in a room at ambient temperature, the two cups will eventually be in equilibrium with the room. As for the 1st law, this can be described as light energy changing into chemical energy through the photosynthesis process. The energy is conserved however, it is transformed into another form of energy. Secondly, the 2nd law of thermodynamics is an example of heat flowing from a hot to cold object. As the heat passes, the thermal energy degrades however is it still conserved when the object is cold. Lastly, the 3rd law can be seen as gas expanding when heated in confined space. The molecules get smaller and the entropy would increase.

← Reply



[Kennedy Dent](https://ecourses.pvamu.edu/courses/13615/users/9352/)

<https://ecourses.pvamu.edu/courses/13615/users/9352/>

Aug 26, 2021

Ariel,

I love you examples for each thermodynamic law. It allowed me to get another perspective of understanding each law.

← Reply



[Dynasty Stephenson](https://ecourses.pvamu.edu/courses/13615/users/1244/)

<https://ecourses.pvamu.edu/courses/13615/users/1244/>

Aug 26, 2021

0th law = When two objects of different temperatures are touching both of the object temperatures will reach an equilibrium temperature resulting in becoming the same temperature. Ex. One hot brick touching a cold brick would result in the hot brick heat flowing to the cold brick until both bricks reach the same temperature.

1st Law = Energy can not be created nor destroyed but can be converted to another form of energy. Ex. When cooking with a gas stove the chemical energy is turned into heat energy to cook the food.

CHEMICAL ENGINEERING THERMODYNAMICS II
FALL 2021

DISCUSSION TOPIC 3

3. Discussion Week 2 - Reversible vs. Irreversible, Intensive vs. Extensive, State vs. Path

Published Edit ...

This is a graded discussion: 100 points possible due Aug 31, 2021

Discussion Week 2 - Reversible vs. Irreversible, Intensive vs. Extensive, State vs. Path

Aug 25, 2021 at 2:25pm
49 50

Discuss these opposing pairs of terms, each pair in turn, explaining how the two items in each pair are different and giving examples in each case: (a) reversible and irreversible processes, (b) intensive and extensive properties, and (c) state and path functions. No file uploads, please. Don't forget to respond to another student's post.

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<https://ecourses.pvamu.edu/courses/13615/users/2584/>
Kiara Graham
<https://ecourses.pvamu.edu/courses/13615/users/2584/>
Aug 27, 2021

⋮

A reversible process is a process in which; the system and its environment can return to the states they were in by following the reverse path. On the other hand, an irreversible process is a process in which the system and its environment can not return to the states they were in. An example of a reversible process is an extension and compression of a spring and an irreversible process example is heat transfer.

Extensive properties depend on the quantity of material. Intensive properties do not depend on the quantity of material. An example of an extensive property is the weight of money and an example of an intensive property is the density of money.

State functions depend only on the initial and final states, not the path taken between states. Path functions depend on the path taken between two states. An example of a state function is entropy and an example of a path function is heat.

↩ Reply
👍

ⓘ

<https://ecourses.pvamu.edu/courses/13615/users/3111/>
Wesley Walsh
<https://ecourses.pvamu.edu/courses/13615/users/3111/>
Aug 30, 2021

⋮

Great job Kiara, I liked reading your reply because it's correct and you took a different approach than the one I used in my post.

↩ Reply
👍

ⓘ

<https://ecourses.pvamu.edu/courses/13615/users/7718/>
Nina Patthammavong
<https://ecourses.pvamu.edu/courses/13615/users/7718/>
Aug 28, 2021

⋮

- a) A reversible process is one in which both the system and its environment can return to exactly the states they were in by following the reverse path. For example, slow compression of the gas in a cylinder is a reversible process as gas can be expanded slowly by decreasing the weight on the piston to reverse the operation.
 - An irreversible process is one in which the system and its environment cannot return together to exactly the states that they were in. For example, the conduction of heat from a hot body to a cold body.
- b) Intensive properties do not depend on the quantity of matter. Examples include density, state of matter, and temperature.
 - Extensive properties depend on sample size. Examples include volume, mass, and size.
- c) State functions do not depend on the path or process. A state function only depends on the current state of the thermodynamic system and its initial state (independent from the path). Examples include mass, energy (enthalpy, internal energy, Gibbs free energy), entropy, pressure, and temperature.

- On the other hand, path functions depend on path or process. In other words, a path function depends on the path taken to reach a final state from an initial state. For example, mechanical work, heat, and arc length.

