

**PRAIRIE VIEW A&M UNIVERSITY
ROY G. PERRY COLLEGE OF ENGINEERING
DEPARTMENT OF CHEMICAL ENGINEERING
CHEG 3315 – Introduction to Biotechnology
SPRING 2022**

I. COURSE SYLLABUS IN ABET FORMAT

II. ASSESSMENT RESULTS FOR CURRENT AND PAST THREE PERIODS

Program Outcomes Assessed in Course

Assessment Summary of Class Semester Averages for Outcomes

End of Semester Course Outcomes Assessment Reports

III. EXAMS

Summary of Topics covered by Exam

Original Test Questions & Master Solution/grading scheme used

Above Average (Graded original work)

Average (Graded original work)

Below Average (Graded original work)

IV. HOMEWORK ASSIGNMENTS

Summary of Topics covered by Homework

Original Homework Questions & Master Solution/grading scheme used

Above Average (Graded original work)

Average (Graded original work)

Below Average (Graded original work)

CHEG 3315: INTRODUCTION TO BIOTECHNOLOGY

- | | |
|---|---|
| 1. Course number and name: | CHEG 3315 Introduction to Biotechnology |
| 2. Credits, contact hours, categorization: | 3-Credit Hour, 3-Contact Hours, Engineering Topic |
| 3. Instructor's name: | Dr. Michael Gyamerah |
| 4. Text book: Title:
Author(s):
Publisher, Year & Edition: | BIOPROCESS ENGINEERING: BASIC CONCEPTS
Michael L. Shuler and Fikret Kargi
Prentice Hall, 2001, 2 nd Edition |
| a. Other Supplemental material | Bioprocess Engineering Principles, 2nd Edition,
Pauline M. Doran, Academic Press, 2013 |
| 5. Specific course information | |
| a. Brief description of the content of the course (catalog description) | CHEG 3315 (0-3) Credit 3 semester hours. This course introduces students of chemical engineering, biological sciences, and chemistry to biological concepts and nanoscale considerations in engineering applications. It provides training for effective communication, hands-on skills, and analytical tools needed to pursue careers in biological/biochemical, and pharmaceutical process industries. Ties to relevant current research will be explored. |
| b. Prerequisites | CHEM 1304 or CHEM 1403 and CHEM 2303 |
| c. *Indicate whether a required, elective, or selected elective (as per definition provided) course in the program | Elective/Selected elective (bioengineering concentration) |
| 6. Specific goals for the course | Students will be able to: |
| a. Specific outcomes of instruction (e.g. The student will be able to explain the significance of current research about a particular topic.) | (i) Demonstrate an understanding of the principles of bioprocess engineering, and for the biological sciences and chemistry student demonstrate an awareness of engineering concepts and ways of thinking.
(ii) Communicate on a professional level with process engineers and know the type of expertise they can offer.
(iii) Demonstrate an understanding of the engineering approach to process analysis and carry out routine calculations and checks on processes, in the case of the biological sciences or chemistry major.
(iv) Critically evaluate new bioprocessing proposals and work at the interface of biology and engineering science
(v) Characterize growth and production behavior of cells whether genetically engineered or not as a function of the culture environment |

- (vi) Demonstrate an understanding of process development from shake-flask through bench-scale and the criteria for pilot-scale work
- (vii) Demonstrate a thorough knowledge of FDA regulations per cGMP and documentation under validation, and NIH Biohazard containment guidelines

- b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course.

This course addresses:

Chemical Engineering Department student outcome D1 (an ability to identify, formulate, and solve fundamental engineering problems by applying principles of engineering, science, and mathematics). It involved application of basic knowledge and fundamental concepts of cell and molecular biology to the practical application in engineering processes.

7 Brief list of topics to be covered

- i. Introduction: Steps in bioprocess development as an interdisciplinary challenge.
- Basic microbiology and biochemistry: Micro-organisms, pure culture and aseptic technique. Elements of life, elemental composition of microbial cells and microbial nutrition (9 hours)
- ii. The use of elemental composition of microbial cells, and cellular yield coefficients in material balances for fermentation medium design and formulation (9 hour)
- iii. Basic Biochemistry: Nucleic acids, DNA and RNA, genes and gene expression. Molecular biology: Genetic analysis and studying genes. Genetic engineering (9 hours)
- iv. Proteins and protein synthesis (3 hours)
- v. Catabolic and anabolic pathways (6 hours)
- vi. Shake-flask and bench-scale fermentations: Growth and production behavior of cells whether or not genetically engineered from shake-flask through bench-scale (9 hours)
- vii. Regulatory compliance: Regulators and their Guidelines; US Food and Drug Administration (FDA's) Current Good Manufacturing Practices (cGMPs), Code of Federal Regulations Title 21 (CFR 21), and Validation and cGMPs (9 hours)

II ASSESSMENT RESULTS FOR CURRENT AND PAST TWO PERIODS

Program Outcomes Assessed in this course

Chemical Engineering Department student learning outcome D1: An ability to apply basic knowledge and fundamental concepts of cell and molecular biology to practical application in engineering processes

Assessment Summary of Class Semester Averages for Outcomes Spring 2020-Spring 2022

Outcomes	Chemical Engineering Department student outcome D1 An ability to apply basic knowledge and fundamental concepts of cell and molecular biology to practical application in engineering processes
Semester	Semester Class Average (%)
Spring 2022	81
Spring 2021	79
Spring 2020	86
Comments on Trend of Data (Improving or deteriorating)	Students' performance was above the expected average over the three consecutive spring semesters the course was taught. The 7 % points decrease in 2021 compared to the 2020 performance, was however, followed by 2 % points increase in 2022 on the 2021 performance.

*Expected Semester Class Average = 70% (or as defined by the program)

Ideal Semester Class Average =75% (or as defined by the program)

End of Semester Course Assessment Reports Spring 2020 and Last Two Assessment Periods.

Each summary contains the following Information

1. Performance Statistics

- Total number of students in class
- The class average performance (**stated as %**) in each course outcome assessed in this class and the **two previous times course was assessed**.
- The acceptable class average for the class in each outcome area as set by your Department.
- Percentage of students who scored below the expected average in each outcome.

2. Implementation Summary

- Brief summary of plans implemented during the semester based on last assessment report

3. Perceived Problems

- Instructor's **critical evaluation** of perceived problems that affected students' performance. **Realistic problems should be identified throughout the semester and summarized in this section of the report.**

4. New Plans for Addressing Problems

- Instructor's plans for addressing the perceived problems the next time the class is taught. **These should be specific enough for another instructor to implement. Most of these should be things that, you, the instructor can implement to help students to improve. Be creative.**

5. Overall Trend over last three assessment periods

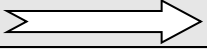
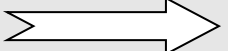
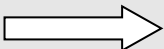
- Instructors summary of overall performance trend for each outcome measured over the last three periods.

5. Were Expectations Met?

- Answer **YES** if the **class average was above the expected average** and the **stated percentage of students** scored at or above the expected average, else answer **NO**.

**Table 2.1 END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT
CHEG 3315-001- INTRODUCTION TO BIOTECHNOLOGY
SPRING 2022 SEMESTER**

Report Prepared by: Dr. Michael Gyamerah Report Date: May 25, 2022

Semester	Analysis Type	Number of Students	CHEG Department student outcome D1 An ability to apply basic knowledge and fundamental concepts of cell and molecular biology to practical application in engineering processes.			
			Expected Class Average	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average
Spring 2021	Direct	5	75	70	81	100
Spring 2021	Direct	8	75	70	79	90
Spring 2020	Direct	5	75	70	86	100
Implementation Summary	Items implemented from previous report or after meeting previous instructor 		The importance of organic chemistry and macro-molecules of life were stressed at the start of the course. The hierarchy of life was also emphasized.			
Perceived Problems	Perceived problems are directly related to the PC and the sub items under them 		The students' ability to apply knowledge of general and organic chemistry in biology and biochemistry was not satisfactory. Students were unable to recall material studied in their organic chemistry course.			
Plans for Addressing Problems	Plans for address specific measures to address PC and their sub areas 		The following will continue to be implemented the next time the course is taught: Brief reviews of relevant organic chemistry and physical chemistry will continue to presented during class			
Overall Trend over Periods	Ascertain if there were improvements over previous semesters 		Student' performance was above the expected average. The 7 % points decrease in 2021 compared to the 2020 performance, was however, followed by 2 % points increase in 2022 on the 2021 performance.			
Were Expectations Met?	Class Average $\geq 75\%$ and $\geq 70\%$ of Students Performed at or Above Expected Average 		YES			

INTRODUCTION TO BIOTECHNOLOGY SPRING 2022

Title of Assignment: EXAM 1

TOPICS COVERED IN EXAM 1

Exam 1 covered the following topics:

1. Fermentation medium design
2. Differences between DNA and RNA
3. Genes and carriers of biological information and gene expression
4. Classification of prokaryotes and eukaryotes
5. DNA as a carrier of genetic information
6. Single stranded and double stranded viral DNA
7. Determining the sequence of complimentary strand of DNA

INTRODUCTION TO BIOTECHNOLOGY SPRING 2022

SAMPLE QUESTIONS, SOLUTION, AND GRADING SCHEME FOR EXAM 1

Introduction to Biotechnology CHEG 3315: Exam I (Spring 2022)

March 2, 2022

Answer all questions. You will be graded based on your ability to solve engineering problems. Clarity of presentation would ensure that you do not lose all the points for a calculation if you should make a mistake.

1. (a) List four differences between procaryotes and eukaryotes

(b) Place the following under either prokaryotes or eucaryotes: *Penicillium chrysogenum*, *Streptococcus lactis*, *Aspergillus terreus* and *Streptomyces griseus*

2. (i) List four differences between DNA and RNA

(ii) Given the following sequence for one strand of DNA, write the sequence of the complimentary strand:

5¹ ...ACCGTAAGGCTTTA... 3¹

Intro to Biotechnology - HEC 3315

EXAM 1: KEY

- 1 (a)
- (i) Prokaryotes have one DNA while Eukaryotes have more than one
 - (ii) Prokaryotes have no nuclear membrane
 - (iii) Prokaryotes have no mitochondria
 - (iv) Spores of prokaryotes have high heat resistance while spores of Eukaryotes have low heat resistance

- (b)
- | Prokaryotes | Eukaryotes |
|--------------------------------|-----------------------------------|
| 1. <u>Streptococcus lactis</u> | 1. <u>Penicillium chrysogenum</u> |
| 2. <u>Streptomyces griseus</u> | 2. <u>Aspergillus terreus</u> |

2. (i)

DNA	RNA
1. Double-stranded helix polynucleotide	Single-stranded polynucleotide
2. Adenine, Guanine, Thymine and Cytosine bases	Adenine, Guanine, Uracil and Cytosine bases. Thymine in DNA replaced by Uracil in RNA
3. 5-carbon deoxyribose sugar	5-carbon ribose sugar
4. Nucleus, mitochondria or chloroplast	Cytoplasm

Introduction to Biotechnology CHEG3315

2 of 2

- 2 (ii) Given DNA strand: ...5' A CCGTAAGGCTTA 3' (5)
Complementary strand: ...3' TGGCATTCCGAAAT...5' (10)

ABOVE AVERAGE

Above Average Student Original Graded Assignment

**CHEMICAL ENGINEERING DEPARTMENT
INTRODUCTION TO BIOTECHNOLOGY CHEG 3315
COURSE ASSIGNMENT GRADING AND OUTCOME ASSESSMENT
SHEET FOR SPRING 2022 SEMESTER**

STUDENT LEARNING OUTCOME: Ability to apply the knowledge of science.

Assignments that test competency in this area will include problems that test the student's ability to apply knowledge of chemistry and biology in engineering.

