MULTIPLE CHOICE QUESTIONS FOR CHEMICAL ENGINEERING COURSES

By:

MUSAIDA MERCY MANYUCHI

Department of Chemical and Process Systems Engineering

Harare Institute of Technology

To: Celine, Danielle, Ethan and Sean

CONTENTS

PREFACE

This book gives multiple choice questions for selected courses in Chemical Engineering. The multiple choice questions are intended for students at both undergraduate and graduate levels to help improve their knowledge and zeal in the Chemical Engineering field. The courses include Mass Transfer, Heat Transfer, Separation Processes, Chemical Technology, Environment Engineering Principles, Chemical Engineering Reactors and Kinetics, Bioprocess Engineering Principles, Plant Equipment and Process Design, Chemical Engineering Economics as well as Process Simulation, Synthesis and Optimization. Research Methodology and Statistical Design and Analyses of Experiments were also included as preliminary courses as they are essential and applied to all Chemical Engineering Courses. The courses objectives, descriptions and content were given and the multiple choice questions are also given.

Musaida Mercy Manyuchi

Department of Chemical and Process Systems Engineering

Harare Institute of Technology

CHAPTER 1: RESEARCH METHODOLOGY

1.1 Course Objectives

By the end of this course students should be able to understand concepts of research and its methodologies, identify suitable research topics, state suitable research problem and its variables, write a research proposal, organize and conduct research and finally write a research paper or thesis.

1.2 Course Description

Research methodology is a through process of obtained data, information and evidence (*www.ihmctan.edu/PDF/notes/Research_Methodology.pdf)*. This process involves identification of the need for research, formulating the research problem and carrying out the research. In addition, it explains on how to prepare a quality research report or thesis.

1.3 Course Content

The course content includes research and research methodologies overview, literature review, research problem formulation, conducting the research, report and thesis writing and lastly referencing.

1.4 Multiple Choice Questions

1. Research methodology is defined as:
   A. A set of abstracts
   B. Aspects of implementation of the method
   C. Procedures for gathering information
2. The two types of research data are:
   A. Primary and secondary
   B. Quantitative and qualitative
   C. Predictive and quantitative
3. The aim of the study is presented in the:
   A. Introduction
   B. Methodology
   C. Literature Review
4. A variable that is controlled by researchers is:
   A. Independent variable
   B. Dependent variable
   C. Experimental variable
5. Quantitative research is a measure of:
   A. Feelings and numbers
   B. Numbers and opinions
   C. Numbers and figures
6. Selection of a certain number of population for a study is called:
   A. Sampling
   B. Survey research
   C. Quantitative research

7. A critical literature review:

   A. Identifies strengths and limitations of previous research

   B. Identifies weaknesses of previous research

   C. Summarizes information from previous research

8. Critical analyses of qualitative research is useful for assessing:

   A. Literature review

   B. Methodology

   C. Analysis of experimental data

9. The population which is selected for a research study is:

   A. Total population

   B. Target population

   C. Random population

10. The surname of the first author followed by et al. is only used when the authors are more than:

   A. 3

   B. 4

   C. 6

1.5 Bibliography

Books

Kumar, Ranjit. *Research Methodology: A Step by Step for Beginners*. Second Edition, SAGE Publications. London 2005.

Journal Articles

Case, J. M. and Light. G., *"Emerging Methodologies in Engineering Education Research"*, Journal of Engineering Education, 100 (1), pp. 186–210, January 2011.

Borrego, M., Douglas, E. P. and Amelink, C.T., *"Quantitative, Qualitative, and Mixed Research Method",* Engineering Education, 53-66, 2009.

Websites

www.ihmctan.edu/PDF/notes/Research_Methodology.pdf

file:///C:/Users/MMANYUCHI/Desktop/AIU/Phase%202/Curriculum%20Proposal/Research%20methods/chapter2.asp.htm

http://www.socialresearchmethods.net/kb/datatype.php

CHAPTER 2: STATISTICAL DESIGN AND ANALYSES OF EXPERIMENTS

2.1 Course Objectives

By the end of this course students should be able to design experiments, perform statistical analyses on experimental data and use software packages such as R and STATISTICA for experimental data analyses.

2.2 Course Description

Statistical Design and Analyses of experiments focuses on the experimental design and statistical analyses of gathered information and data. The course critically looks at design of experiments, data visualization, descriptive statistics and test of hypotheses.

2.3 Course Content

The course content includes aim for experimentation, experimentation techniques, experiments design, factorial designs, experimental design evaluation using statistical analyses software, experimental data summary and hypothesis testing.