← Reply



Vivian Patthammavong

<https://ecourses.pvamu.edu/courses/13615/users/6204/>

Aug 28, 2021

Great example! Your explanation is obvious, and it is easy to understand the difference between each of them.

← Reply



Alexis Rabb

<https://ecourses.pvamu.edu/courses/13615/users/4179/>

Aug 30, 2021

I enjoyed your examples, they were very clear and gave me more insight.

← Reply



Vivian Patthammavong

<https://ecourses.pvamu.edu/courses/13615/users/6204/>

Aug 28, 2021

1. The basic difference between reversible and irreversible processes is that in the reversible process is a slow process which goes through various smaller stages which maintains equilibrium between the system and the surroundings. Also, it can be brought back to the initial state without making any change in the surroundings. For example, expansion or compression of spring.

in the irreversible process is a comparatively fast process. No equilibrium is maintained between the system and the surroundings, and it cannot be brought back to its initial state without making a change in the surroundings. For example, A hot cup of tea left on its own to cool down, an explosion, producing heat by the passing of current through an electrical resistance, and the conduction of heat from a hot to a cold body

2. Intensive properties are bulk properties, which mean they do not depend on the amount of matter that is present. These physical properties are used for sample identification because they are the same under different condition and for all the sample sizes. Example of intensive properties include boiling point, concentration, odor, magnetic permeability, temperature, and melting point.

Extensive properties do depend on the amount of matter that is present. An extensive property is considered addition for subsystems. While extensive properties aren't useful for sample identification, they are great for describing it. example, volume, mass, size, weight, heat capacity, and length.

3. State function does not depend on the path taken to reach that specific value is known as state functions or point functions. Also, it is the values which depend on the state of the substance like temperature, pressure, volume, mass, or the amount or type of the substance. As a matter of fact, state functions do not depend on how the state was reached or established. However, the path function is depended on the path taken to establish the property or value. It requires multiple integrals and limits of integration to integrate, and it is based on how the state of the system was established. For example, heat and arc length.

Edited by Vivian Patthammavong (<https://ecourses.pvamu.edu/courses/13615/users/6204/>) on Aug 28, 2021 at 8:44pm

← Reply



Nina Patthammavong

<https://ecourses.pvamu.edu/courses/13615/users/7718/>

Aug 30, 2021

Hi, I agree with your explanations and examples. It gives me a lot of important detail and clearly understand of the differences.

← Reply



Edgar Mendoza

<https://ecourses.pvamu.edu/courses/13615/users/4205/>

Aug 30, 2021

I really grasped the concepts by the way you grouped your thoughts and the information which made it flow smoothly and made it easier to comprehend. Good work!

← Reply

 [Kiara Graham](https://ecourses.pvamu.edu/courses/13615/users/2584)
<https://ecourses.pvamu.edu/courses/13615/users/2584>
 Aug 31, 2021

Great examples and explanations.

 [Reply](#) 

 [Wesley Walsh](https://ecourses.pvamu.edu/courses/13615/users/3111)
<https://ecourses.pvamu.edu/courses/13615/users/3111>
 Aug 30, 2021

- A reversible process is an ideal process used to make predictions and ease calculations. Using formulas and calculations for a reversible process allows a person to gauge the best possible outcome of a process. An example of this would be using an ideal gas EOS to determine the amount of work produced by a system. The irreversible process is a process more like what happens in the real world. Not all energy is converted to the desired form, some will be lost or trapped in the process. An example of this would be using an efficiency formula to figure out how much of the ideal process work done would be produced in real life.
- Intensive properties are properties that only depend on the type of material being studied. These could include color, melting/boiling points, and density. Extensive properties depend on the amount of material being studied like, volume, mass, and enthalpy.
- Path functions such as work and heat, depend on how the system arrives at those values. State functions like enthalpy and internal energy could be the same in two different processes because they only depend on the current thermodynamic state of the system.

 [Reply](#) 

 [Maya Spears](https://ecourses.pvamu.edu/courses/13615/users/8535)
<https://ecourses.pvamu.edu/courses/13615/users/8535>
 Aug 30, 2021

Great definitions and response Wesley! I really like how you gave multiple examples for the different definitions.

 [Reply](#) 

 [Alexis Rabb](https://ecourses.pvamu.edu/courses/13615/users/4179)
<https://ecourses.pvamu.edu/courses/13615/users/4179>
 Aug 30, 2021

(A) A reversible process allows for the system to return to its previous state, while an irreversible process does not allow for the system to return to its previous state. An example of a reversible process is a spring that can be stretched and returns back to its original state. An example of an irreversible process is the conversion of fuel into heat in vehicles.