Name: Vivian Patthamravong

Title of Assignment: Exam I Due Date: 03/02/2022

Description of Performance Criteria Being Assessed	Max for this Assignment	Your Score
Ability to apply knowledge of science in engineering. <i>The assignment tests students' competency in their ability to apply chemistry and biology in biotechnology</i>	100	90
TOTAL	100	90

1. (a)

Prokaryotes

- ① it does not have nucleus ^{77 nuclear membrane}
- ② prokaryotic cell has a small cell size. it's generally range from 0.1 micrometer to 5 micrometer
- ③ it does not have membranes-bound nucleus or organelles.
- ④ it has only asexual reproduction occurs
- ⑤ prokaryotic cell has circular-strands of DNA
- ⑥ Mitochondria is absent
- ⑦ The endoplasmic reticulum is not present in prokaryotic cell
- ⑧ Only one chromosome is there in prokaryotic cell

80

eukaryotes

- ① every eukaryotic cell has nucleus ^{nuclear membrane}
- ② eukaryotic cell has a cell size range from 10 to 100 micrometer which is a larger cell size
- ③ Eukaryotic cell contains a nucleus and organelles that bound by plasma membrane
- ④ it has both sexual and asexual reproduction occurs
- ⑤ eukaryotic cell has multiple molecule of double-strands, linear DNA.
- ⑥ Mitochondria is present
- ⑦ The endoplasmic reticulum is present in eukaryotic cell
- ⑧ There are many chromosome that present in eukaryotic cell

(b)

Prokaryotes

- Streptococcus lactis Streptococcus lactis
- Streptomyces griseus Streptomyces griseus

eukaryotes

- Penicillium chrysogenum Penicillium chrysogenum
- Aspergillus terreus Aspergillus terreus

2. (1)

DNA

① DNA is found in nucleus, with a small amount of DNA also present in Mitochondria

② The sugar of DNA is deoxyribose sugar

③ DNA replicates and store the genetic information. It's blueprint for all genetic information contained within an organism

④ DNA has double-strands and has a long chain of nucleotides

⑤ DNA can replicate on it own. It's self-replicating

⑥ The base pair of DNA are
G-C (Guanine pair with cytosine)
A-T (Adenine pair with Thymine)

⑦ DNA is susceptible to UV damage

RNA being single stranded does not have a complementary strand to pair with.

(ii) 5' ... A C C G T A A G G C T T T A ... 3'
3' ... T G G C A T T C C G A A A T ... 5'

RNA

① RNA is formed in nucleus, and move to specialized region of the cytoplasm and ribosome depending on type of RN formed

② The sugar of RNA is ribose sugar

③ RNA is convert the genetic information contained within a DNA to format used to build protein, and then move it to ribosomal protein factories

④ RNA has a single-strand, and it has a shorter chain of nucleotide

⑤ RNA does not replicate on it own. It's synthesized from DNA when required.

⑥ The base pair of RNA are
G-C (Guanine pair with cytosine)
A-U (Adenine pair with Uracil)

⑦ Compare to DNA, RNA is relatively resistant to UV damage

5

10

AVERAGE

Average Student Original Graded Assignment

**CHEMICAL ENGINEERING DEPARTMENT
INTRODUCTION TO BIOTECHNOLOGY CHEG 3315
COURSE ASSIGNMENT GRADING AND OUTCOME ASSESSMENT
SHEET FOR SPRING 2022 SEMESTER**

STUDENT LEARNING OUTCOME: Ability to apply the knowledge of science.

Assignments that test competency in this area will include problems that test the student's ability to apply knowledge of chemistry and biology in engineering.

Name: KAYION ATKINSON

Title of Assignment: EXAM 1 Due Date: MARCH 2, 2022

Description of Performance Criteria Being Assessed	Max for this Assignment	Your Score
Ability to apply knowledge of science in engineering. <i>The assignment tests students' competency in their ability to apply chemistry and biology in biotechnology</i>	100	80
TOTAL	100	80

KAYDEN ATKINSON

EXAM 1

① Prokaryotes do not contain a ~~nucleus~~ ^{nucleus} like a eukaryotic cell. (64)
Prokaryotes also don't have a golgi apparatus, endoplasmic reticulum, or a mitochondria like eukaryotes. Eukaryotes are for plant and animal cells. Prokaryotes are for cells like bacteria.

b) Prokaryotes: Streptococcus latris, Streptomyces griseus
Eukaryotes: Penicillium chrysogenum, Aspergillus terreus

② i) DNA has deoxyribose as its sugar, RNA has ribose.

③ DNA has thymine that bonds with adenine. In RNA they have uracil instead of thymine. DNA and RNA have cytosine that bonds with guanine. DNA has a hydrogen to replace the OH, unlike RNA that has an OH on the 2nd carbon. DNA is the original strand and RNA is a copy of the DNA genetic strand. DNA is a double helix. RNA is a single strand.

ii) 5' ACCGTAA GG CTTTA 3' DNA
3' TGGCA TTCCGAAAT 5'

BELOW AVERAGE

Below Average Student Original Graded Assignment

**CHEMICAL ENGINEERING DEPARTMENT
INTRODUCTION TO BIOTECHNOLOGY CHEG 3315
COURSE ASSIGNMENT GRADING AND OUTCOME ASSESSMENT
SHEET FOR SPRING 2022 SEMESTER**

STUDENT OUTCOME: Ability to apply the knowledge of mathematics, science, and engineering.

Assignments that test competency in this area will include problems that test a student's ability to apply knowledge of and (1) solve algebraic, integral and differential equations analytically or numerically, and (2) apply knowledge of chemistry and biology in engineering.

Name: Erranequia Tatmon

Title of Assignment: Exam 1 Due Date: 03/10/22

Description of Performance Criteria Being Assessed	Max for this Assignment	Your Score
Ability to apply knowledge of science in engineering. <i>The assignment tests students' competency in their ability to apply chemistry and biology in engineering.</i>	100	67
TOTAL	100	67

Exam 1

Tatman

1) Four differences btwn prokaryotes : eukaryotes

a) Prokaryotes	Eukaryotes	b) Eukaryotes	Prokaryotes
(2) 1 cell	multicellular	(2) <u>Aspergillus</u>	<u>Streptococcus</u> lat3 (3 1/2)
(2) no golgi??	Golgi apparatus	(2) <u>Penicillium</u>	<u>Streptomyces</u> <u>griseus</u> (2)
(5) no mitochondria	mitochondria		
(3) no nucleus	has nucleus		
no nuclear membrane	has nuclear membrane		

2) 4 difference btwn RNA : DNA

a) DNA	RNA
(3) <u>Double</u> helix	Single helix <u>strand</u>
Pair A to T	Pairs A to U
original strand	Copy of DNA
Oxygen on 2' carbon is missing	has oxygen on 2' carbon
5-uridine or cytosine sugar	5-uridine or cytosine sugar

b) 5' ... ACCGTAGGCTTTA ... 3'
3' ... TGGCATCCGAAAT ... 5'

Page T8

21
23
44

INTRODUCTION TO BIOTECHNOLOGY SPRING 2022

HOMEWORK 1

TOPICS COVERED IN HOMEWORK 1

1. Classification of prokaryotes and eukaryotes
2. Process description of a complete industrial bioprocess for the production of a recombinant-DNA-derived biopharmaceutical

INTRODUCTION TO BIOTECHNOLOGY SPRING 2022

HOMEWORK #1 QUESTIONS, SOLUTION, AND GRADING SCHEME

Introduction to Biotechnology: Homework 1 (Spring 2022)

January 31, 2022

Due Date: February 14, 2022

Answer all questions. You will be graded based on your ability to apply knowledge of chemistry and biology to basic microbiology bioprocess engineering. Clarity of presentation would ensure that you do not lose all the points for ambiguity in expressing your understanding of the subject.

- 1. i) List four differences between prokaryotes and eukaryotes
(ii) Place the following under either prokaryotes or eucaryotes: *Escherichia coli*; baker's yeast (*Saccharomyces cerevisiae*); fungi such *Aspergillus flavus* and mushrooms; cyanobacteria; *Streptococcus lactis* and plants**
- 2. Describe the steps required to develop a complete industrial bioprocess for the production of a recombinant-DNA-derived biopharmaceutical such as human growth hormone.**

Introduction to Biotechnology

Hom. 2 until 1

- (i) (a) Prokaryotes have one DNA while Eukaryotes have more than one 3pts
(b) Prokaryotes have no nuclear membrane 3pts
(c) Prokaryotes have no mitochondria 3pts
(d) Spores of prokaryotes have high heat resistance while spores of Eukaryotes have low heat resistance 3pts

(ii) Prokaryotes	Eukaryotes
1. <u>E. coli</u> 4pts	1. <u>S. cerevisiae</u> 4pts
2. <u>Cyanobacteria</u> 4pts	2. <u>Aspergillus flavus</u> 4pts
3. <u>Streptococcus lactic</u> 4pts	3. <u>monascus</u> 4pts
	4. <u>Plants</u> 4pts

2. (i) Genetic manipulation of host organism (10pts)
(60) (ii) shake-flask cultures (10pts)
(iii) Process-scale up (bench-scale for 2-1 fermenter) (10pts)
(iv) Pilot-scale bioreactor (8pts)
(v) Industrial-scale operation (8pts)
(vi) Product recovery/downstream processing (8pts)
(vii) Packaging and marketing (6pts)

ABOVE AVERAGE

Above Average Student Original Graded Assignment

**CHEMICAL ENGINEERING DEPARTMENT
INTRODUCTION TO BIOTECHNOLOGY CHEG 3315
COURSE ASSIGNMENT GRADING AND OUTCOME ASSESSMENT
SHEET FOR SPRING 2022 SEMESTER**

STUDENT LEARNING OUTCOME: Ability to apply the knowledge of science in engineering.

Assignments that test competency in this area will include problems that test a student's ability to apply knowledge of and (1) solve algebraic, integral and differential equations analytically or numerically, and (2) apply knowledge of chemistry and biology in engineering.

Name: Nina Patthammavong

Title of Assignment: Homework #1

Due Date: 02/23/2022

Competency Area	Max for this Assignment	Your Score
Ability to apply knowledge of science in engineering. <i>The assignment tests students' competency in their ability to apply chemistry and biology in engineering.</i>	100	94
TOTAL	100	94

39

1. (i) Four differences between prokaryotes and eukaryotes

3

Eukaryotes have a nucleus which contain the cell's genetic material, while Prokaryotic don't have a nucleus.

3

Eukaryotes have several organelles, such as mitochondria, the endoplasmic reticulum, and Golgi apparatus while Prokaryotes don't have.

2

Eukaryotes reproduce sexually via mitosis or meiosis while Prokaryotes reproduce asexually and usually divide by binary fission.

3

Eukaryotes have many chromosomes, while Prokaryotes have only one chromosome which is not true chromosome plastids.

(ii) Prokaryotes:

4

- *Escherichia coli*

4

- *Streptococcus lactis*

4

Cyanobacteria

Eukaryotes:

4

- Baker's yeast (*Saccharomyces cerevisiae*)

4

- *Aspergillus flavus*

4

Mushrooms

4

Plants

50

2. Describe the steps required to develop a complete industrial bioprocess to produce a recombinant-DNA-derived biopharmaceutical of insulin.

Insulin is an essential hormone for the human body. This hormone controls the amount of glucose in the bloodstream, stores glucose in the liver muscles, and regulates the metabolism of carbs, lipids, and proteins in the body. If the human body does not produce insufficient insulin, it

can lead to diabetes. Diabetes causes long-term damage to large and small blood vessels that cause serious illnesses, including heart attacks, strokes, and problems with the kidneys, eyes, feet, and nerves. As a medication, insulin therapy is used to treat diabetes. Insulin's critical role is recognized as controlling blood sugar and preventing diabetes complications, including type I diabetes and type II diabetes. Insulin is frequently used for acute complications, such as diabetic ketoacidosis, hyperosmolar, and hyperglycemia. As a result, bioprocess development of insulin is necessary. There are multiple steps to produce insulin using recombinant DNA.

Before genetic bioengineering, insulin is produced from the pancreas of pigs or cows. At the first steps, a small piece of a circular plasmid is extracted from the bacteria or yeast cell, such as *Escherichia coli* or *Saccharomyces cerevisiae*. Then, cutting the small circular plasmid by using restriction endonuclease enzyme. The next step is the cutting gene from part of an animal chromosome inserted into the opened gap plasmid, and both recombined together using DNA ligase enzyme. After inserting this recombined plasmid into a new microorganism, such as *Escherichia coli*, this cell will start to divide and produce insulin. This cell division grows in a small scale of shake flasks of 250 milliliters to 1-liter capacity, but the growing cell depends on the medium composition, temperature, pH, and other environmental conditions. The more the cells grow, the more insulin is produced.