2.4 Multiple Choice Questions

1. The ANOVA procedure determines whether the:

   A. Averages of two samples are equal

   B. Averages of more than two samples are equal

   C. Averages of two populations are equal

2. When analyzing variance, if SST = 60, SSTR = 40, then SSE =

   A. 20

   B. 40

   C. 60

3. In ANOVA, a factor is defined as the:

   A. Dependent variable

   B. Independent variable

   C. Both

4. During experimental design, a variable is defined as:

   A. Treatment

   B. Factor

   C. Variance

5. In factorial designs, the number of times a condition is noted is called:

   A. Randomization

   B. Factorization

   C. Replication

6. Scatter diagrams show the relationship between:

   A. Two variables

   B. The dependent variable along the y axis

   C. The dependent variable along the x axis

7. Correlation analysis enables the understanding of:

   A. Different variables

   B. The strength of association between two variables

   C. The strength of association between the intercept and the x-axis

8. From the least squares regression analysis equation: Y = 7.1 + 3.4X:

   A. The dependent variable increases by 6.8 after an increase of 2 in X

   B. The Y intercept lies at 7.1

   C. Both A and B are true

9. Calculate the mean for the following SO_2 particulates being emitted into the environment: 2ppm, 5ppm, 7ppm and 9ppm.

   A. 6.75

   B. 5.75

   C. 6.25

10. In hypotheses testing, the p value is a:

   A. Parameter in the null hypothesis

   B. Value less than the significance level

   C. Probability

2.5 Bibliography

Books

Navidi, William. *Statistics for Engineers and Scientists*. Second Edition, McGraw Hill. USA, 2005.

Journal Articles

Collins, L. M.; Dziak, J J.; Runze, L., "*Design of experiments with multiple independent variables: A resource management perspective on complete and reduced factorial designs"*, Psychological Methods, 14 (3), 202-224., doi: 10.1037/a0015826, Sep 2009.

Knight, K. L., *"Study/Experimental/Research Design: Much More Than Statistics"*, Journal of Athletic Training, 98–100, Jan-Feb; 45 (1), 2010.

Websites

http://bloguna.tolafghan.com/assets/documents/24/587/Experimental_Designs_English.pdf

http://www4.ncsu.edu/~fisik/WPS%20415%20Lecture%20Notes.pdf

CHAPTER 3: MASS TRANSFER

3.1 Course Objectives

By the end of this course students should be able to understand fundamentals of mass transfer, carry out mass and energy balances, explain interphase mass transfer theories, apply empirical and theoretical concepts in designing mass transfer operations, carry out preliminary design of absorption and stripping equipment and finally carry out preliminary design of humidifying and drying equipment

3.2 Course Description

Mass transfer is a course that is designed to give information about the net movement of mass from one point to another. The movement involves processes gas-liquid, liquid-liquid and fluid-solid mass transfers. This makes the knowledge about diffusion coefficients and mass transfer coefficients in various mass transfer equipment's such as distillation columns, absorption towers, cooling towers and driers important

3.3 Course Content

The course content include the introduction to mass transfer, diffusion coefficients, mass transfer coefficients and mass transfer unit operations.

3.4 Multiple Choice Questions

1. The mass transfer rate is independent of :
   A. Turbulence effect
   B. Physical properties
   C. Chemical properties
2. According to the two film theory, the diffusion coefficient and the mass transfer coefficient are:
   A. Direct proportionally related to each other
   B. Inverse proportionally related to each other
   C. Not related to each other
3. Fick's law of diffusion is determined by:
   A. Concentration gradient
   B. Diffusing components characteristics
   C. Both A and B
4. Efficiency during distillation is measured by:

A. Actual plates/Ideal plates

B. Ideal plates/Actual plates

C. Reflux ratio

5. The design of a drier is not affected by:
   A. Temperature
   B. Diffusion
   C. Air velocity
6. The absorption factor in terms of the solvent flow rate, S, and the gas flow rate, G, is optimized by:
   A. Increasing S and decreasing G
   B. Increasing both S and G
   C. Decreasing both S and G

7. During the cooling process, the following parameter is a variable:

   A. Vapor partial pressure

   B. Specific humidity

   C. Temperature

8. Carbon dioxide is physically removed from a system through:

   A. Adsorption

   B. Absorption

   C. Ion exchange

9. The leaching efficiency ---------with increase in temperature

   A. Decreases

   B. Increases

   C. Remains constant

10. The SI units for diffusivity are:

   A. cm^2/s

   B. cm/s

   C. cm/s^2

3.5 Bibliography

Books

Robert. E. *Mass Transfer Operations*. Third Edition. McGraw-Hill. 1980.

Journal Articles

Hukka, A., *"The Effective Diffusion Coefficient and Mass Transfer Coefficient of Nordic Softwoods as Calculated from Direct Drying Experiments"*, Holzforschung. 53 (5), 534–540, ISSN (Print) 0018-3830, DOI: 10.1515/HF.1999.088, June 2005.

Montoya, A., Mondragó F. and Truong, T. N., *"CO_2 adsorption on carbonaceous surfaces: a combined experimental and theoretical study"*, Carbon 41, 29–39, 2003.