(B) An intensive property does not depend on the amount of substance, but an extensive property does depend on the amount of a substance. Examples of an intensive property include temperature and color, while examples of an extensive property includes volume and weight.

(C) State functions properties solely depend on the initial and final state of the system, whereas path functions properties depend on the "path" taken. Examples of state functions include temperature and density, while examples of path functions include work and heat.

 [Reply](#) 

 [Byron Henderson](https://ecourses.pvamu.edu/courses/13615/users/2582)
<https://ecourses.pvamu.edu/courses/13615/users/2582>
 Aug 30, 2021

You gave great explanations Alexis ! I liked the examples you used for each process as well, I didn't think of a spring being a reversible process until you mentioned it.

 [Reply](#) 

 [Ariel Kinsey](https://ecourses.pvamu.edu/courses/13615/users/8134)
<https://ecourses.pvamu.edu/courses/13615/users/8134>
 Aug 31, 2021

These are all great examples! This was very clear and easy to understand.

CHEMICAL ENGINEERING THERMODYNAMICS II
FALL 2021

DISCUSSION TOPIC 4

4. Discussion Week 3_ P-H (versus the T-S) diagrams

Published

Edit

This is a graded discussion: 100 points possible

due Sep 8, 2021

Discussion Week 3: P-H (versus the T-S) diagrams

Sep 3, 2021 at 7:50am
46 49

Holiday Discussion: P-H (versus the T-S) diagrams

What is a P-H diagram? What is its importance? With respect to the assigned design project, how is its importance different from that of the T-S diagram? How can it help you identify the proper refrigerant for your design? Use the assigned readings and resources to assist you with this. Post at least once on this topic and respond at least once to another student's post for full credit. (No file uploads, please.)

- 

<https://ecourses.pvamu.edu/courses/13615/users/8204/>
Vivian Patthammavong
Sep 5, 2021

The P-H diagram is a graphical that represent of the refrigerant as it travels through the refrigeration system. The pressure-enthalpy (P-H) diagram is an important tool for refrigeration engineers, designers, and service technicians. It can use to predict several system conditions, such as the pressure and temperature for the refrigerant at various location within the system. In order to draw this process on a P-H diagram, some system conditions must be known: saturation pressures of the refrigerant in the evaporator and condenser; pressure and temperature of the refrigerant entering the compressor; and pressure and temperature of refrigerant entering the metering device.

← Reply 👍
- 

<https://ecourses.pvamu.edu/courses/13615/users/7755/>
Kalaya Anderson
Sep 6, 2021

Hi Vivian. I think you did a very good job of explaining the purpose of a P-H diagram. I like how you added what system conditions must be known in order to illustrate the process of a P-H diagram. I think you may benefit from outlining specifically how a P-H diagram will help identify the proper refrigerant to use for your design. Otherwise, very good job!

← Reply 👍
- 

<https://ecourses.pvamu.edu/courses/13615/users/2584/>
Kiara Graham
Sep 7, 2021

I love how you put what needs to be known in order to use the P-H diagram.

← Reply 👍

- 

<https://ecourses.pvamu.edu/courses/13615/users/7718/>
Nina Patthammavong
Sep 5, 2021

The P-H diagram is a figure with a vertical axis of absolute pressure and a horizontal axis of specific enthalpy. On the other hand, T-S diagram is used to visualize changes to temperature and specific entropy during a thermodynamic process or cycle. Both are an important diagram used frequently for a performance calculation of a refrigerating machine. P-H diagram can be used to predict the approximate discharge temperature of the refrigerant leaving the compressor. It can demonstrate how an excessive suction line pressure drop and excessive return vapor temperature can cause an increase in the discharge temperature.

← Reply



Alexis Rabb

<https://ecourses.pvamu.edu/courses/13615/users/4173/>

Sep 6, 2021

Your description of a P-H diagram gave me more insight on how the diagram works. I never thought of a PH diagram demonstrating suction line pressure.