After that, the system scales up to fermentation vessels to produce larger cells. There are three fermentation systems, such as Bench-top bioreactor, Pilot-scale bioreactor, and Industrial-scale operation. For Bench-top bioreactor, measuring temperature, pH, oxygen concentration, and stirred speed of cultures must be more carefully monitored. This process requires the calculation of mass transfer coefficients, mixing time, oxygen rate, energy dissipation rate, and decision of cultures if it is a batch, semi-batch, or continuous process. For the Pilot-scale bioreactor, this process aims to examine the response of cells to scale up since loss or variation

Reference

- Baeshen, Nabih A, et al. "Cell Factories for Insulin Production - Microbial Cell Factories." *BioMed Central*, BioMed Central, 2 Oct. 2014, <https://microbialcellfactories.biomedcentral.com/articles/10.1186/s12934-014-0141-0>.
- Yaturu, Subhashini. *Insulin Therapies: Current and future trends at dawn*, Word Journal of Diabetes, 15 Feb. 2013, www.ncbi.nlm.nih.gov/pmc/articles/PMC3596776/.
- Karki, Gaurab. *Human Insulin Production by Genetic Engineering*, Online Biology Notes, 27 Oct. 2018, www.onlinebiologynotes.com/human-insulin-production-by-genetic-engineering/.

AVERAGE

Average Student Original Graded Assignment

**CHEMICAL ENGINEERING DEPARTMENT
INTRODUCTION TO BIOTECHNOLOGY CHEG 3315
COURSE ASSIGNMENT GRADING AND OUTCOME ASSESSMENT
SHEET FOR SPRING 2022 SEMESTER**

STUDENT LEARNING OUTCOME: Ability to apply the knowledge of science in engineering.

Assignments that test competency in this area will include problems that test a student's ability to apply knowledge of and (1) solve algebraic, integral and differential equations analytically or numerically, and (2) apply knowledge of chemistry and biology in engineering.

Name: Kaylon Atkinson_____

Title of Assignment: __Homework 1_____ Due Date: February 21, 2022_____

Competency Area	Max for this Assignment	Your Score
Ability to apply knowledge of science in engineering. <i>The assignment tests students' competency in their ability to apply chemistry and biology in engineering.</i>	100	79
TOTAL	100	79

Kaylon Atkinson

Introduction to Biotechnology: Homework 1 (Spring 2022)

February 21, 2022

Due Date: February 21, 2022

Answer all questions. You will be graded based on your ability to apply knowledge of chemistry and biology to basic microbiology bioprocess engineering. Clarity of presentation would ensure that you do not lose all the points for ambiguity in expressing your understanding of the subject.

1-29
2-33
62

1. i) List four differences between prokaryotes and eukaryotes

Eukaryotes have nucleus to contain the DNA, in prokaryotes they float freely. Prokaryotes do not have a mitochondria, endoplasmic reticulum or a Golgi apparatus unlike eukaryotes which contains them all.

(ii) Place the following under either prokaryotes or eukaryotes: *Escherichia coli*; baker's yeast (*Saccharomyces cerevisiae*); fungi such *Aspergillus flavus* and mushrooms; cyanobacteria; *Streptococcus lactis* and plants

Prokaryotes	Eukaryotes
<i>Escherichia Coli</i>	<i>Saccharomyces cerevisiae</i>
Cyanobacteria	<i>Aspergillus flavus</i>
	Mushrooms
	<i>Streptococcus lactis</i>
	Plants

2. Describe the steps required to develop a complete industrial bioprocess for the production of a recombinant-DNA-derived biopharmaceutical such as insulin

1. Get the DNA needed to produce insulin
 - a. The DNA that is required for the production of insulin is found in pigs
 - b. To produce insulin, DNA is required from the pancreas cells of the pig
2. Get the protein from the DNA
 - a. Isolate the gene using gene splicing to get the gene alone by cutting the DNA in specific locations by the function of spliceosome
 - b. Transcribe the DNA into RNA by matching up the adenine with uracil instead of thymine from the DNA strand as well as pairing cytosine with guanine
 - c. Completion of protein synthesis by translating the RNA into protein
3. Genetic Manipulation of the host cell
 - a. Attach the cloned DNA strand into the host cell (human cell) where the cell recombines

4. Gene Expression
- a. The newly inserted gene, that codes for insulin using yeast, positioned in the microorganism will grow and multiply
5. Cell Division
- a. After the cell is fully formed, it will then start to divide
- b. One cell will split into two cells then those two into four cells and they will continue dividing
- c. The equation 2^n can be used to determine the specific number of cells during the division process
- ⑤ 6. Small-Scale Culturing
- a. The cells will be contained inside a beaker or flask where it will then be added with nutrients in order for the cells to continue growing
- b. During this process, cells can be measured for temperature, and pH levels amongst other things
- where is the bench-scale culture?*
7. Bioreactor
- a. Cells can then be transferred into a bioreactor where the insulin will bind to the cell's membrane through its receptors, which will things such as glucose and proteins to enter the cell
- b. During this process, we can examine the response of the cells where we will notice how glucose will allow the cells to do various functions, and could even lower a person's blood sugar level
- ⑤ 8. Industrial Scale Operation
- a. Once the process occurs to be successful, we need to ensure that the proper equipment and preparations are made to continue this fermentation process on an industrialized scale *how?*
9. Product recovery
- a. The mixture will go through many steps of being treated to get the final product
- i. This will include filtration and centrifugation, for the separation of product (cells) from the liquid/broth mixture
10. Packaging and marketing
- ⑤ a. Lastly, the insulin (product) will be purified where it will be ready to be packaged, and marketed at required locations
- Not a beaker; shake-flask cultures*

BELOW AVERAGE

Below Average Student Original Graded Assignment

60

Clement Adeyemi
CHEG 3315
Due 2/14/22

CHEG 3315 Introduction to Biotechnology: Homework 1

Question 1

- i) List four differences between prokaryotes and eukaryotes

Solution

Eukaryotes	Prokaryotes
They have a nucleus	There is no nucleus <i>no membrane-bound nucleus</i>
They have mitochondria	They have no mitochondria
There are usually multicellular	There are usually unicellular
They have larger ribosomes	They have smaller ribosomes

- (ii) Place the following under either prokaryotes or eucaryotes: Escherichia coli; baker's yeast (Saccharomyces cerevisiae); fungi such Aspergillus flavus and mushrooms; cyanobacteria; Streptococcus lactis and plants.

Solution

Prokaryotes: Cyanobacteria, Escherichia coli, Streptococcus lactis

Eucaryotes: Aspergillus flavus, Plants, Baker's yeast (Saccharomyces cerevisiae), Mushrooms

Question 2

2. Describe the steps required to develop a complete industrial bioprocess for the production of a recombinant-DNA-derived biopharmaceutical such as insulin.

Solution

The production of a recombinant-DNA- derived biopharmaceutical is achieved in a laboratory by scientists by building the human insulin gene in the laboratory and following these steps:

Step 1: Retrieve the plasmid, i.e. a loop of DNA known from the bacteria

Step 2: insert the isolated human insulin gene into the plasmid of the bacteria.

Step 3: Re-insert the plasmid to the bacteria

Step 4: Place the recombinant bacteria in fermentation tanks.

Step 5: The recombinant bacteria produce human insulin using their newly-acquired gene.

Step 6: Scientists are now able to collect the insulin from the bacteria

Step 7: The insulin can be put in finished products for people to consume.

7
10
10
6
33
3
36

INTRODUCTION TO BIOTECHNOLOGY SPRING 2022

Title of Assignment: MIDTERM EXAM

TOPICS COVERED IN MIDTERM EXAM

Midterm Exam covered the following topics:

- 1. Fermentation medium design**
- 2. Differences between DNA and RNA**
- 3. Classification of prokaryotes and eukaryotes**
- 4. DNA as a carrier of genetic information**
- 5. Single stranded and double stranded viral DNA**
- 6. Determining the sequence of complimentary strand of DNA**

INTRODUCTION TO BIOTECHNOLOGY SPRING 2022

SAMPLE QUESTIONS, SOLUTION, AND GRADING SCHEME FOR MIDTERM EXAM

Introduction to Biotechnology CHEG 3315: Midterm (Spring 2022)

March 9, 2022

Answer all questions. You will be graded based on your ability to apply knowledge of chemistry and biology.

1. Design a medium to grow a mold aerobically on 100g/L glucose if all the glucose is consumed in the production of the mold biomass. The elemental cell composition of the mold (% dry cell weight) is as given below:

**C: 51%
N: 8%
O: 24.4%
P: 2.5%
H: 7%
S: 0.3%
Mg: 0.3%
Ash: 6.5%**

You may use the following molar masses: K = 39.1; H=1.008; P = 30.97; O = 16.00; N = 14.01; S = 32.07; Cl = 35.45 and Mg = 24.31; C = 12.01.

- (i) Calculate the amount (in gm) of the nitrogen source you selected**
- (ii) How much dry biomass (in gm) would be produced?**
- (iii) Calculate the amount in gm of your (a) phosphorus, (b) sulfur and (c) magnesium sources used for the medium design**
- (iv) Explain the basis of your choice of compounds added to the glucose in the design/ formulation of the medium.**

2. (a) List four differences between procaryotes and eukaryotes

(b) List four differences between DNA and RNA

(c) It is known that regardless of where a sample of DNA came from and whatever its total nucleotide composition, it always contained equal amounts of adenine and thymine, and exactly equal amounts of guanine and cytosine. Why is this statement true?

(d) A viral DNA is analyzed and found to have the following base composition in mole percent: A = 32, G = 16, T = 40 and C = 12. What can you immediately conclude about this DNA?

(e) Given the following sequence for one strand of a double-strand oligonucleotide, write the sequence of the complimentary strand:

5¹....TCAGTAAGGCTTCAT... 3¹.

Introduction to Biotechnology ^{CHFG} 3153 ^{10/6}

Midterm Exam

1. (48) Given: 100g/L glucose for aerobic growth of a mold

$$\% \text{wt N} = 8.0$$

$$\% \text{wt P} = 2.5$$

$$\% \text{wt S} = 0.3$$

$$\% \text{wt Mg} = 0.3$$

(i) To calculate nitrogen source requirement, dry wt of mold is ~~calculated~~
For aerobic growth of mold, cellular yield coefficient ~~is~~

$$Y_{X/S} = \frac{0.5 \text{ g dry wt mold}}{\text{g glucose}}$$

$$\text{Hence } \frac{x \text{ g dry wt mold}}{100 \text{ g glucose}} = \frac{0.5 \text{ g dry wt mold}}{\text{g glucose}} \quad (4)$$

$$\therefore \text{Dry wt of mold for growth on 100g/L glucose} = 0.5 \times 100 \text{ g dry wt} = 50 \text{ g} \quad (4)$$

(ii) using $(\text{NH}_4)_2\text{SO}_4$ as Nitrogen and Sulfur sources, the $(\text{NH}_4)_2\text{SO}_4$ required is calculated as ff:

$$\text{For 50g dry wt of mold, the wt. of N} = \frac{8.0 \text{ g N}}{100 \text{ g mold}} \times 50 \text{ g mold} = 4.0 \text{ g N} \quad (4)$$

$$\therefore \frac{4.0}{x} = \frac{28.02}{132.154} \quad \text{where } x = \text{wt. of } (\text{NH}_4)_2\text{SO}_4 \quad (4)$$

$$\therefore (\text{NH}_4)_2\text{SO}_4 \text{ required} = \frac{132.154}{28.02} \times 4.0 = 18.866 \text{ g}$$

2 of 6

Introduction to Biotechnology CHE 3153

Midterm Exam

(ii) or using $(\text{NH}_4)_2\text{SO}_4$ as source of sulfur, Sulfur present in $18.866\text{g } (\text{NH}_4)_2\text{SO}_4$

$$= \frac{32.07}{132.154} \times 18.866\text{g} = 4.578\text{g} \quad (4)$$

Sulfur present in $50\text{g dry wt mold} = \frac{0.3\text{g S}}{100\text{g mold}} \times 50\text{g mold} = 0.15\text{g} \quad (4)$

Hence $18.866\text{g } (\text{NH}_4)_2\text{SO}_4$ also satisfies the S Requirement. (4)

(b) Phosphorus may be provided by KH_2PO_4

Phosphorus Requirement $\Rightarrow \frac{2.5\text{g Phosphorus}}{100\text{g mold}} = \frac{X}{50\text{g mold}}$

$$X = \text{Phosphorus Required} = \frac{2.5\text{g Phosphorus}}{100\text{g mold}} \times 50\text{g mold} = 1.25\text{g Phosphorus} \quad (4)$$