Websites

http://www.che.iitb.ac.in/courses/uglab/manuals/coollabmanual.pdf

http://www.powerplantccs.com/ref/glos/physical_absorption.html

CHAPTER 4: HEAT TRANSFER

4.1 Course Objectives

By the end of this course students should be able to understand fundamentals of heat transfer, explain the mechanisms involved in conduction, convection and radiation heat transfer methods, Identify heat transfer equipment, understand the importance of heat transfer equipment and design heat exchangers

4.2 Course Description

This course aims to enable students to design analytical and design skills in the area of heat transfer. Students will gain an understanding in the three methods of heat transfer which are conduction, convection and radiation. In addition, they will be able to identify heat transfer equipment such as heat exchangers, evaporators and condensers as well as their design.

4.3 Course Content

The course content includes the Introduction to heat transfer, heat transfer by conduction, heat transfer by convection, heat transfer by convection and heat transfer equipment.

4.4 Multiple Choice Questions

1. Which of the following is not a property of heat waves:

   A. Ability to travel in a straight line

   B. Ability to be reflected in a mirror

   C. Ability to pass through a vacuum

2. -------are not considered as opaque surfaces in radiation.

   A. Gases

   B. Liquids

   C. Solids

3. Black surfaces are good for-------heat transfer.

   A. Conduction

   B. Radiation

   C. Convection

4. Fourier's law explains heat transfer due to:

   A. Convection

   B. Conduction

   C. Radiation

5. Convective heat transfer normally occurs in:

   A. Gases

   B. Liquids

   C. Fluids

6. The fouling factor

   A. Is a dimensionless number

   B. Is a safety factor

   C. Accounts for all resistances due to heat transfer

7. Kirchhoff's law is used in --------radiation.

   A. Alpha

   B. Total

   C. Gamma

8. The units for the log mean temperature difference are:

   A. ◦C

   B. 1/◦C

   C. Dimensionless

9. Thermal conductivity of a given liquid dependent on:

   A. Viscosity

   B. Temperature

   C. Pressure

10. The evaporator economy is dependent on the:

   A. Mass transfer rate

   B. Heat transfer rate

   C. Energy balance considerations

4.5 Bibliography

Books

Incropera, Frank. P DeWitt, David. P *Fundamentals of Heat and Mass Transfer*. Sixth Edition, John Wiley and Sons. 2007.

Journal Articles

Erdoğdu, F., Uyar, R. T., and Palazoğlu, K., *"Experimental Comparison of Natural Convection and Conduction Heat Transfer",* Journal of Food Process Engineering, DOI:10.1111/j.1745-4530.2008.00309.x, 17 JUL 2009.

Kaya, A., *"Effects of Conjugate Heat Transfer on Steady MHD Mixed Convective Heat Transfer Flow over a Thin Vertical Plate Embedded in a Porous Medium with High Porosity"*, Mathematical Problems in Engineering, doi:10.1155/2012/261871, 2012.

Websites

http://galileo.phys.virginia.edu/classes/152.mf1i.spring02/HeatTransport.pdf

http://www.powersleuth.org/docs/EHM%20Lesson%205%20FT.pdf

CHAPTER 5: SEPARATION PROCESSES

5.1 Course Objectives

By the end of this course students should be able to understand the theory behind separation processes, familiarize with separation processes equipment, describe chemical engineering separation processes and use mass and heat transfer concepts in separation processes.

5.2 Course Description

Separation processes allows the conversion of mixtures to distinct products without chemical reactions involved in process industries. The major separation processes involved include: evaporation, crystallization, filtration, chromatography and membrane processes.

5.3 Course Content

The course content includes the introduction to separation processes, techniques for evaporation, crystallization, filtration, chromatography and membrane processes.

5.4 Multiple Choice Questions

1. Substances that are mixed together but are not chemically combined are called are called a…….

   A. Mixture

   B. Solution

   C. Solute

2. ----------is a mixture.

   A. Water

   B. Salt

   C. Seawater

3. The following substances can be separated by distillation:

   A. Salt and water

   B. Methanol and water

   C. Sand and water

4. The process used to obtain the solute from the solution is called:

   A. Evaporation

   B. Distillation

   C. Condensation

5. A/An------is used to separate two liquids that cannot mix.

   A. Condenser

   B. Evaporator

   C. Separating funnel

6. Immiscible liquids:

   A. Are flammable

   B. Do not mix

   C. Are volatile

7. ------cannot separate a liquid from an insoluble solid.

   A. Chromatography

   B. Decanting

   C. Drying

8. Sugar cane crystals form from the concentrated sugar cane solution through a process called:

   A. Distillation

   B. Crystallization

   C. Chromatography

9. The process of separating solid-solid components is called:

   A. Evaporation

   B. Filtration

   C. Dissolution

10. Residue is the term given to the solid obtained from:

   A. Crystallization

   B. Filtration

   C. Chromatography

5.5 Bibliography

Books

Seader, J. D. Henley, Ernest. J. *Separation Processes Principles*. Second Edition. John Wiley and Sons. 2006

Journal Articles

Andreu, J. S., Barbero, P., Camacho, J. and Faraudo, J., *"Simulation of Magnetophoretic Separation Processes in Dispersions of Super paramagnetic Nanoparticles in the Noncooperative Regime,"* Journal of Nanomaterials, doi:10.1155/2012/678581, 2012.