← Reply



Zenab Coulibaly-Diakite

<https://ecourses.pvamu.edu/courses/13615/users/11080/>

Sep 9, 2021

Hello Nina, I learned additional information on P-H diagram through your explanation. Thank you

← Reply



Alexis Rabb

<https://ecourses.pvamu.edu/courses/13615/users/4173/>

Sep 6, 2021

A P-H diagram is a figure depicting pressure and enthalpy. The horizontal (x) axis is the enthalpy, H, and the vertical (y) axis is the pressure. A P-H diagram is frequently used to analyze refrigerants. Furthermore, each refrigerant's P-H diagram will be different from one another. In this project, a P-H diagram will help my group to find a refrigerant that is suitable for our temperature restraints. A T-S diagram visually depicts the change in temperature and specific entropy, ultimately viewing the energy transfer of a system's cycles.

← Reply



Kalaya Anderson

<https://ecourses.pvamu.edu/courses/13615/users/7755/>

Sep 6, 2021

A P-H diagram is a way to illustrate the process of a refrigeration cycle in terms of pressure and enthalpy. You can also determine if phase changes occur and if constant temperature is occurring within the cycle based on this diagram. The importance of a P-H diagram is that it helps you identify what is taking place at specific points of the refrigeration cycle more specifically where heat is extracted and where heat is discharged in the process. It also helps you identify where constant entropy and enthalpy are occurring within the process. The importance of a P-H diagram is different than that of a T-S diagram because it will be much easier to find a corresponding P-H diagram for the refrigerant we want to use for the design process of the refrigeration cycle than it will be to find a T-S diagram. A P-H diagram is also important because it shows the changes in pressure and enthalpy for the process whereas a T-S diagram shows the changes in temperature and entropy for the process. A P-H diagram will help us identify the proper refrigerant because based on the minimum and maximum temperatures given to us, we can see where those temperatures lie on the corresponding P-H diagram for the refrigerant. If the temperatures that are given aren't within the range of the liquid/gas mixture phase on the P-H diagram for the corresponding refrigerant or the given temperatures are too close to the critical point, then you know that specific refrigerant wouldn't be proper for your design.

← Reply



Vivian Patthammavong

<https://ecourses.pvamu.edu/courses/13615/users/8204/>

Sep 7, 2021

Hi Kalaya

you point out each detail clearly, and it is easy to understand the difference between T-S and P-H diagrams, which will help a lot in the project

← Reply



Nina Patthammavong

<https://ecourses.pvamu.edu/courses/13615/users/7718/>

Sep 7, 2021

Hi Kalaya, you provide enough important details of P-H and T-S diagram. Your description help me which diagram I should use for my refrigerant design.

[← Reply](#) 



Erron Williams

<https://ecourses.pvamu.edu/courses/13615/users/4653/>

Sep 7, 2021

Hey Kalaya, Great description of the P-H graph and how it can be used to find the proper refrigerant. Not sure if it was a typo but I believe you meant to say that the P-H graph can be used to find constant enthalpy in the process and the T-S diagram can be used to find constant entropy.

[← Reply](#) 



Kiara Graham

<https://ecourses.pvamu.edu/courses/13615/users/2584/>

Sep 7, 2021

A P-H diagram is a diagram that shows the pressure versus enthalpy of a working fluid. This diagram is important because you can see the calculations of the pressure along with enthalpy values. Not only are pressures and enthalpies values on this diagram, but also temperatures and entropy lines. This importance is different from a T-S diagram because a T-S diagram shows the temperature versus the entropy. This diagram can be much harder to find versus a P-H diagram. The P-H diagram can be helpful in identify the proper refrigerant for the design because; if our T_{Low}, min or T_{High}, max are not represented on the diagram the group chose, then we know we need to look at another refrigerant diagram with these represented values.

[← Reply](#) 



Kennedy Dent

<https://ecourses.pvamu.edu/courses/13615/users/5352/>

Sep 7, 2021

I agree. You made some great points on how the P-H diagram helps us select the correct refrigerant. I would also like to add that under the curve on a P-H diagram, phase change occurs which also helps select the correct working fluid.

[← Reply](#) 



Erron Williams

<https://ecourses.pvamu.edu/courses/13615/users/4653/>

Sep 7, 2021

A P-H Diagram is a Graph that helps you visualize the Phase Changes of a Substance with respect to Pressure and Enthalpy. In these Diagrams, you can also use the isotherms which are lines of constant Temperature to see your bubble and dew Points at different pressures. Although the cycle Refrigeration cycle would look slightly different on a T-S Diagram you can use either one to find your Pressure and Temperature values for each process because both Pressure and Temperature are constant during a phase change. It is just important to note that a T-S Diagram is shown with respect to temperature and entropy and uses isobars which are lines of constant pressure to show the dew and bubble points. That being said you would find a refrigerant that is capable of having a boiling point that is lower than the temperature of your cold reservoir at a reasonable pressure and also capable of having a boiling point hotter than your Hot Reservoir at a higher pressure.