But $\frac{Y\text{g } \text{KH}_2\text{PO}_4}{1.25\text{g Phosphorus}} = \frac{136.086}{30.97}$

$$\therefore Y\text{g } \text{KH}_2\text{PO}_4 \text{ required} = \frac{136.086}{30.97} \times 1.25\text{g} = 5.493\text{g} \quad (4)$$

(c) Mg may be provided by MgSO_4

Hence Mg required may be obtained from:

$$\frac{0.3\text{g Mg}}{100\text{g mold}} = \frac{X}{50\text{g mold}} \quad \text{and}$$

$$X = 0.15\text{g of Mg} \quad (4)$$

Introduction to Biotechnology CHB3153

Midterm Exam

(c) ... Mg required $x = 0.15g$

Using $MgSO_4$, $\frac{120.38}{24.31} = \frac{MgSO_4 \text{ required}}{0.15}$

$\therefore MgSO_4 \text{ required} = 120.38 \times \frac{0.15}{24.31}$ (4)

$\approx 0.743g$

Sulfur provided by $0.743g$ $MgSO_4$ is given
by $\frac{32.07}{120.38} \times 0.743g = 0.198g$ (4)

Total sulfur provided in medium $= (4.578 + 0.198)g$
 $= 4.776g$ from $MgSO_4$ and $(NH_4)_2SO_4$

Glucose: $100g/L$

$(NH_4)_2SO_4$: $18.866g/L$

KH_2PO_4 = $5.493g/L$

$MgSO_4$ = $0.743g/L$

Introduction to Biotechnology CH03/53

Midterm EXAM

- ⑤ 2. (i) (a) Prokaryotes have one DNA while Eukaryotes have more than one
- ③ (b) Prokaryotes have no nuclear membrane
- ③ (c) Prokaryotes have no mitochondria
- ③ (d) Spores of prokaryotes have high heat resistance while spores of eukaryotes have low heat resistance.

2 (ii)	DNA	RNA
③ 1.	Double-stranded helix polynucleotide	Single stranded polynucleotide
③ 2.	Adenine, Guanine, Thiamine and Cytosine bases	Adenine, Guanine, Uracil and Cytosine bases
③ 3.	5-Carbon deoxyribose sugar	5-Carbon ribose sugar
③ 4.	Nucleus	Cytoplasm

Introduction to Biotechnology CHEG-3153

Midterm Exam

- 2 iii) The statement that there are equal amounts of Adenine and Thymine and equal amounts of Guanine and Cytosine in DNA samples, regardless of source is true based on the following:
- ③ 1) DNA is a double helix consisting of a double strand polynucleotide/oligonucleotide
 - 2) The polynucleotide of each strand is made up of nucleotides with general structure
... phosphate - ^{base}sugar - phosphate
 - ③ 3) Four different types of base are bonded to the 5-carbon sugar in the general structure; these bases are Adenine (A), Thymine (T), Guanine (G) and Cytosine (C)
 - 4) The double-helix structure that provides stability to the DNA is possible only when hydrogen bonding occurs between
 - ⑤ 5) G on one strand and C on the complementary strand, while A on one strand forms hydrogen bonds with T on the complementary strand

Introduction to Biotechnology CHGG3153
Midterm Exam

2 (iv) Role % of viral DNA:

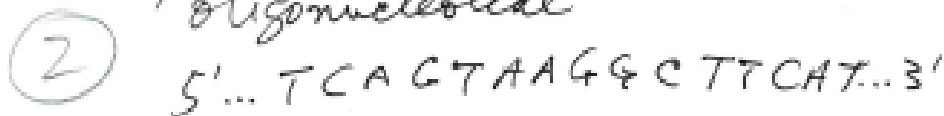
$$A = 32, G = 16, T = 40 \text{ and } C = 12$$

③ Ratio of $A:T = 32:40 \neq 1:1$

④ Ratio of $G:C = 16:12 \neq 1:1$

⑤ Hence the viral DNA is single-stranded.

2 (v) Sequence of one strand of double-stranded oligonucleotide



Complementary strand



ABOVE AVERAGE

Above Average Student Original Graded Assignment

**CHEMICAL ENGINEERING DEPARTMENT
INTRODUCTION TO BIOTECHNOLOGY CHEG 3315
COURSE ASSIGNMENT GRADING AND OUTCOME ASSESSMENT
SHEET FOR SPRING 2022 SEMESTER**

STUDENT OUTCOME: Ability to apply the knowledge of mathematics, science, and engineering.

Assignments that test competency in this area will include problems that test a student's ability to apply knowledge of and (1) solve algebraic, integral and differential equations analytically or numerically, and (2) apply knowledge of chemistry and biology in engineering.

Name: Vivian Patthammavong

Title of Assignment: Mid-term Due Date: 03/09/2022

Description of Performance Criteria Being Assessed	Max for this Assignment	Your Score
Ability to apply knowledge of science in engineering. <i>The assignment tests students' competency in their ability to apply chemistry and biology in engineering.</i>	100	85
TOTAL	100	85

1)

$$Y_{X/S} = \frac{\text{g of cell}}{\text{g of substrate}}$$

$$0.5 = \frac{\text{g of cell}}{100 \text{ g/L}} \quad (4)$$

$$\Rightarrow \text{g of cell} = 50 \text{ g/L} \quad (4)$$

element	cell composition
N	8%
C	51%
P	2.5%
S	0.9%
Mg	0.3%

37

37

(i) nitrogen source

$$(NH_4)_2SO_4 = (14.01 \times 2) + (1.01 \times 8) + (32.07) + (16 \times 4)$$

$$(NH_4)_2SO_4 = 132.17 \text{ g/mol}$$

$$N = 28.02 \text{ g N/mol } (NH_4)_2SO_4$$

$$H = 8.08 \text{ g H/mol } (NH_4)_2SO_4$$

$$S = 32.07 \text{ g S/mol } (NH_4)_2SO_4$$

$$O = 64 \text{ g O/mol } (NH_4)_2SO_4$$

yield coefficient of nitrogen?

$$100 \text{ g/L} \rightarrow 8 \text{ g N}$$

$$50 \text{ g/L} \rightarrow x$$

$$x = \frac{(50 \text{ g/L})(8 \text{ g N})}{100 \text{ g/L}} \quad (4)$$

$$x = 4 \text{ g N}$$

(ir) expected yeast produce

$$28.02 \text{ g N} \rightarrow 132.17 \text{ g } (NH_4)_2SO_4$$

$$4 \text{ g N} \rightarrow x$$

$$x = \frac{(4 \text{ g N})(132.17 \text{ g } (NH_4)_2SO_4)}{28.02 \text{ g N}} \quad (4)$$

$$x = 18.90 \text{ g } (NH_4)_2SO_4$$

(iii) © magnesium source

$$MgSO_4 = 24.31 + 32.07 + (16 \times 4)$$

$$= 120.38 \text{ g/mol}$$

$$Mg = 24.31 \text{ g Mg/mol } MgSO_4$$

$$S = 32.07 \text{ g S/mol } MgSO_4$$

$$O = 64 \text{ g O/mol } MgSO_4$$

find yield coefficient of Mg?

$$100 \text{ g/L} \rightarrow 0.3 \text{ g Mg}$$

$$50 \text{ g/L} \rightarrow x$$

$$x = \frac{(50 \text{ g/L})(0.3 \text{ g Mg})}{100 \text{ g/L}} = 0.15 \text{ g Mg} \quad (4)$$

find expected yeast growth

$$24.31 \text{ g Mg} \rightarrow 120.38 \text{ g } MgSO_4$$

$$0.15 \text{ g Mg} \rightarrow x$$

$$x = 0.74 \text{ g } MgSO_4 \quad (4)$$

• (a) phosphorus source

$$\text{KH}_2\text{PO}_4 = 39.1 + (1.01 \times 2) + 30.97 + (16 \times 4)$$

$$\text{KH}_2\text{PO}_4 = 136.09 \text{ g/mol}$$

$$\text{K} = 39.1 \text{ g K/mol KH}_2\text{PO}_4$$

$$\text{H} = 2.02 \text{ g H/mol KH}_2\text{PO}_4$$

$$\text{P} = 30.97 \text{ g P/mol KH}_2\text{PO}_4$$

$$\text{O} = 64 \text{ g O/mol KH}_2\text{PO}_4$$

* yield coefficient⁹

$$100 \text{ g/L} \rightarrow 2.5 \text{ g P}$$

$$50 \text{ g/L} \rightarrow x$$

$$x = \frac{(50 \text{ g/L})(2.5 \text{ g P})}{100 \text{ g/L}}$$

$$x = 1.25 \text{ g P} \quad (4)$$

$$\Rightarrow 30.97 \text{ g P} \rightarrow 136.09 \text{ g KH}_2\text{PO}_4$$

$$1.25 \text{ g P} \rightarrow x$$

$$x = \frac{(1.25 \text{ g P})(136.09 \text{ g KH}_2\text{PO}_4)}{30.97 \text{ g P}}$$

$$x = 5.49 \text{ g KH}_2\text{PO}_4 \quad (4)$$

(b) Sulfur source

$$\text{MgSO}_4 = 24.31 + 32.07 + 64$$

$$= 120.38 \text{ g/mol}$$

$$100 \text{ g/L} \rightarrow 0.3 \text{ g S}$$

$$50 \text{ g/L} \rightarrow x$$

$$x = 0.15 \text{ g S} \quad (4)$$

expected mold produced

$$32.07 \text{ g S} \rightarrow 120.38 \text{ g MgSO}_4$$

$$0.15 \text{ g S} \rightarrow x$$

$$x = \frac{(0.15 \text{ g S})(120.38 \text{ g MgSO}_4)}{32.07 \text{ g S}} \quad (1)$$

$$x = 0.56 \text{ g MgSO}_4$$

(iv) My choice compounds that added into glucose are MgSO_4 , KH_2PO_4 , and $(\text{NH}_4)_2\text{SO}_4$ because all these compounds contain N, P, S, and Mg. Also, The reason I chose these elements because Mg, S, P, and N, are all going into the cell composition.

2.1 (a) List differences between prokaryote and eukaryotes

35 1/2

Prokaryotic

- it does not have a nucleus

nuclear membrane

- Prokaryotic cell has a smaller cell size. it's generally range from 0.1 micrometer to 5 micrometer

- it does not have a membranes-bound nucleus or organelled

- Prokaryotic cell has a circular strands of DNA

- It has only asexual reproduction occurs

- mitochondria is absent

- The endoplasmic reticulum is not presenting in prokaryotic cell

- only one chromosome is there in Prokaryotic cell

eukaryotic

- every eukaryotic cell has a nucleus

nuclear membrane

- Eukaryotic cell has a cell size range from 10 micrometer to 100 micrometer which is a larger cell size

- Eukaryotic cells contain nucleus and organelled that bound by plasma membranes

- Eukaryotic cell has multiple molecules of double-strands, linear DNA

- it has both sexual and asexual reproduction occurs

- Mitochondria is present

- The endoplasmic reticulum is present in eukaryotic cell

- There are many chromosome is present in eukaryotic cell

(b)

DNA

- DNA is found in nucleus, with a small amount of DNA also present in mitochondria

- The sugar of DNA is deoxyribose

- DNA replicate and stores the genetic information. It's blueprint for all genetic information contained within an organism

RNA

- RNA is formed in nucleus, and moved it to specialized region of cytoplasm and ribosome depending on type of RNA formed

- The sugar of RNA is ribose sugar

- RNA is convert genetic information contained within a DNA to a format used to build protein and moved it to the ribosomal protein factories

1-37

2-35 1/2

72 1/2

You were to give 4 differences NOT 9.