Palit. *S., "A Brief Insight into the Science of Nanofiltration and Membrane Separation Processes"*, International Journal of Chemical and Analytical Science, 3 (5), 2012.

Websites

http://www.apv.com/pdf/catalogs/Evaporator_Handbook_10003_01_08_2008_US.pdfht

http://www.whiting-equip.com/media/swenson_crystallization.pdf

CHAPTER 6: CHEMICAL TECHNOLOGY

6.1 Course Objectives

By the end of this course students should be able to understand problems of chemical industries, appreciate that heat and mass transfer processes are fundamental in chemical technology, name raw materials used in chemical industries, explain the production process of given products, identify unit operations in the processes and explain the principle of operation of equipment used.

6.2 Course Description

Chemical Technology deals with the conversion of raw materials into given products and the chemical processes involved. The course aims at selected industries such as fermentation, soaps and detergents, sugar and starch, oils and fats, wastewater purification and the fertilizer industries. In addition, it focuses on the unit operations involved in these industries and the equipment used.

6.3 Course Content

The course content includes the introduction to chemical technology, fermentation industries, soaps and detergents, sugar and starch industries, oils and fats industries, water and wastewater purification processes and fertilizer industries.

6.4 Multiple Choice Questions

1. The working volume of a fermenter should be within------of the fermenter capacity:
   A. 3/5
   B. 3/4
   C. 4/5
2. -------is not produced during fermentation.
   A. O_2
   B. CO_2
   C. Ethanol
3. Lye which is used in soap making is a concentrated solution of:
   A. NaCl
   B. $CaCO_3$
   C. NaOH
4. Detergents are good for use as cleaning agents in hard water because:
   A. They do not precipitate
   B. They do not contain sodium
   C. They are greasy
5. The ratio of hydrogen to oxygen molecules in carbohydrates is:
   A. 1:1
   B. 2:1
   C. 1:2
6. -------is an example of a polysaccharide.
   A. Glucose
   B. Maltose
   C. Amylose

7. Proteins are made up of:

   A. Nucleotides

   B. Amino acids

   C. Fatty acids

8. Unsaturated fats are/have:

   A. Liquids at room temperature

   B. Solids at room temperature

   C. Double bonds between the carbon atoms

9. -------determines the efficiency of an aerobic bio digester.

   A. Temperature

   B. pH

   C. BOD

10. Commercial fertilizers are available in the form of:

   A. Granules

   B. Lumps

   C. Powder

6.5 Bibliography

Books

Uppal, M. M. Bhatia S.C. *Engineering Chemistry (Chemical Technology)*. Seventh Edition, Khana Publishers. 2008.

Journal Articles

Anbessa, Y. and Juskiw, P., *"Nitrogen Fertilizer Rate and Cultivar Interaction Effects on Nitrogen Recovery, Utilization Efficiency, and Agronomic Performance of Spring Barley",* ISRN Agronomy, doi:10.5402/2012/531647, 2012.

Oke, M. O. and Bolarinwa, I. F., *"Effect of Fermentation on Physicochemical Properties and Oxalate Content of Cocoyam (Colocasia esculenta) Flour,"* ISRN Agronomy, doi:10.5402/2012/978709, 2012.

Websites

http://scifun.chem.wisc.edu/chemweek/pdf/fats&oils.pdf

http://www.safewater.org/PDFS/resourcesknowthefacts/WastewaterTreatment.pdf

CHAPTER 7: ENVIRONMENTAL ENGINEERING PRINCIPLES

7.1 Course Objectives

By the end of this course students should be able to examine and discuss concept of ecosystems, describe the concept of ecosystems, describe the impact of human activities on the human mind, understand the environment legislature as well as Identify and explain causes of air, land and water pollution in chemical industries.

7.2 Course Description

This course aims to use basic engineering, chemistry and microbiology in protecting the environment. It focuses on hydrology, waste water systems, hazardous waste and risk assessment. In addition, the course also focuses on air pollution origins and their control as well as the air quality and global atmosphere variation.

7.3 Course Content

The course content includes environmental engineering chemistry, water resources and water pollution, water transport, contamination and remediation, municipal water and wastewater systems, hazardous waste and risk assessment, air pollution origins and control as well as interior air quality and global atmosphere variation.

7.4 Multiple Choice Questions

1. -----is the study of the relationship between plants and animals.

   A. Morphology

   B. Ecology

   C. Hydrology

2. The total organic matter available in an ecosystem is called:

   A. Flora

   B. Fauna

   C. Biomass

3. ------causes the depletion of the ozone layer.

