



NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
FACULTY OF APPLIED SCIENCES

BACHELOR OF APPLIED SCIENCES HONOURS DEGREE

END OF SECOND SEMESTER EXAMINATIONS – MAY 2011

CHEMICAL ENGINEERING PLANT DESIGN - SCH 4108

TIME: THREE (3) HOURS

Instructions to Candidates:

1. Answer five questions only.
 2. Each question carries 20 marks.
 3. Start the answer for each question on a fresh page.
 4. The total score is 100 marks.
-

Question 1

- 1.1 Name four (4) types of machines that can be used to cause movement of fluids in the Chemical Process Industry (CPI) [2 marks]. Further, for each machine that you have named, indicate the circumstances of usage and roughly the pressure up to which the machine is capable of delivering. [4 marks]
- 1.2 Name six (6) Affinity Laws that apply with centrifugal pumps under conditions where the machines run firstly with a constant impeller diameter D ; and secondly under conditions where the machines are run with a constant impeller speed. [6 marks]
- 1.3 Applying one of the Affinity Laws, compute impeller rotations (rpm) N_2 in respect of a centrifugal machine that is pumping water where the following data is provided:
 $N_1 = 125$ impeller rotations per minute(rpm)
 $Q_1 = 120$ litres per second (l/sec) of water pumped
 $Q_2 = 360$ l/sec of water pumped after change of operating conditions. [5 marks]
- 1.4 In what type of a reactor is a heterogeneous reaction carried out [1 mark] and what are the typical operational handicaps of this kind of reactor? [2 marks]

Question 2

- 2.1 What does the term NPSH stand for in the engineering field of pumps, and how is NPSH defined by means of an equation? **[4 marks]**
- 2.2 State some three (3) advantages of a reciprocating pump when compared to a centrifugal pump **[3marks]** and conversely state some three (3) advantages of a centrifugal pump when compared to a reciprocating pump. **[3 marks]**
- 2.3 Illustrate mathematically the role played by Engineering Stress, also referred to as Allowable Stress, in the design of a pressure vessel. **[2 marks]** Further, calculate the Engineering Stress S , in SI units, for design of a pressure vessel given the following data:

$D_i = 50$ inches

$P_i = 100$ psi

$t = 0.17$ inches, and

$E = 0.85$

Where D_i is the internal diameter of the pressure vessel

P_i is the pressure acting inside the pressure vessel

t is the wall thickness of the pressure vessel, and

E is the value of joint efficiency determined by radiography. **[8 marks]**

Question 3

- 3.1 Draw a diagram of a Shell and Tube Heat Exchanger (HE), with not less than eight (8) parts of the HE labelled, such as would be used as a process cooler for process gas in a nitric acid plant with process gas being on the tube side, i.e. inside the tubes, and cooling water coming from a recirculating cooling tower and pumped at a discharge pressure of 4 bars being on the shell side. **[8 marks]**
- 3.2 What parts of the Heat Exchanger that you have drawn would be prone to the following kinds of corrosion. Explain how the corrosion would manifest itself to the naked eye and how it can be minimized or avoided in each case:
- a) Crevice corrosion
 - b) Galvanic corrosion
 - c) Pitting corrosion, and
 - d) Microbiological corrosion. **[12 marks]**

Question 4

- a. Show how a mechanical property called Young’s Modulus of Elasticity, E, arises and indicate the SI units by which it is expressed. [4 marks]

- b. Name three (3) materials that have relatively high values of Young’s Modulus of Elasticity [3 marks] and comment on the physical properties of each in terms of their Stiffness, Malleability, Ductility and Melting Point. [4 marks]

- c. A hemispherical formed head is frequently used to close a cylindrical process vessel, or even a reactor. Provide the following information about this kind of formed head:
 - (i) Under what pressure conditions is this vessel head suitable. [2 marks]
 - (ii) Give the formula that is used to compute the wall thickness of the hemispherical head [5 marks]

 - (iii) What method would you recommend for attachment of this head to the cylinder of the vessel or reactor? [2 marks]

Question 5

You are a professional employee of an organization called the Mish Corporation. The Chief Executive Officer , i.e. the CEO of the Corporation has asked you to analyse two proposed capital investment projects, Project A and Project B. Each project is going to cost \$ 10 000, and the cost of capital for each project is 12%. The projects’ net cash flows are as follows:

<u>Expected net cash flows</u>		
Year	Project A	Project B
0	(\$ 10 000)	(\$ 10 000)
1	6 500	3 500
2	3 000	3 500
3	3 000	3 500
4	1 000	3 500

- 5.1 Calculate each project’s payback period (PBP) [6 marks]

- 5.2 Calculate the Net Present Value (NPV) for each of the projects. [8 marks]

- 5.3 Which project should be adopted if they are mutually exclusive? [2 marks]

5.3 Name four (4) advantages that are enjoyed by a Limited Liability Company over a Business Partnership. [4 marks]

Question 6

6.1 Name and describe briefly the functioning of four (4) devices that ought always to be installed in pressure vessels or reaction vessels to protect the plant, the factory workers and the environment from the hazards of overpressure. [8 marks]

6.2 (a) Name and describe the chemical composition and physical properties of a ferrous alloy that happens to be the most extensively used material for fabrication of process vessels in the Chemical Process Industry. [6marks]

(b) Provide both practical and economic reasons that contribute to this ferrous alloy being the first material of choice. [4 marks]

(c) Explain why the ferrous alloy in question can be used for construction of a tank for safe storage of sulphuric acid at a concentration of upwards of 98% without suffering corrosion. [2 marks]

END OF PAPER!!!!