DNA	RNA
- DNA is double helix that has a long chain of nucleotide	- RNA is single helix that has a short chain of nucleotide
- DNA replicates on it own. It's self-replicating	- RNA does not replicates on it own, but it synthesised from DNA required
- The base pair of DNA is G and C (guanine and Cytosine) A and T (Adenine and Thymine)	- The base pair of RNA are G and C (guanine and Cytosine) A and U (Adenine and Uracil) <i>It is a single strand</i>
- DNA is susceptible to UV damage	- Compare to DNA, RNA is relatively resistant to UV damage

(e) 5'...TCAGTAA GGCTTCAT...3'
3'...AGTCATT CCGAAGTA...5'

- (c) Each strands of DNA molecules is compose of double helix that has a long chain of nucleotide, and it has antiparalleled strands 5' to 3' and 3' to 5'. The nucleotide of DNA is consist of five carbon sugar (deoxyribose) which is attached to phosphate group and four mitrogeneous bases, such as two purine (Adenine and guanine) and two pyrimidine (cytosine and Thymine). The nucleotide are joined together by covalent bond between phosphate of one nucleotide and sugar of the next, forming a phosphate-sugar backbone from which mitrogeneous base protrude. One strand is held together by hydrogen bond between the bases, these sequences is bonding specific, like guanine pair only with cytosine and Adenine pair only with Thymine.

- (d) Base on chagoff's rule, he stated that DNA of all species should have 1:1 stoichiometric ratio of purine (adenine and guanine) and pyrimidine (cytosine and Thymine). Also, The amount of adenine must be equal to Thymine and the amount of guanine should be equal to cytosine. base on given information, we see that Adenine (A=32) is not equal to Thymine (T=40) and guanine (G=16) is not equal to cytosine (C=12). We can conclude that these sequences are not completed ??

AVERAGE

Average Student Original Graded Assignment

**CHEMICAL ENGINEERING DEPARTMENT
INTRODUCTION TO BIOTECHNOLOGY CHEG 3315
COURSE ASSIGNMENT GRADING AND OUTCOME ASSESSMENT
SHEET FOR SPRING 2022 SEMESTER**

STUDENT OUTCOME: Ability to apply the knowledge of mathematics, science, and engineering.

Assignments that test competency in this area will include problems that test a student's ability to apply knowledge of and (1) solve algebraic, integral and differential equations analytically or numerically, and (2) apply knowledge of chemistry and biology in engineering.

Name: Clement Adayemi

Title of Assignment: Midterm 1 Due Date: _____

Description of Performance Criteria Being Assessed	Max for this Assignment	Your Score
Ability to apply knowledge of science in engineering. <i>The assignment tests students' competency in their ability to apply chemistry and biology in engineering.</i>	100	71
TOTAL	100	71

MIDTERM

Question 1 (i)

$$100 \text{ g/L} \times 0.5 \text{ g of cell} = 50 \text{ g} \text{ to be used as basis}$$

What does the 50g represent?

This will be our basis

Hence given a nitrogen source of $(\text{NH}_4)_2\text{SO}_4$, mole weight = $2(14+4) + 32 + 4(16) = 132 \text{ g/mol}$

hence for amount of nitrogen

$$\frac{x}{50 \text{ g/L}} = \frac{8 \text{ g of } (\text{NH}_4)_2\text{SO}_4}{100 \text{ g/L}}$$

How

$(\text{NH}_4)_2\text{SO}_4$ cannot be in the mold.

$$\frac{x}{50 \text{ g/L}} = \frac{8 \text{ g N}}{100 \text{ g/L}}$$

However for the actual mass of nitrogen.

If 132 g of $(\text{NH}_4)_2\text{SO}_4$ gives 2N i.e. $2 \times 14 = 28 \text{ g of N}$ $\Rightarrow 4 \text{ g N in the mold.}$

How many will 4 g of $(\text{NH}_4)_2\text{SO}_4$ give?

$$\begin{matrix} 132 \rightarrow 28 \\ 4 \rightarrow x \\ x = \frac{4 \times 28}{132} = 0.85 \text{ g of Nitrogen} \end{matrix}$$

$$\begin{matrix} 132 \rightarrow 28 \\ x \rightarrow 4 \end{matrix}$$

$$\begin{matrix} \frac{x}{132} = \frac{4}{28} \\ \therefore x = \frac{4}{28} \times 132 = 18.86 \end{matrix}$$

Question 1 (ii)

1) Phosphorus source: KH_2PO_4 , mole weight = $(39 + 2 \times 1 + 31 + 16(4)) = 136 \text{ g/mol}$

$$\frac{x}{50 \text{ g/L}} = \frac{2.5 \text{ g of } \text{KH}_2\text{PO}_4}{100 \text{ g/L}} \text{ gives } 2.5 \text{ g of } (\text{KH}_2\text{PO}_4) \text{ in the mold}$$

actual mass of phosphorus

If 136 g of KH_2PO_4 gives 1P i.e. 31 g of P

How many will 1.25 g of KH_2PO_4 give?

$$\begin{matrix} 136 \rightarrow 31 \\ 1.25 \rightarrow x \\ x = \frac{1.25 \times 31}{136} = 0.277 \text{ g of Phosphorus} \end{matrix}$$

1.25g P in the 50g of mold

$$\begin{matrix} \frac{x}{136} = \frac{1.25}{31} \\ x = \frac{1.25}{31} \times 136 = 5.48 \text{ g of } \text{KH}_2\text{PO}_4 \end{matrix}$$

2) Sulphur source: MgSO_4 , mole weight = $24 + 32 + 16(4) = 124 \text{ g/mol}$

$$\frac{x}{50 \text{ g/L}} = \frac{0.3}{100 \text{ g/L}} \text{ gives } 0.3 \text{ g of } \text{MgSO}_4 \text{ in the mold}$$

However for the actual mass of magnesium

If 124 g of MgSO_4 gives 1S i.e. $1 \times 32 = 32 \text{ g of S}$

How many will 0.15 g of MgSO_4 give

$$\begin{matrix} 124 \rightarrow 32 \\ 0.15 \rightarrow x \\ x = \frac{0.15 \times 32}{124} = 0.039 \text{ g of Sulphur} \end{matrix}$$

$$\begin{matrix} \text{MgSO}_4 = 120.38 \text{ g/mol} \\ 120.38 \rightarrow 32 \\ x \rightarrow 0.15 \\ x = \frac{0.15 \times 120.38}{32} = 0.564 \text{ g of } \text{MgSO}_4 \end{matrix}$$

For Magnesium we will use same source, hence $124 \rightarrow 24$ $x = \frac{0.15 \times 24}{124} = 0.029$

Question (iv)

The compounds were chosen because they are soluble and do not alter the pH of the medium in a negative way

Question (ii)

Dry biomass in gm would be 50g

Question 2(a)

(26½)

Prokaryotes

- 1) They have no nucleus ^{they no nuclear membrane} 1½
- 2) They lack mitochondria 3
- 3) They are usually unicellular 1½
- 4) They reproduce via binary fission 1½

Eukaryotes

- 1) They have nucleus ^{nuclear membrane}
- 2) They have a mitochondria
- 3) They are usually multicellular
- 4) They reproduce via mitosis

Question 2(b)

DNA

- 1) It has deoxyribose as the sugar 3
- 2) It has a double stranded helix 3
- 3) It has thymine as its base ^{It is not the only base} 2
- 4) It is in the nucleus 2

RNA

- 1) It has ribose as its sugar
- 2) It has a single strand
- 3) It has uracil as its base ^{It is not the only base}
- 4) It is stored outside of the nucleus

Question 2(c)

5'...TCAGTAA GGCTTCAT...3' 2
 ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓
 3'...AGUCAUUC CGAAGUA...5'

~~This is not the complementary strand. This is the mRNA as have shown.~~

Question 2(d)

I can conclude that they add up to a 100 mole percent and hence constitute a unit.

It contains pyrimidine bases of Thymine and Cytosine ^{as the larger percentage} and purine bases of Adenine and Guanine of the lesser percentage 2

Question 2(e)

This is because adenine and thymine are complementary so also guanine and cytosine 5

BELOW AVERAGE

Below Average Student Original Graded Assignment

**CHEMICAL ENGINEERING DEPARTMENT
INTRODUCTION TO BIOTECHNOLOGY CHEG 3315
COURSE ASSIGNMENT GRADING AND OUTCOME ASSESSMENT
SHEET FOR SPRING 2022 SEMESTER**

STUDENT LEARNING OUTCOME: Ability to apply the knowledge of science.

Assignments that test competency in this area will include problems that test the student's ability to apply knowledge of chemistry and biology in engineering.

Name: Ezraequia Tatmun

Title of Assignment: Mid-term Due Date: 03/10/22

Description of Performance Criteria Being Assessed	Max for this Assignment	Your Score
Ability to apply knowledge of science in engineering. <i>The assignment tests students' competency in their ability to apply chemistry and biology in biotechnology</i>	100	68
TOTAL	100	68

Midterm

glucose $(\text{NH}_4)_2\text{SO}_4$
 MgSO_4 KH_2PO_4

Tatmon

i) Medium

100g/L glucose = 50g/L cells

ii) Nitrogen

$$\frac{8}{100g} = \frac{x}{50g}$$

$$8(50) = x(100)$$

$$400g = x(100)$$

$$x \text{ of N} = 40g$$

$$\frac{14.01}{132.07} = \frac{x}{40}$$

$$x = 377.07g$$

$$x = 4.0g$$

iv)

x is $(\text{NH}_4)_2\text{SO}_4$ not N

$$\frac{28.02}{132.07} = \frac{4}{x}$$

$$x = 18.87g (\text{NH}_4)_2\text{SO}_4/L$$

ii) for 100g/L of glucose
we can produce 50g/L of
dry biomass

iii)

a) Phosphorus

$$\frac{2.5}{100g} = \frac{x \text{ g P}}{50g}$$

$$x = 1.25g \text{ P}$$

$$\frac{30.97}{136.086} = \frac{1.25}{x}$$

$$30.97x = 1.25(136.086)$$

$$x = 5.49g \text{ of P}$$

x is a phosphate
salt
eg KH_2PO_4
molar = 136.08 g/mol

b) sulfur

$$\frac{0.3}{100g} = \frac{x \text{ g S}}{50g}$$

$$x = 0.15$$

$$\frac{32.07}{120.36} = \frac{0.15}{x}$$

$$x = 0.56g \text{ of S}$$

x is sulfur but
not MgSO_4

c) magnesium

→ same as sulfur
what does this mean?

$$\frac{24.31}{120.36} = \frac{0.15}{x}$$

$$x = 0.74g \text{ of Mg}$$

MgSO_4

$$\frac{23}{18} = \frac{41}{41}$$

2)

Prokaryotes	Eukaryotes
1 cell	multicellular
no golgi	golgi apparatus
no mitochondria	has mitochondria
<u>no nucleus</u>	has <u>nucleus</u>
no nuclear membrane	nuclear membrane

18

DNA	RNA
Double helix	Single helix
base pairing Pair A+T	Pair A+U
original strand	Copy of DNA
no oxygen on 2' carbon	has oxygen on 2' carbon
5-carbon deoxyribose sugar	5-carbon ribose sugar

single stranded poly nucleotide
It is a single strand and does not have a strand to pair with

c) This statement is true because there is a 1:1 ratio between the bases

d) That the total nucleotide composition is not equal.

e) 5'...TCAGTAAGGCTTCAT...3'
3'...AGTCATTCCGAAGTA...5'

INTRODUCTION TO BIOTECHNOLOGY SPRING 2022

Title of Assignment: FINAL EXAM

TOPICS COVERED IN FINAL EXAM

Final Exam covered the following topics:

1. Fermentation medium design
2. Differences between DNA and RNA
3. DNA as a carrier of genetic information
4. Determining the sequence of complimentary strand of DNA
5. Determining the mRNA transcript and the polypeptide sequence when a gene with known sequence is expressed
6. Plasmids, restriction enzymes and polymerase chain reaction
7. Metabolism and metabolic pathways

INTRODUCTION TO BIOTECHNOLOGY

SPRING 2022

SAMPLE QUESTIONS, SOLUTION, AND GRADING SCHEME FOR FINAL EXAM

Introduction to Biotechnology: Final Exam (Spring 2022)

May 11, 2022

Answer all questions. You will be graded based on your ability to (i) apply knowledge of chemistry and biology, and ability to solve engineering problems involving biological systems. Clarity of presentation would ensure that you do not lose all the points for a calculation if you should make a mistake.