   A. NO_2

   B. SO_2

   C. Chlorofloro carbon

4. Acid rain mainly occurs due to which pollutants?

   A. SO_2

   B. NO_2

   C. SO_2 and NO_2

5. Water pollution is mainly caused by:

   A. Sewage water

   B. Precipitation

   C. Rain water

6. Green house effects are mainly caused by:

A. SO_2

B. NO_2

C. CO_2

7. -------is a waterborne disease.

A. Typhoid

B. Headache

C. Malaria

8. The World Environment Day is celebrated on which day?

A. 22 April

B. 13 May

C. 5 June

9. Water is covered with ------water.

A. 71

B. 75

C. 85

10. Deforestation is caused by:

A. Green house effects

B. Cutting trees

C. Disrupting the ecosystem

7.5 Bibliography

Books

Davis, Mackenzie. L. Cornwell, David. A. *Introduction to Environmental Engineering*. Fourth Edition. McGraw-Hill. USA, 2006.

Journal Articles

Jacobson, M. Z., *"Review of solutions to global warming, air pollution, and energy security"*, Energy and Environmental Science, DOI: 10.1039/b809990c, 2008.

Vogel, R.M, Sieber, J., Archfield, S. A., Smith, M. P., Apse, C. D and Huber-Lee, A., *"Relations among storage, yield, and instream flow",* Water Resources Research, 43, W05403, doi:10.1029/2006WR005226, 2007.

Websites

http://www.careercornerstone.org/pdf/env/enveng.pdf

http://bieap.gov.in/Environmentalengg.pdf

CHAPTER 8: CHEMICAL ENGINEERING REACTORS AND KINETICS

8.1 Course Objectives

By the end of this course students should be able to understand the basic concepts in using rate equations and kinetic constants, derive rate equations for homogeneous and heterogeneous catalytic systems, perform material and energy balances on reactors, derive design equations for continuous, batch and plug flow reactors, establish the influence of temperature and pressure on reversible and irreversible reactions as well as understand reactor stability and reactor performance.

8.2 Course Description

The course aims to develop a basic understanding of the application principles in heat and mass transfer and chemical kinetics to the design of chemical reactors. The course focuses on Chemical Reaction Engineering Principles, Rate Laws, Catalysis and various types of chemical reactors.

8.3 Course Content

The course content includes chemical reaction engineering principles, rate laws, catalysis and catalytic reactions, batch reactor design, isothermal reaction design as well as non-isothermal reaction design.

8.4 Multiple Choice Questions

1. Which of the following is a chemical process?

   A. Solidification of liquids to gases

   B. Liquefaction of solids to liquids

   C. Decay of matter

2. Chemical changes are:

   A. Irreversible

   B. Permanent

   C. Both A and B

3. Which of the following is a symbol for Magnesium?

   A. M

   B. Mg

   C. Ma

4. Ammonia is produced by a reversible reaction from hydrogen and nitrogen in the presence of --------as a catalyst.

   A. Cobalt

   B. Iron

   C. Nickel

5. Sulphuric acid is manufactured using the:

   A. Contact Process

   B. Haber Process

   C. Markov Process

6. A reversible reaction is denoted by:

   A. 

   B. 

   C. 

7. In a one-step reaction:

   A. There is one transition stage involved

   B. The reaction is only exothermic

   C. There are two transition stages involved

8. What are the units for a first order reaction?

   A. $MolL^{-1}S^{-1}$

   B. S^{-1}

   C. $Mol^{-1}LS^{-1}$

9. For a rate equation: A + B = C, Rate = k[A][B], the rate of reaction is:

   A. Independent of concentration of A

   B. Independent of concentration of B

   C. Dependent of concentration of A and B

10. The formation of sulphur trioxide from sulphur and oxygen in the presence of a vanadium catalyst is an example of:

   A. Homogeneous catalysis

   B. Heterogeneous catalysis

   C. Irreversible reaction

8.5 Bibliography

Books

Davis, Mark. E. Davis, Robert. J. *Fundamentals of Chemical Reaction Engineering*. McGraw-Hill. USA, 2003.

Journal Articles

Petrasch, J., Oscha, P. and Steinfeld, A., *"Dynamics and control of solar thermochemical reactors,"* Chemical Engineering Journal, 145, 362–370, 2009.

Ivanovich, Z. V., Gennadievich, N. D. and Fedorovich, C. V., *"Investigation of the Pulsed Annular Gas Jet for Chemical Reactor Cleaning",* International Journal of Chemical Engineering, doi:10.1155/2012/517465, 2012.

Websites

http://www.csus.edu/indiv/m/mackj/chem142/kinetics.pdf

http://jbrwww.che.wisc.edu/home/jbraw/chemreacfun/ch5/slides-kinetics-2up.pdf

CHAPTER 9: BIOPROCESS ENGINEERING PRINCIPLES

9.1 Course Objectives

By the end of this course students should be able to analyze mechanisms of enzymatic reactions, apply enzyme technologies for production of industrial products, design enzyme reactors, predict microbial yield coefficients, apply cell kinetics in design and scaling up of bioreactors, optimize bioprocesses, outline the importance of sterilization in bioprocesses, measure and calculate the oxygen transfer coefficient as well as identify technologies required for downstream processing.