[← Reply](#) 



Dynasty Stephenson

<https://ecourses.pvamu.edu/courses/13615/users/1244/>

Sep 7, 2021

Hi, Erron

Good job for pointing out that both P-H and T-S diagrams can be used to find the pressure and temperature values for each process rather than having us look at the cycle as a whole. It helped me not only see the big picture but details needed within the process.

[← Reply](#) 

CHEMICAL ENGINEERING THERMODYNAMICS II
FALL 2021

DISCUSSION TOPIC 5

5. Discussion Topic_ Theorem of Corresponding States (Chapter 3)

Published

Edit

This is a graded discussion: 100 points possible

Discussion Topic: Theorem of Corresponding States (Chapter 3)

Discuss the Theorem of Corresponding States. What is it? How does the theorem relate to real gases in connection with an ideal gas. How can we as engineers make use of this theorem, in practice. Post and respond to another student's post, for full credit.

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Kiara Graham

https://ecourses.pvamu.edu/courses/13615/users/26841

Sep 24, 2021

The theorem of Corresponding States is a theorem that is stated by Van der Waals and reads: substances behave alike at reduced states. This theorem relates real gases to ideal gases by saying: all fluids, when compared at the same reduced temperature and reduced pressure, have approximately the same compressibility factor, and all deviate from ideal-gas behavior to about the same degree. We as engineers can make use of this theorem when we are determining the degree of departure from ideal gas behavior. We know that when calculating the compressibility factor, as the value approaches 1, the gas behaves like an ideal gas. But, when calculating the using the Theorem of Corresponding States, we take into account the volume and molecular interactions and we can then take the ratio of Z , ideal, and Z , actual to find out if the gas behaves ideally or not.

Reply

http

Kennedy Dent

https://ecourses.pvamu.edu/courses/13615/users/63521

Sep 24, 2021

I agree. You made great points regarding the comparison of reduced temperature and pressure to observe that fluids will behave similarly. I also agree that engineers use this value to determine if gases are ideal or not, just as we have done in this course.

Reply

http

Kalaya Anderson

https://ecourses.pvamu.edu/courses/13615/users/77551

Sep 27, 2021

Hi Kiara. I agree with your statement on the definition of the theorem of corresponding states. I like how you broke down the explanation of how engineers are able to make use of the theorem by determining the degree of departure from ideal gas behavior. Great explanation!

Reply

https://

Kennedy Dent

https://ecourses.pvamu.edu/courses/13615/users/63521

Sep 24, 2021

The Theorem of Corresponding States is the idea that all fluids have approximately the same compressibility factor, Z , when compared at the same reduced temperature and reduced pressure. Real gases that are compared at the same reduced temperature and same reduced pressure must also depart from ideal gas behavior by the same amount. Therefore, we can assume these fluids behave alike. Engineers can use this theorem to determine if a specific fluid can replace another, for instance in a refrigerator. Many refrigerant fluids have been replaced due to high global-warming potential, however they are replaced with refrigerants that behave similarly.

Reply

https://ecourses.pvamu.edu/courses/13615/discussion_topics/75220

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 [Kiara Graham](https://ecourses.pvamu.edu/courses/13615/user/2584/)
(<https://ecourses.pvamu.edu/courses/13615/user/2584/>)
Sep 24, 2021

Love your response. I like the refrigerator example you use.

 [Kalaya Anderson](https://ecourses.pvamu.edu/courses/13615/user/7755/)
(<https://ecourses.pvamu.edu/courses/13615/user/7755/>)
Sep 27, 2021

The theorem of corresponding states is a theorem that states the compressibility factor of any substances are the same, based on if the thermodynamic properties (T_r and P_r) of the substances are the same, regardless of the type of substances in question. The said substances in question also depart from ideal gas behavior to the same degree in order to be considered for this theorem. The theorem relates real gases to ideal gases because for whatever fluids are being considered to have the same compressibility factor, we assume that they deviate from ideal gas behavior meaning that at high temperatures and low pressures, real gases tend to showcase ideal gas behaviors more approximately. The reduced temperature and pressure equations ($T_r = T/T_c$, $P_r = P/P_c$) are used to measure the amount of deviation from the critical temperature and pressure of the associated fluids. Engineers are able to make use of this theorem by using refrigerants for refrigeration cycles that behave similarly to ideal gases. Engineers are also able to replace poor refrigerants based on their global warming effects on the environment.