1. As a Bioprocess Engineer in charge of a plant producing baker's yeast on a contract basis for a local bakery, your calculations show that glucose is the most expensive element of the process, and so wish to utilize all medium glucose in growing the organism. Design a medium (give g/L of component) to produce 30g/L yeast (on a dry basis) using any of the following as medium components. Give your reason for selecting a component instead of the alternative(s) listed:

Glucose, starch, methanol, KH_2PO_4 , H_3PO_4 , $(\text{NH}_4)_2\text{SO}_4$, NH_4Cl , NH_3 , MgCl and MgSO_4 . The molar masses are K = 39.1; H=1.008; P = 30.97; O = 16.00; N = 14.01; S = 32.07; Cl = 35.45 and Mg = 24.31; C = 12.01

For aerobic growth of yeast on glucose, a cellular yield coefficient $Y_{x/s} = 0.5\text{g yeast/g glucose}$ may be assumed. The elemental cell composition of the yeast (% dry cell weight) is as given below:

C: 47%
N: 7.5%
O: 30%
P: 1.5%
H: 6.5%
S: 1%
Mg: 0.5%
Ash: 6%

2. (a) Cite four differences between DNA and RNA; (b) Explain concisely those features of the structure of DNA which enable it to serve as a store of genetic information; (c) What is (i) a gene, and what is (ii) gene mutation?; (d) Given the following sequence for one strand of a double-strand oligonucleotide, write the sequence of the complimentary strand: 5' TCAACCTGTTACTGGACGCAT 3'

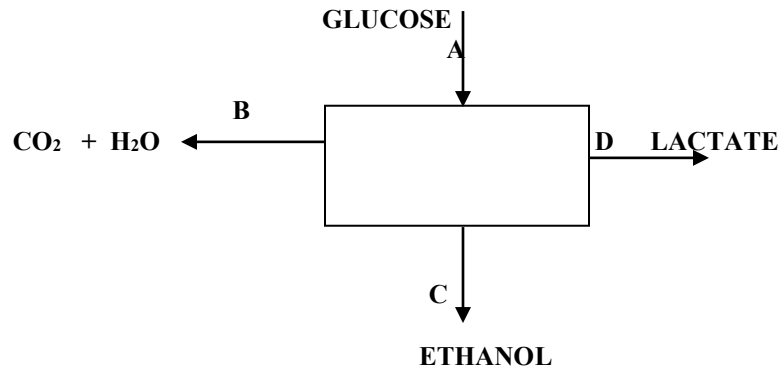
(e) Given that the nucleotide sequence contains the gene as shown below, write (i) the complimentary strand, (i) the mRNA you would expect, and (iii) the resulting polypeptide sequence if the gene is expressed:

5' ...ATGCGTCCAGTAACATGA... 3'

(f) (i) What are restriction enzymes? (ii) What are plasmids? (iii) What are monoclonal antibodies?
(iv) What is polymerase chain reaction (PCR)?

3. (a) Why is ATP so important a compound? (b) State two different ways by which cells can produce ATP

(c) Give the name of the intermediate missing in the box below, (d) the names of the pathways A and B, and (e) name all the enzymes in the pathways D and C.



Introduction to Biotechnology CHEG3153 1 of 7

FINAL EXAM - KEY

- 30
1. Given: 30g/L yeast (on a dry basis)
- Selection of medium components
- (i) Glucose — Carbon Source ①
 - (ii) KH_2PO_4 — Source of phosphorus ①
 - (iii) $(\text{NH}_4)_2\text{SO}_4$ — Source of nitrogen and Sulfur ②
 - (iv) MgSO_4 — Source of Mg ①

a) Glucose requirement
For aerobic growth of yeast, cellular yield coefficient

$$Y_{x/s} = \frac{0.5 \text{ g yeast}}{\text{g of glucose}}$$

$$\frac{30 \text{ g dry wt of yeast}}{X \text{ g glucose}} = \frac{0.5 \text{ g yeast}}{1 \text{ g of glucose}} \quad ①$$

$$\therefore X = \frac{30}{0.5} \text{ g glucose} = \frac{60.0 \text{ g glucose}}{1}$$

$$X = 60 \text{ g/L glucose} \quad ②$$

(b) Phosphorus Requirement as KH_2PO_4

For 30g dry wt. yeast, the wt. of P = $\frac{1.5}{100} \times 30 \text{ g} = 0.45 \text{ g}$ ① ②

$$\frac{\text{wt of } \text{KH}_2\text{PO}_4}{0.45 \text{ g P}} = \frac{136.086}{30.97} \quad ③$$

$$\text{KH}_2\text{PO}_4 \text{ required} = \frac{136.086}{30.97} \times 0.45 \text{ g} = 1.98 \text{ g/L}$$

Introduction to Biotechnology 2 of 7
FINAL EXAM - KEY

3(c) Nitrogen requirement as $(\text{NH}_4)_2\text{SO}_4$

$$30 \text{ g/L of yeast dry wt} = \frac{7.5}{100} \times 30 \text{ g N} \quad (1)$$

$$= 2.25 \text{ g N}$$

$$\frac{132.154 (\text{NH}_4)_2\text{SO}_4}{28.02 \text{ g N}} = \frac{X \text{ g } (\text{NH}_4)_2\text{SO}_4}{2.25 \text{ g N}} \quad (1)$$

$$(\text{NH}_4)_2\text{SO}_4 \text{ required} = \frac{132.154}{28.02} \times 2.25 \text{ g} = 10.61 \text{ g} \quad (3)$$

$$= 10.61 \text{ g/L}$$

(d) Amount of Sulfur in $10.61 \text{ g/L } (\text{NH}_4)_2\text{SO}_4$ is given by:

$$\frac{X \text{ g S}}{10.61 \text{ g } (\text{NH}_4)_2\text{SO}_4} = \frac{32.07}{132.154}$$

$$\text{S in } 10.61 \text{ g } (\text{NH}_4)_2\text{SO}_4 = \frac{32.07}{132.154} \times 10.61 \text{ g} \quad (2)$$

$$= 2.625 \text{ g} = 2.63 \text{ g}$$

$$\text{Sulfur in } 30 \text{ g/L dry yeast} = \frac{1}{100} \times 30 \text{ g} = 0.30 \text{ g/L} \quad (1)$$

$\therefore 10.61 \text{ g/L } (\text{NH}_4)_2\text{SO}_4$ satisfies the S requirement (1)

(e) Mg in 30 g/L yeast given by: $\frac{0.5}{100} \times 30 \text{ g/L}$

$$\text{MgSO}_4 \text{ required is given by: } = 0.15 \text{ g Mg/L} \quad (1)$$

$$\frac{X \text{ g } \text{MgSO}_4}{0.15 \text{ g Mg}} = \frac{120.38}{24.31} \quad (3)$$

$$\text{MgSO}_4 \text{ required} = \frac{120.38}{24.31} \times 0.15 \text{ g} = 0.74 \text{ g/L}$$

Introduction to Biotechnology 3 of 7
FINAL EXAM - KEY

Media	Medium Composition	(5)
1. Glucose	3/2 60	
2. KH_2PO_4	1.98	
3. $(NH_4)_2SO_4$	10.61	
4. $MgSO_4$	0.75	
5. Trace Elements Solution	as required	

Introduction to Biotechnology 4 of 7

FINAL EXAM - KEY

2(a)

DNA	RNA
1. Double-stranded helix polynucleotide ①	Single-stranded polynucleotide ①
2. Adenine, Guanine, Thymine and Cytosine bases ①	Adenine, Guanine, Uracil and Cytosine bases. Thymine in DNA replaced by Uracil in RNA ①
3. 5-Carbon deoxyribose sugar ①	5-Carbon ribose sugar ①
4. Found in nucleus, mitochondria or chloroplast ①	Cytoplasm ①

(b) (i) DNA is a double-stranded polynucleotide made up of nucleotides ^{in a double-helix} with the general structure of a strand as:

— phosphate - sugar - phosphate

(ii) Four different types of base are bonded to the 5-Carbon sugar in the general structure and they are Adenine (A), Thymine (T), Guanine (G) and Cytosine (C) ①

(iii) The double helix structure provides stability to the DNA through hydrogen bonding of G on one strand and C on the complementary strand and between A on one strand and T on the complementary strand ①

(iv) The sequence of bases on the DNA serves as code or store of genetic information that determines sequences of bases in the messenger RNA and subsequent synthesis of amino acids ③

Introduction to Biotechnology 5 of 7

in the polypeptide or protein formed in gene expression.

- (c) (i) A gene is a segment of DNA whose base sequence
 (3) codes for the sequence of amino acids in a polypeptide
 (ii) A gene mutation is a change in the sequence of
 (3) triplet codons

- (d) Strand sequence: $5' \dots \text{TCA ACC TGT TAC TGG ACC CAT} \dots 3'$
 (2) Complementary strand: $3' \dots \text{AGT TGG ACA ATG ACC TGC GTA} \dots 5'$

- (e) The DNA sequence of the gene is given by:

$5' \dots \text{ATG CGT CCA GTA ACA TGA} \dots 3'$

this is the coding strand. The complementary strand
 or the template strand from which the RNA is
 transcribed is given by:

(2) $3' \dots \text{TAC GCA GGT CATT GTA CT} \dots 5'$, hence

mRNA $5' \dots \text{AUG CGU CCA GUA ACA UGA} \dots 3'$

- (1) The translation step using the genetic code is:

(3) $5' \dots \text{AUG CGU CCA GUA ACA UGA} \dots 3'$
 $\begin{array}{ccccccc} \text{Met} & \text{Arg} & \text{Pro} & \text{Val} & \text{Thr} & \text{Stop} \end{array}$

The polypeptide sequence is:

- (2) - methionine - arginine - proline - valine - threonine

Introduction to Biotechnology

6 of 7

FINAL EXAM - KEY

24) (i) Restriction enzymes also referred to as restriction endonucleases are enzymes that recognize specific sequences of bases of double-stranded DNA (usually 4 or 6 base pairs in length) and cleave (cut) the DNA at these specific sites

(ii) monoclonal antibodies are antibodies that arise from a single clone of cells in response to an antigen

(iv) Polymerase chain reaction (PCR) is an in vitro procedure used to obtain a lot of a DNA sequence or segment that codes for a gene of interest.

(vi) Plasmids: They are double-stranded covalently closed or circular DNA molecules that reside or lie outside the chromosome and are self-replicating.

Introduction to Biochemistry 7 of 7
FINAL EXAM - KEY

30

3. (a) ATP is a very important compound because it is the biological store of energy and is the most universal energy transfer compound in living cells.

(b) ATP may be produced from any two of the following three ways:

- (i) Substrate level phosphorylation via the EMP pathway
- (ii) TCA Cycle, and:
- (iii) Oxidative phosphorylation

(c) Pyruvate.

(d) A - EMP pathway / Glycolytic Pathway
B - Krebs Cycle / TCA cycle

(e) D - Lactate Dehydrogenase

C - Pyruvate decarboxylase and Alcohol dehydrogenase

ABOVE AVERAGE

Above Average Student Original Graded Assignment

**CHEMICAL ENGINEERING DEPARTMENT
INTRODUCTION TO BIOTECHNOLOGY CHEG 3315
COURSE ASSIGNMENT GRADING AND OUTCOME ASSESSMENT
SHEET FOR SPRING 2022 SEMESTER**

STUDENT OUTCOME: Ability to apply the knowledge of mathematics, science, and engineering.

Assignments that test competency in this area will include problems that test a student's ability to apply knowledge of and (1) solve algebraic, integral and differential equations analytically or numerically, and (2) apply knowledge of chemistry and biology in engineering.

STUDENT OUTCOME: Ability to identify, formulate, and solve engineering problems.

Assignments that test competency in this area will include problems that test a student's ability to (1) apply systematic problem solving methodology that includes identifying all known and unknown variables, (2) construction of reasonable schematic representation of the problem, listing appropriate assumptions, determining appropriate property values, (3) applying the appropriate conservation laws, physical and chemical laws, and mathematics to solve the problem, and (4) evaluating the reasonableness of the computed results.