9.2 Course Description

Bioprocess Engineering is a part of Chemical Engineering that deals with unit operations that entangle biological processes. The course focuses on cells and enzymes as well their kinetics involved. In addition, it focuses on bioreactor designs, oxygen transfer measurement in bioprocesses and the downstream processes involved.

9.3 Course Content

The course content includes enzyme and enzyme kinetics, classification and composition of cells, cell kinetics, bioreactor design, operation and control, oxygen transfer measurement in bioprocesses, sterilization of media and equipment as well as downstream processing.

9.4 Multiple Choice Questions

1. The……. explains that substrates alter the shapes of the active sites in enzymes for activation.
   A. Lock and key hypothesis
   B. Induced fit theory
   C. Michaeli-Menten's equation
2. The enzymes kinetics are best described by:
   A. Monod's equation
   B. Eadie-Hofstee equation
   C. Michaeli-Menten's equation
3. The cell kinetics are best described by:
   A. Monod equation
   B. Eadie-Hofstee equation
   C. Michaeli-Menten's equation
4. In batch cell growth, the phase whereby all nutrients are utilized and cells die is called:
   A. Lag
   B. Death
   C. Stationary
5. Organisms in a bioreactor receive oxygen through:
   A. Aeration
   B. Fermentation
   C. Inoculation
6. As agitation increases in an aerobic maintained bioreactor,
   A. The oxygen transfer coefficient increases
   B. The oxygen transfer coefficient decreases
   C. The oxygen transfer coefficient is not changed

7. Foaming can be prevented by:

   A. Mixing

   B. Increasing oxygen supply

   C. Adding a surfactant

8. The disengagement zone in an airlift bioreactor:

   A. Increases the velocity of the air bubbles

   B. Decreases the velocity of the air bubbles

   C. Enables reduction in liquid loss

9. Mechanicals seals on a bioreactor:

   A. Prevents contaminants from entering the reactor

   B. Allows contaminants from entering the reactor

   C. Allows cells from to enter the reactor

10. ------is a physicochemical method of cell rupture.

   A. Homogenization

   B. Ultrasonic vibrations

   C. Enzymatic digestion

9.5 Bibliography

Books

Shuler, Michael. L. Kargi, Ficket. *Bioprocess Engineering Basic Concepts.* Second Edition. Prentice Hall. Upper Saddle River, 2002

Journal Articles

Clarke, K.G. and Manyuchi, M. M., *"Methodology for advanced measurement accuracy of the overall volumetric oxygen transfer coefficient with application to hydrocarbon–aqueous dispersions,"* Journal of Chemical Technology and Biotechnology, DOI:10.1002/jctb.3853, 2012.

Munasinghe, P. C. and Khanal, S. K., *"Syngas fermentation to biofuel: Evaluation of carbon monoxide mass transfer coefficient (kLa) in different reactor configurations,"* Biotechnology Progress, DOI:10.1002/btpr.473, 2010.

Websites

http://class.fst.ohio-state.edu/fst605/605p/Enzymekinetics.pdf

http://hugroup.cems.umn.edu/Cell_Technology/cdrom/Stoichiometry%20and%20Cell%20Kinetics/Stoichiometry%20and%20Cell%20Kinetics.pdf

CHAPTER 10: PLANT EQUIPMENT AND PROCESS DESIGN

10.1 Course Objectives

By the end of this course students should be able to understand the steps and basic steps in plant equipment and process design, understand the importance of plant equipment, plant facilities and process design, develop process flow sheets, prepare piping and instrumentation diagrams for given plants, select appropriate materials of construction for plant equipment, choose plant layouts and sites as well as understand the need for heat integration.

10.2 Course Description

The Plant and Process Equipment course focuses on the development and design of both the complete process and plant equipment. It centers on process equipment, process selection, materials selection, plant layouts and the piping design. In addition, it also looks at the heat integration systems for maximum energy usage across the whole plant.

10.3 Course Content

The course content includes an introduction to plant equipment and process design, process equipment, documents and materials selection, plant layouts and plot plans, piping and instrumentation diagrams, plant layout and piping design as well as pinch technology.