 [Yazmine Rincon](https://ecourses.pvamu.edu/courses/13615/user/10784/)
(<https://ecourses.pvamu.edu/courses/13615/user/10784/>)
Sep 28, 2021

Hello Kayla,

You are absolutely right in regards to why we use this theorem and our jobs as engineer to make sure our society and environment is safe from any potential harm such as the poor refrigerants as you mentioned in your statement. It is crucial to find an economical refrigerant as soon as possible.

 [Alexis Rabb](https://ecourses.pvamu.edu/courses/13615/user/4173/)
(<https://ecourses.pvamu.edu/courses/13615/user/4173/>)
Sep 28, 2021

Hi Kalaya, I did not even think of using the theorem to replace poor refrigerants. I like how you thought outside of the box providing the example.

 [Yazmine Rincon](https://ecourses.pvamu.edu/courses/13615/user/10784/)
(<https://ecourses.pvamu.edu/courses/13615/user/10784/>)
Sep 28, 2021

The Law of Corresponding States tells us that at the same values of reduced pressure and temperature will indicate the fluid to be near the same value of compressibility factor and these fluids may exhibit relatively close degree of deviation from the ideal gas behavior. This is achieved by using the Van Der Waals Equation. Reduced pressure and temperature measures the amount of deviation from the fluids critical pressure and temperature. This theorem is crucial to us as it is a method to study the behavior of different types of fluids.

 [Maya Sinsars](https://ecourses.pvamu.edu/courses/13615/user/8635/)
(<https://ecourses.pvamu.edu/courses/13615/user/8635/>)
Sep 28, 2021

Hi Yazmine! I really like your definition and example of real life practice. Great work!

-  <https://ecourses.pvamu.edu/courses/13615/users/4179/>
Alexis Rabb
Sep 28, 2021
- The theorem of corresponding states implies that all fluids with the same reduced temperature and reduced pressure have the same compressibility factor. They also all deviate from the ideal gas law. The closer the compressibility factor is to 1, the closer the gas is to an ideal gas. On the other hand, the farther the compressibility factor is from 1, the closer the gas is to being a real gas. With this knowledge, we as engineers can quickly complete tasks involving reduced temperatures and pressure to determine whether the gas is ideal or not. When dealing with refrigerants in the superheated and saturated vapor phase, this theorem can come in handy.
-  
-  <https://ecourses.pvamu.edu/courses/13615/users/2582/>
Byron Henderson
Sep 28, 2021
- Hi Alexis, I loved your explanation and the example you gave when using the theorem in hand with a P-H Diagram !
-  
-  <https://ecourses.pvamu.edu/courses/13615/users/2682/>
Byron Henderson
Sep 28, 2021
- The theorem of corresponding states, says that all fluids that have the same reduced temperature and reduced pressure, will in turn have the same compressibility factor and depart from ideal gas behavior at the same degree as well. It relates to real gases because the further the compressibility factor is to 1, the further it is from being an ideal gas and the closer it is to being a real gas. Vice versa, the closer the compressibility factor is to 1, the more ideal that gas is. As engineers we can use this by applying it to refrigerants or refrigeration cycles that behave similarly/ closely to ideal gases.
-  
-  <https://ecourses.pvamu.edu/courses/13615/users/8134/>
Ariel Kinsey
Sep 28, 2021
- Hi Byron, I really like how you explained the difference between the compressibility factors of a real and ideal gas!
-  
-  <https://ecourses.pvamu.edu/courses/13615/users/6204/>
Vivian Patthammavong
Sep 29, 2021
- Hi Byron
- I am agree with you that this theorem can apply to refrigeration cycles. Also, it could helps the understanding and calculating of thermodynamic, transport, and surface properties of substances in various states
-  
-  <https://ecourses.pvamu.edu/courses/13615/users/8595/>
Maya Spears
Sep 28, 2021
- The Theorem of Corresponding States is an assumption made by van der Waals about real gases. He stated that all gases at corresponding states should behave in a similar manner and the corresponding state he used is called the reduced state. This reduced state is badges on the deviation of the substance's critical conditions. This theorem relates to real gases in connection with ideal gases because all the fluids will have approximately the same Z factor. This number for the compressibility factor will deviate from ideal gas behavior to the same degree. The closer to 1 this value is, the more ideal the fluids be gave. As this value gets further from 1, it can be assumed to be a real gas. Engineers can make use of this theorem in the process of creating refrigeration cycles.
-  