Name: Vivian Patthammavong

Title of Assignment: Final Exam Due Date: 05/11/2022

Description of Performance Criteria Being Assessed	Max for this Assignment	Your Score
Ability to apply knowledge of science in engineering. <i>The assignment tests students' competency in their ability to apply chemistry and biology in biotechnology</i>	70	65
Ability to identify engineering problems. <i>The problem tests the students ability to (i) understand the given problem and identify the subject area and concepts involved, (ii) convert the problem into a well labeled sketch, and (iii) identify the system of units applicable to the problem</i>	30	
Ability to formulate engineering problems. <i>The problem tests the students ability to (i) define the known and unknown variables, (ii) state relevant laws and equations needed to solve the problem, and (iii) list and apply any assumptions to the relevant laws and equations to obtain equation specific to the problem.</i>	30	22
Ability to solve engineering problems. <i>The problem tests the students ability to (i) implement a strategy to solve the engineering problem, (ii) solve the problem showing consistent units throughout, and (iii) evaluating and interpreting the result.</i>		
TOTAL	100	87

10/

element	dry weight
C	47.1%
N	7.5%
O	30.1%
P	1.5%
H	6.5%
S	1%
Mg	0.5%
Ash	6%

$$Y_{X/S} = \frac{\text{g of cell}}{\text{g of substrate}}$$

$$0.5 = \frac{\text{g of cell}}{30 \text{ g/L yeast}}$$

$$\Rightarrow \text{g of cell} = 15 \text{ g/L}$$

① The nitrogen source

$$\textcircled{1} (\text{NH}_4)_2\text{SO}_4 = (14.01 \times 2) + (1.008 \times 8) + 32.07 + (16 \times 4)$$

$$= 132.15 \text{ g}(\text{NH}_4)_2\text{SO}_4$$

find the yield coefficient?

$$100 \text{ g/L} \rightarrow 7.5 \text{ g N}$$

$$30 \text{ g/L} \rightarrow x$$

$$x = \frac{(15 \text{ g/L})(7.5 \text{ g N})}{(100 \text{ g/L})}$$

$$x = 1.125 \text{ g N}$$

find expected yeast growth?

$$28.02 \text{ g N} \rightarrow 132.15 \text{ g}(\text{NH}_4)_2\text{SO}_4$$

$$1.125 \text{ g N} \rightarrow x$$

$$x = \frac{1.125 \text{ g N} \times 132.15 \text{ g}(\text{NH}_4)_2\text{SO}_4}{28.02 \text{ g N}}$$

$$x = 5.31 \text{ g}(\text{NH}_4)_2\text{SO}_4$$

(b) phosphorus source

$$\text{KH}_2\text{PO}_4 = 39.1 + (1.008 \times 2) + 30.97 + (16 \times 4) \\ = 136.08 \text{ g KH}_2\text{PO}_4$$

find yield coefficient?

$$100 \text{ g/L} \rightarrow 1.5 \text{ g P}$$

$$300 \text{ g/L} \times 15 \text{ g/L} \rightarrow x \\ x = \frac{(15 \text{ g/L})(1.5 \text{ g P})}{100 \text{ g/L}}$$

$$x = 0.225 \text{ g P}$$

find expected yeast grow?

$$30.97 \text{ g P} \rightarrow 136.08 \text{ g KH}_2\text{PO}_4$$

$$0.225 \text{ g P} \rightarrow x$$

$$x = \frac{(0.225 \text{ g P})(136.08 \text{ g KH}_2\text{PO}_4)}{30.97 \text{ g P}}$$

$$x = 0.998 \text{ g KH}_2\text{PO}_4 \quad 1.98 \text{ g/L KH}_2\text{PO}_4$$

(c) Magnesium Source

$$\text{MgSO}_4 = 24.31 + 32.07 + (16 \times 4) \\ = 120.38 \text{ g MgSO}_4$$

yield coefficient?

$$100 \text{ g/L} \rightarrow 0.5 \text{ g Mg}$$

$$300 \text{ g/L} \times 15 \text{ g/L} \rightarrow x \\ x = \frac{(15 \text{ g/L})(0.5 \text{ g Mg})}{100 \text{ g/L}}$$

$$x = 0.075 \text{ g Mg}$$

expected yeast will grow?

$$24.31 \text{ g Mg} \rightarrow 120.38 \text{ g MgSO}_4$$

$$0.075 \text{ g Mg} \rightarrow x$$

$$x = \frac{(0.075 \text{ g Mg})(120.38 \text{ g MgSO}_4)}{24.31 \text{ g Mg}} = 0.37 \text{ g MgSO}_4 \quad 0.74 \text{ g/L}$$

(d) Sulfur Source

$$\text{MgSO}_4 = 24.31 + 32.07 + (16 \times 4) \\ = 120.38 \text{ g MgSO}_4$$

yield coefficient?

$$100 \text{ g/L} \rightarrow 1 \text{ g S}$$

$$15 \text{ g/L} \rightarrow x$$

$$x = \frac{(15 \text{ g/L})(1 \text{ g S})}{100 \text{ g/L}}$$

$$x = 0.15 \text{ g S}$$

How much S in $(\text{NH}_4)_2\text{SO}_4$

$$\frac{32.07 \text{ g S}}{132.15 \text{ g } (\text{NH}_4)_2\text{SO}_4} = \frac{x_1}{5.31 \text{ g } (\text{NH}_4)_2\text{SO}_4}$$

$$x_1 = 1.29 \text{ g S}$$

How much S in MgSO_4

$$\frac{32.07 \text{ g S}}{120.38 \text{ g MgSO}_4} = \frac{x_2}{0.37 \text{ g MgSO}_4}$$

$$x_2 = 0.098 \text{ g S}$$

$$x_1 + x_2 = 1.388 \geq 0.15 \text{ g S}$$

I chose the compound $(\text{NH}_4)_2\text{SO}_4$, MgSO_4 , and KH_2PO_4 because all compound contain S, Mg, N, and P in it. Also, the reason I chose these compounds because all these elements are all going into the cell.

$$\begin{array}{r} 1-15 \\ 2-44 \\ \hline 59 \end{array}$$

2. a) four difference between DNA and RNA

①

- | | |
|---|---|
| - DNA is found in nucleus, with a small amount of DNA also present in mitochondria | - RNA is form in nucleus, and move it to specialized region to the ribosome and cytoplasm depending on type of RNA formed |
| - DNA has five carbon sugar (deoxyribose) sugar. It replicates on it own. It's self-replicating | - The sugar of RNA is ribose sugar. It does not replicate on it own but synthesized of DNA required |
| - DNA is replicating the genetic information. It's blue print of all genetic information contain within an organism | - RNA is converted genetic information contain within DNA to format that use to build protein, and move it to ribosomal protein factories |
| - DNA is double helix that has long chain of nucleotide | - RNA is single <u>helix</u> that has a short chain of nucleotide |

② each strand of DNA molecules has double helix that has a long chain of nucleotide, and it has anti-parallel strands of 3' to 5' and 5' to 3'

- The nucleotide of DNA is consist of five carbon sugar (deoxyribose) with attached to phosphate group and nitrogenous base, such as two purine (Adenine and Guanine) and two pyrimidine (Cytosine and Thymine)

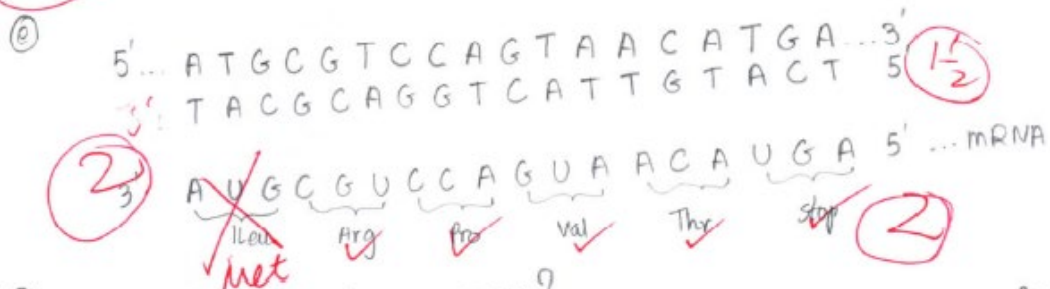
③ The nucleotide are joined together by covalent bonding between the phosphate of one nucleotide and sugar of the next, forming the phosphate-sugar backbone contain within nitrogenous base protude.

- one strand is held together by hydrogen bonding with specific base like Cytosine pair only with Guanine and Adenine pair only with the Thymine.

④ (ii) gene mutation is the change of the nucleotide (bases) the sequence of gene.

③ Therefore, mutation is occurred when there is a change in the sequence triplet codon, This is regardless whether it is change in observable change in characteristic (phenotype) of an organism

- (i). A gene can be defined as the heritable segment sequence of DNA (2)
 Compose of specific sequence of the base, such as purine and pyrimidine,
 which in turn determined, by the transcription, the sequence of base in
 RNA molecules. by the subsequent process of translation, the sequence
 (3) of base in RNA molecules specified the sequence of amino acid that
 incorporated into the polypeptide chain.
 - A gene, therefore, is a segment of DNA whose bases of Purine and
 Pyrimidine the sequence code of the sequence amino acid and polypeptide



(f) (i) what is restriction enzymes?

(2 1/2) They are enzymes that cleave a genetic sequence at a specific or
 desired selection along the molecules. There are two group base type of
 cut, such as cuts with sticky end and blunt end. It also refers as
 restriction enzymes specific the sequence base of four basic chemical
 subunit of linear two strand of DNA

(ii) what are plasmids?

(3)

There is a small molecules that distinct from cell's chromosomal DNA. It naturally exists in the bacterial cells and occur in some of eukaryotes. The gene carried in plasmid often provide bacteria with genetic advantage, such as Antibiotic resistance

- It's also double-strands covalently close and circular molecules DNA carrying

② a gene that might exist outside of the chromosome, and it replicates independently chromosome. It can serve as vehical for introducing and propagating foreign DNA in microbe

- plasmid can integrate to the host cell's chromosome, describing as have the episomal function. It's generally dispensable to the cell. It may lose it due to the replicate during the cell division or during interruption of their replication by chemical or physical agents.

(iii) what are monoclonal antibodies?

They are antibodies that rise of a single cell of clone. it can derived it as the clone of single B cell that produce a large of quantities

② identical cell processing with an affinity the same as epitope of specific antigen

- monoclonal antibodies are typically use in immunotherapy, such as autoimmune or cancer. It's also used in the diagnostic test or cell identification

(iv) what is the polymerase chain reaction (PCR)

It is the techniques that use to make numerous copies of the specific segment of DNA quickly and accurately. It is also use to amplify the desired

② DNA processing in vitro which mean the test is conducted outside of an organism.

- the process consist of 3 type:

① Denaturation: this process is done by heating the start material to separate two strand of DNA to single strand.

⑤. Priming: when the temperature is lowered enable DNA primer (annealing) ④
to template of DNA

⑥ Extension: when the temperature is risen, the new strand is made by
the lag polymerase enzymes.

3-1 a) why ATP is important compound?

ATP plays a critical role in maintaining the cell's structure by facilitating the assembly cytoskeletal compound. ATP and its hydrolysis product are stable in the water at physiological pH. ΔG of ATP is large enough that release a fair amount of free energy of couple metabolism reaction. Also, ΔG of ATP hydrolysis is small enough that can be reversed the energy to the ATP

⑦ There are different way that can produce ATP. The main source energy of cellular metabolism is glucose. There are three process of producing ATP, such as glycolysis, tricarboxylic acid cycle, and oxidative phosphorylation. First, when glucose is converted to the pyruvate, the amount of ATP is low. Then, the pyruvate is converted to the acetyl coenzyme A (acetyl CoA), and entering to the TCA cycle to produce NADH. After that, NADH will generate the proton to inner mitochondria membrane. This is important for produce a large amount of ATP

⑧ intermediate missing is pyruvate

⑨ Pathway A and B is glycolysis and oxidation

⑩ name all the pathway D and C are acetyl CoA and acetaldehyde,

AVERAGE

Average Student Original Graded Assignment

CHEMICAL ENGINEERING DEPARTMENT
INTRODUCTION TO BIOTECHNOLOGY CHEG 3315
COURSE ASSIGNMENT GRADING AND OUTCOME ASSESSMENT
SHEET FOR SPRING 2022 SEMESTER

STUDENT OUTCOME: Ability to apply the knowledge of mathematics, science, and engineering.

Assignments that test competency in this area will include problems that test a student's ability to apply knowledge of and (1) solve algebraic, integral and differential equations analytically or numerically, and (2) apply knowledge of chemistry and biology in engineering.

STUDENT OUTCOME: Ability to identify, formulate, and solve engineering problems.