10.4 Multiple Choice Questions

1. The initial step a designer takes when given an idea to develop is:
   A. Research
   B. Develop a prototype
   C. Conceptualize
2. The final step a designer carries out on project is to:
   A. Research
   B. Conceptualize
   C. Produce
3. The engineering design process starts by:
   A. New product development idea
   B. Identifying the need for a solution of a given problem
   C. Information gathering
4. A------is used to examine various areas of a product before the design is ended.
   A. Prototype
   B. Model
   C. Pilot plant
5. Loss prevention in the general design considerations is accounted for in:
   A. HAZOP studies
   B. Faulty tree analysis
   C. Both A and B
6. A ------is used to show how a product will work.
   A. A Prototype
   B. Model
   C. Pilot plant

7. Iteration in engineering design helps to:

   A. Use different software

   B. Use maths in engineering

   C. Ascertain optimal operating conditions

8. Which of the following is a correct sequence for formulating a design problem?

   A. Product specification-Design problem-Process design

   B. Design problem-Product specification-Process design

   C. Process design- Design problem-Product specification

9. CAM stands for:

   A. Computer aided methods

   B. Computer aided design

   C. Computer aided manufacturing

10. In equipment design, the following factor/s is/are considered:

   A. Materials of selection

   B. Safety factors

   C. Both A and B

10.5 Bibliography

Books

Smith, Robin. *Chemical Process: Design and Integration*. First Edition. John Wiley and Sons. 2005.

Journal Articles

Pecenka, R, Luhr, C. and Gusovius, H., *"Design of Competitive Processing Plants for Hemp Fibre Production",* ISRN Agronomy, doi:10.5402/2012/647867, 2012.

Leite, M. S., Fujiki, T. L., Silva, F. V. and Fileti, A. M. F., *"Online Intelligent Controllers for an Enzyme Recovery Plant: Design Methodology and Performance"*, Enzyme Research, doi:10.4061/2010/250843, 2010.

Websites

http://userpages.umbc.edu/~dfrey1/ench445/heat_exch_design.pdf

http://www.opendesign.org/CHIRP_Open_Design_Mfg_Equipment.pdf

CHAPTER 11: CHEMICAL ENGINEERING ECONOMICS

11.1 Course Objectives

By the end of this course students should be able to evaluate cost revenue, profit and risk of chemical engineering processes as well as evaluate the cost implication in design, optimization and application of chemical engineering processes, products and design.

11.2 Course Description

Chemical Engineering Economics is the application of economic principles to Chemical Engineering problems. The course focuses on optimum cost effectiveness, focusing on the time value of money, interest and cash flows estimation. It also focuses on quantitative methods of measuring profitability.

11.3 Course Content

The course content includes capital investment estimation, production costs, depreciation costs and cash flow of a given chemical engineering process, profitability analysis, net present value, rate of return and payback period, Corporate financial structure, cost of capital as well as economic risk analysis, scenario and sensitivity analysis, decision tree analysis, risk-adjusted cost of capital, expected net value and real options.

11.4 Multiple Choice Questions

1. Depreciation refers to:
   A. Loss of equipment due to wear and tear over time
   B. Destruction of a plant due to a fire
   C. Closure of a plant due to lack of manpower
2. The term Overall domestic capital formation refers to:
   A. Production rate exceeding demand
   B. Physical assets net expenditure
   C. Net addition to stock after depreciation
3. Which of the following is found in a balance sheet
   A. Available raw materials cost
   B. Total capital
   C. Both A and B
4. Which of the following is an example of a capital cost?
   A. Fixed equipment
   B. Direct costs
   C. Fixed costs
5. Which of the following is not an example of an operating cost?
   A. Direct costs
   B. Fixed costs
   C. Working capital
6. Fixed capital + working capital + start-up capital refers to:
   A. Depreciation
   B. Fixed assets
   C. Total capital

7. The compound interest is calculated as:

   A. Present sum of money x (1 + Interest rate)^number of years + present sum of money

   B. Present sum of money x (1 + Interest rate)^number of years – present sum of money

   C. Present sum of money x (1 - Interest rate)^number of years – present sum of money

8. Calculate the simple interest for a principal amount of $4000, at an interest rate of 7% for 3 years.

A. $840

B. $740

C. $4840

9. If it costs $80 per annum to maintain a detergent manufacturing plant at 9.0% per annum. Calculate the amount of money to be set aside per annum without using the principal amount.

   A. $888

   B. $72

   C. $862

10. Which of the following method does not measure liquidity?

   A. Simple payback period

   B. Discounted payback period

   C. Depreciation

11.5 Bibliography

Books

Fraser, Niall. M Bernhardt, Irwin. Jewkes, Elizabeth. M. Tajima, May *Engineering Economics in Canada.* Second Edition. Prentice Hall. Canada, 2000.

Journal Articles

van Raaij, E. M, "*The strategic value of customer profitability analysis*", Marketing Intelligence and Planning, 23 (4), pp.372 – 381, 2005.

Saltelli, A., Ratto, M., Tarantola, S. and Campolongo, F., *"Sensitivity Analysis for Chemical Models"*, American Chemical Society, 10.1021/cr040659d, 2004.

