

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF CHEMICAL ENGINEERING

Plant And Equipment Design – TCE3101

FIRST SEMESTER EXAMINATIONS FEBRUARY 2010

Time allowed: 3hours

INSTRUCTIONS TO CANDIDATES

1. Answer any five questions
2. Each question carries 20marks.

Question 1

- (a) An Aluminium rod is required to withstand an applied force of 20 430kg. To assure a sufficient factor of safety, the maximum allowable stress on the rod is limited to 173 375kPa. The rod must be at least 381cm long but must deform elastically no more than 0.635cm when the force is applied. Design the appropriate rod. **[8marks]**
- (b) Name three (3) main classes of stainless steel designated in accordance with their metallurgical structure. In addition, briefly describe the main features of each of these classes, citing their field of usage. **[7marks]**
- (c) Give examples of alloys that falls in each of the categories of stainless steel cited in (b). **[3marks]**
- (d) What is the difference between cast iron and carbon steel? Which of the two materials would you use to manufacture an impeller for an air supply compressor? **[2marks]**

Question 2

- (a) Name any four (4) types of head designs that are fitted on pressure vessels used in the Chemical Process Industry (CPI). In addition, briefly explain the appropriateness of each head design on CPI vessels. **[4marks]**
- (b) Calculate the thickness of an ellipsoidal head that is fitted to a pressure vessel with a cylindrical shell whose inside diameter D_i is 1.016metres. The vessel is subject to a pressure P of 3102.66kPa, the joint efficiency value E is 1.0 and the stress intensity factor K is 1.83. **[8marks]**
- (c) Discuss two types of corrosion that commonly affect heat exchangers in the Chemical Process Industry (CPI). In your discussion include how the corrosion manifests itself,

where possible, use an illustrative diagram. Also describe the methods of preventing the corrosion. **[8marks]**

Question 3

- (a) Name any six means that can be used to make liquids to flow. **[3marks]**
- (b) Name two key differences between a pump and a compressor. **[2marks]**
- (c) Draw two fully labeled sketches of the following pieces of equipment:
- (i) A reciprocating pump. **[2marks]**
 - (ii) A centrifugal pump. **[2marks]**
- For each of the above types of pump, explain the mode of suction of the liquid of the liquid and describe the operation of the valve system. **[4marks]**
- (d) Given that the head developed by an ideal centrifugal pump is directly proportional to the square of the impeller speed and that a centrifugal pump delivers 378.5litres per minute of water at 20⁰C when the impeller speed is 1750rpm. Estimate the rate of water delivery if the pump operation is ideal. **[7marks]**

Question 4

- (a) Under what operating conditions does a stem piping system suffer from ‘water hammer’ and how can the problem be avoided or dealt with? **[3marks]**
- (b) A process pipe has a bursting pressure of 170bar. The safe working pressure is roughly 90% of bursting pressure. Calculate the safe working stress S of the pipe given that the pipe has a minimum wall thickness t of 10mm and a mean diameter D_m of 0.15metres. **[6marks]**
- (c) Using guidelines provided by the American Standards Association, determine the schedule number of the pipe involved in (b). **[4marks]**
- (d) Name any three instruments that are extensively used in industrial operations to measure fluid flow. **[3marks]**
- (e) State and fully describe the basic equation for design and operation of an orifice meter. **[4marks]**

Question 5

- (a) State three fixed assets that almost every enterprise would acquire. **[3marks]**
- (b) Explain why fixed assets are acquired by enterprises. In addition, explain how such acquisitions are usually funded. **[3marks]**

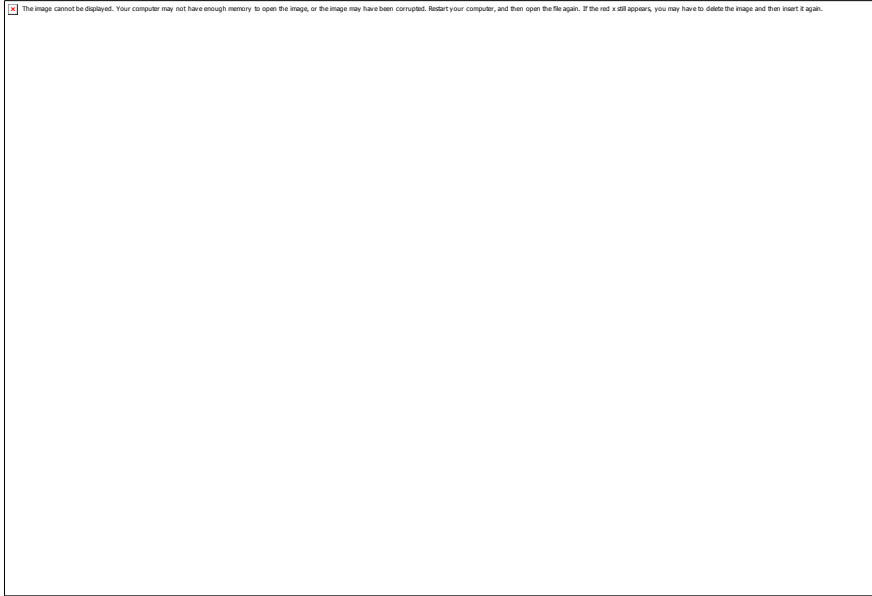
- (c) Give the general formula for calculating the annual depreciation of an asset using the straight-line depreciation method. Further, explain how company management use the concept of depreciation to protect the financial viability of a company. **[4marks]**
- (d) Sabelo (Pvt) Limited is considering two capital investment projects, Project A and Project B. The details are outlined below:

Project	A	B
Estimated life	3Years	5Years
Commencement date	01.01.2011	01.01.2011
Project cost at 01.01.2011	\$100 000	\$100 000
Estimated net cash flows:		
Year to :		
31.12.2011	20 000	10 000
31.12.2012	80 000	40 000
31.12.2013	40 000	40 000
31.12.2014	-	40 000
31.12.2015	-	20 000

Sabelo (Pvt) Limited wants a rate of return of 10% p.a on its capital employed. Using the Net Present Value (NPV) method of project appraisal, assess which project would be more profitable. A table of discount factors is provided. **[10marks]**

Question 6

- (a) What is the significance of temperature approach in Pinch Technology? **[5marks]**
- (b) How do the laws of thermodynamics help in Pinch Technology? **[5marks]**
- (c) Design a Heat Exchanger Network that minimizes energy consumption for the process shown below: **[7marks]**



(d) Construct both the Grand composite curve and the grid diagram for a process whose stream data is presented in the table below: **[8marks]**

TYPICAL STREAM DATA					
STREAM NUMBER	STREAM NAME	SUPPLY TEMP. °C	TARGET TEMP. °C	HEAT CAP. FLOW. kW /°C	ENTH. CHANGE kW
1	FEED	60	205	20	2900
2	REAC.OUT	270	160	18	1980
3	PRODUCT	220	70	35	5250
4	RECYCLE	160	210	50	2500