Assignments that test competency in this area will include problems that test a student's ability to (1) apply systematic problem solving methodology that includes identifying all known and unknown variables, (2) construction of reasonable schematic representation of the problem, listing appropriate assumptions, determining appropriate property values, (3) applying the appropriate conservation laws, physical and chemical laws, and mathematics to solve the problem, and (4) evaluating the reasonableness of the computed results.

Name: KAYLON ATKINSON

Title of Assignment: Final Exam Due Date: MAY 11, 2022

Description of Performance Criteria Being Assessed	Max for this Assignment	Your Score
Ability to apply knowledge of science in engineering. <i>The assignment tests students' competency in their ability to apply chemistry and biology in biotechnology</i>	70	60
Ability to identify engineering problems. <i>The problem tests the students ability to (i) understand the given problem and identify the subject area and concepts involved, (ii) convert the problem into a well labeled sketch, and (iii) identify the system of units applicable to the problem</i>		
Ability to formulate engineering problems. <i>The problem tests the students ability to (i) define the known and unknown variables, (ii) state relevant laws and equations needed to solve the problem, and (iii) list and apply any assumptions to the relevant laws and equations to obtain equation specific to the problem.</i>	30	20
Ability to solve engineering problems. <i>The problem tests the students ability to (i) implement a strategy to solve the engineering problem, (ii) solve the problem showing consistent units throughout, and (iii) evaluating and interpreting the result.</i>		
TOTAL	100	80

KATION ATKINSON

① glucose = $30 \text{ g/L} \times 0.5 \text{ g/L} = 15 \text{ g/L}$ glucose (new mold)

Nitrogen source

$(\text{NH}_4)_2\text{SO}_4 = 132 \text{ g/mol}$

$\frac{x}{15 \text{ g/L}} = \frac{7.5 \text{ g/L N}}{100 \text{ g/L}} \rightarrow \frac{1.125 \text{ g N}}{x} = \frac{28 \text{ g/mol}}{132 \text{ g/mol } (\text{NH}_4)_2\text{SO}_4} \rightarrow 5.3 \text{ g } (\text{NH}_4)_2\text{SO}_4$

Mg Source

$\text{MgSO}_4 = 120 \text{ g/mol}$

$\frac{x}{15 \text{ g/L}} = \frac{0.5 \text{ g/L Mg}}{100 \text{ g/L}} \rightarrow \frac{0.075 \text{ g Mg}}{x} = \frac{24 \text{ g/mol Mg}}{120 \text{ g/mol } (\text{MgSO}_4)} \rightarrow 0.38 \text{ g } \text{MgSO}_4$

Sulfur sources

$(\text{NH}_4)_2\text{SO}_4$

$\frac{x}{5.3 \text{ g } (\text{NH}_4)_2\text{SO}_4} = \frac{32 \text{ g/mol S}}{132 \text{ g/mol}} \rightarrow 1.28 \text{ g S}$

MgSO_4

$\frac{x}{0.38 \text{ g } \text{MgSO}_4} = \frac{32 \text{ g/mol S}}{120 \text{ g/mol}} \rightarrow 0.10 \text{ g S}$

P source

$\text{KH}_2\text{PO}_4 = 136 \text{ g/mol}$

$\frac{x}{15 \text{ g/L}} = \frac{1.5 \text{ g/L P}}{100 \text{ g/L}} \rightarrow \frac{0.225 \text{ g P}}{x} = \frac{31 \text{ g/mol P}}{136 \text{ g/mol } \text{KH}_2\text{PO}_4} \rightarrow 0.99 \text{ g } \text{KH}_2\text{PO}_4$

② DNA: A double stranded helix polynucleotide, 5 carbon deoxyribose sugar, contains the base Thymine that pairs with the base Adenine through hydrogen bonding, and contains the genetic information to form new cells and organisms.

RNA: A single stranded polynucleotide, 5 carbon ribose sugar, contains the base Uracil instead of Thymine, and sends information to ribosomes to make proteins.

b) DNA contains a base, sugar, and a phosphate group. The bases are either Adenine, Thymine, Cytosine, and Guanine. Adenine pairs with Thymine and Cytosine with Guanine to form the double helix structure through hydrogen bonding. The sugar is a 5 carbon deoxyribose sugar with an OH missing on the 3' carbon. DNA has a sugar phosphate backbone structure.

c) i) What is a gene? A gene is a segment of DNA whose base sequence codes for the sequence of amino acids in a polypeptide chain. (3)

c) ii) What is gene mutation? Gene mutation is when there is a change or alteration in the nucleotide sequence. This can occur through the insertion of an extra base, substituting one base for another, or deleting a base from the sequence. (3)

d) 5' TCAACCTGTTACTGGACGCAT 3' (2)
3' AGTTGGACAATGACCTGCGTAS

e) 5'...ATGCGTCCAGTAACATGA...3' (2)

i) 3'...TACGCAAGTCATTGTACT...5'

ii) 5'...AUGCGUCCAGUAACAUGA...3' (5)

iii) (2) Met Arg Pro Val Thr stop

f) i) Restriction enzymes are enzymes that cleave/split/divide genes from a DNA sequence to insert it to a plasmid through sticky ends. (12)



ii) Plasmids are genetic structures in a cell that can replicate. They are small circular strands of DNA from the cytoplasm. (12)

iii) Monoclonal antibodies are genes formed in a lab that are made to fight against/revist harmful things in the body. Mainly used for the immune system. (1)

iv) Polymerase Chain Reaction (PCR) is used to replicate strands of DNA to make a small batch that scientists can use to test and prepare a larger batch from. This process occurs by using heat to denature the double stranded DNA to open it up. Then Annealing where a primer comes and is placed where the replication needs to begin in the DNA sequence. Lastly is DNA synthesis/extension where DNA polymerase comes in and starts adding the corresponding bases needed to be paired with the original DNA strand, creating it from a 5' to 3' sequence. (1)

③ a) ATP is important because it is the energy currency of the cell and is stable in H_2O with a pH of 7.

b) Cells can produce ATP through the Emp pathway/glycolysis and the Citric Acid Cycle (CAC).

c) Pyruvate ①

d) A: Emp pathway / glycolysis ③

B: Citric Acid Cycle (CAC) Krebs ③

e) C: ATP, ADP, NADP, NADPH

D: ATP, NADH, NAD⁺, FADH, FAD⁺

BELOW AVERAGE

Below Average Student Original Graded Assignment

**CHEMICAL ENGINEERING DEPARTMENT
INTRODUCTION TO BIOTECHNOLOGY CHEG 3315
COURSE ASSIGNMENT GRADING AND OUTCOME ASSESSMENT
SHEET FOR SPRING 2022 SEMESTER**

STUDENT OUTCOME: Ability to apply the knowledge of mathematics, science, and engineering.

Assignments that test competency in this area will include problems that test a student's ability to apply knowledge of and (1) solve algebraic, integral and differential equations analytically or numerically, and (2) apply knowledge of chemistry and biology in engineering.

STUDENT OUTCOME: Ability to identify, formulate, and solve engineering problems.

Assignments that test competency in this area will include problems that test a student's ability to (1) apply systematic problem solving methodology that includes identifying all known and unknown variables, (2) construction of reasonable schematic representation of the problem, listing appropriate assumptions, determining appropriate property values, (3) applying the appropriate conservation laws, physical and chemical laws, and mathematics to solve the problem, and (4) evaluating the reasonableness of the computed results.

Name: Ezra Nequia Tatmon

Title of Assignment: Final Due Date: May 11th

Description of Performance Criteria Being Assessed	Max for this Assignment	Your Score
Ability to apply knowledge of science in engineering. <i>The assignment tests students' competency in their ability to apply chemistry and biology in biotechnology</i>	70	55
Ability to identify engineering problems. <i>The problem tests the students ability to (i) understand the given problem and identify the subject area and concepts involved, (ii) convert the problem into a well labeled sketch, and (iii) identify the system of units applicable to the problem</i>		
Ability to formulate engineering problems. <i>The problem tests the students ability to (i) define the known and unknown variables, (ii) state relevant laws and equations needed to solve the problem, and (iii) list and apply any assumptions to the relevant laws and equations to obtain equation specific to the problem.</i>	30	15
Ability to solve engineering problems. <i>The problem tests the students ability to (i) implement a strategy to solve the engineering problem, (ii) solve the problem showing consistent units throughout, and (iii) evaluating and interpreting the result.</i>		
TOTAL	100	70

1) $(\text{NH}_4)_2\text{SO}_4 = 132 \text{ g/mol}$

$$\frac{x}{30 \text{ g/L}} = \frac{7.5 \text{ g N}}{100 \text{ g/L}} \Rightarrow \frac{4.5 \text{ g N}}{x} = \frac{28.0 \text{ g/mol of N}}{132 \text{ g } (\text{NH}_4)_2\text{SO}_4} = 21.2 \text{ g of N}$$

$\text{MgSO}_4 = 120 \text{ g/mol}$

$$\frac{x}{30 \text{ g/L}} = \frac{0.5 \text{ g Mg}}{100 \text{ g/L}} = \frac{0.3 \text{ g Mg}}{x} = \frac{24.31 \text{ g/mol of Mg}}{120 \text{ g/mol } \text{MgSO}_4} = 1.48 \text{ g of Mg}$$

$(\text{NH}_4)_2\text{SO}_4 = 132 \text{ g/mol}$

$$\frac{x}{30 \text{ g/L}} = \frac{1 \text{ g S}}{100 \text{ g/L}} = \frac{0.6 \text{ g S}}{x} = \frac{32.07 \text{ g/mol of S}}{132 \text{ g/mol } (\text{NH}_4)_2\text{SO}_4} = 2.46 \text{ g of S}$$

$\text{MgSO}_4 = 120 \text{ g/mol}$

$$\frac{x}{30 \text{ g/L}} = \frac{1 \text{ g S}}{100 \text{ g/L}} = \frac{0.6 \text{ g S}}{x} = \frac{32.07 \text{ g/mol of S}}{120 \text{ g/mol } \text{MgSO}_4} = 2.24 \text{ g of S}$$

$\text{KH}_2\text{PO}_4 = 136 \text{ g/mol}$

$$\frac{x}{30 \text{ g/L}} = \frac{1.5 \text{ g K}}{100 \text{ g/L}} = \frac{0.9 \text{ g K}}{x} = \frac{39.1 \text{ g/mol of K}}{136 \text{ g/mol } \text{KH}_2\text{PO}_4} = 3.13 \text{ g of K}$$

Assume 100 g/L for % dry cell weight
given 30 g/L yeast = 40 g/L glucose

2) a) DNA vs RNA

DNA:

- double strand helix (1)
- Polynucleotide (1)
- 5 carbon deoxyribose sugar (1)
- Adenine pair w/ base Thymine (1)
- Cytosine w/ base Guanine (1)
- genetic information to make new cells (1)

RNA:

- single strand helix (1)
- polynucleotide (1)
- 5 carbon ribose sugar (1)
- has uracil not Thymine (1)
- Transfer genetic code from nucleus to ribosome to make proteins

b)

c) i) gene: a segment of DNA whose base sequence codes for what? (1 1/2)

ii) gene mutation: change in the nucleotide sequence of a gene (3)

d) 5' TCACCTGTTACTGACGAT 3'
3' AGTTGGACAAATGACCTGCGTA 5' (2)

e) 5' ATGCGTCCAGTAACATGA 3'
i) 3' TACGCAAGTCATTGTA 5'
ii) 3' UACGCAAGUCAUUAUACU 5' X

iii) Seralaglyhis cyst thr

$$\begin{array}{c} \text{OH} \\ | \\ \text{CH}_2 \\ | \\ \text{H}_3\text{N} - \text{C} - \text{COO}^- \\ | \\ \text{H} \end{array}$$

f)

i) restriction enzymes:

- A protein that is isolated from bacteria and splits into fragments

ii) monoclonal antibodies:

- lab produced molecules that act as substituted antibodies that can restore and enhance the immune system

iii) plasmids:

- genetic structures in cells that can replicate
- a small circular DNA strand in the cytoplasm

iv) PCR:

- It's the denaturation, annealing, and elongation of cells.

3)

a) ATP is so important because it produces energy currency.

b) Cells can produce ATP by aerobic and anaerobic methods.

c) Name in box: Pyruvate

d) A: U-phosphate

B:

e) C: $\text{NADH} + \text{H}^+ \rightarrow \text{NAD}^+$

D: NADH
 NAD^+