Websites

http://ocw.mit.edu/courses/chemical-engineering/10-490-integrated-chemical-engineering-i-fall-2006/projects/eng_econ_lecture.pdf

http://www.ics.trieste.it/media/139073/df6099.pdf

CHAPTER 12: PROCESS SIMULATION, SYNTHESIS AND OPTIMIZATION

12.1 Course Objectives

By the end of this course students should be able to familiarize with techniques for both steady state and non-steady state systems, introduce students to computer aided process synthesis, simulation and optimization, understand the use of computer simulation packages as well as understand the mathematical application of linear and non-linear programming in optimization

12.2 Course Description

Process Simulation, Synthesis and Optimization focuses on simulation, synthesis and optimization of steady sate and non-steady state chemical engineering processes. It focuses on using computer aided software as tools in tools in simulation and programming as optimization tools.

12.3 Course Content

The course content includes an introduction to simulation, synthesis and optimization, steady state and non-steady state systems, process optimization techniques as well as mathematical optimization in Chemical Engineering.

12.4 Multiple Choice Questions

1. Which of the following is not a type of process simulation?
   A. Predictive simulation
   B. Dynamic simulation
   C. Steady state simulation
2. Which of the following tools is not relevant in process synthesis?
   A. Equipment
   B. Flow sheet
   C. Plot plan
3. Different type of models can be classified as:
   A. Simple and non-linear equations
   B. Simple equations and predictive models
   C. Non-linear equations and predictive models
4. Process Optimization is a mathematical discipline that focuses on finding:
   A. Maxima points of a process
   B. Maxima and minima points of a process
   C. Minima points of a process
5. The rate of a parameter, x is given by: f (x) = x^2 + 3x. Calculate the stationery point of this parameter.
   A. (3/2; 9/2)
   B. (3/2; -9/2)
   C. (-3/2; -9/2)
6. The process optimization chain is as follows:
   A. Measuring-Controlling-Optimizing
   B. Controlling-Measuring- Optimizing
   C. Optimizing-Measuring-Controlling

7. One advantage of process simulation is:

   A. It's helpful where mathematical models are not applicable

   B. It can be used to find an optimal solution

   C. Simulation models are cheap to build

8. Which one of the following is not a benefit of process optimization?

   A. Reduced costs

   B. Increased through put

   C. Lengthened audits

9. -------is/are used to maximize energy usage in a plant.

   A. Loops

   B. Pinch Technology

   C. Pathways

10. Process optimization methods can be defined as:

   A. Constrained and unconstrained

   B. Function and unconstrained

   C. Function and unconstrained

12.5 Bibliography

Books

Seider, Warren. D. Seader, J.D. Lewin, Daniel, R. *Product and Process Design Principles: Synthesis, Analysis and Evaluation*. Third Edition. Wiley. 2008

Journal Articles

Barnicki, S. D and Siirola, J. J*., "Process synthesis prospective"*, Computers and Chemical Engineering, 28, 441–446, 2004.

Gosling, I., *"Process Simulation and Modeling for Industrial Bioprocessing: Tools and Techniques,"* Industrial Biotechnology, 1 (2), 2005.

Websites

http://www.bre.com/portals/0/technicalarticles/Process%20Simulation%20and%20Optimization%20of%20Cryogenic%20Operations%20Using%20Multi-Stream%20Brazed%20Aluminum%20Exchangers.pdf

www.cabeq.pbf.hr/pdf/17_1_2003/Cabeq_2003-01_1.pdf

APPENDICES: SOLUTIONS TO MULTIPLE CHOICE QUESTIONS

Appendix 1: Research Methodology

1. C
2. B
3. A
4. B
5. C
6. A
7. C
8. C
9. B
10. C

Appendix 2: Statistical Design and Analyses of Experiments

1. C
2. A
3. B
4. B
5. C
6. A
7. B
8. C
9. B
10. C

Appendix 3: Mass Transfer

1. C
2. A
3. C
4. B
5. B
6. A
7. C
8. A
9. B
10. A

Appendix 4: Heat Transfer

1. C
2. A
3. B
4. B
5. C
6. C
7. B
8. A
9. B
10. C

Appendix 5: Separation Processes

1. A
2. C
3. B
4. A
5. C
6. B
7. A
8. B
9. C
10. B

Appendix 6: Chemical Technology

1. B
2. A
3. C
4. A
5. B
6. C
7. B
8. A
9. C
10. A

Appendix 7: Environmental Engineering Principles

1. B
2. C
3. C
4. C
5. A
6. C
7. A
8. C
9. A
10. B

Appendix 8: Chemical Engineering Reactors and Kinetics

1. C
2. C
3. B
4. B
5. A
6. C
7. A
8. B
9. C
10. B

Appendix 9: Bioprocess Engineering Principles

1. B
2. C
3. A
4. B
5. A
6. A
7. C
8. B
9. C
10. A

Appendix 10: Plant Equipment and Process Design

1. A
2. C
3. B
4. A
5. C
6. B
7. C
8. A
9. C
10. C

Appendix 11: Chemical Engineering Economics

1. A
2. C
3. C
4. A
5. A
6. C
7. B
8. A
9. A
10. C

Appendix 12: Process Simulation, Synthesis and Optimization

1. A
2. C
3. B
4. B
5. C
6. A
7. A
8. C
9. B
10. A