NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 4101 INDUSTRIAL PHYSICS

EXAMINATION

BSc HONOURS PART IV: December 2004 **DURATION: 3 HOURS**

ANSWER ALL PARTS OF QUESTION 1 IN SECTION **A** AND ANY THREE QUESTIONS FROM SECTION **B**. SECTION **A** CARRIES 40 MARKS WHILE SECTION **B** CARRIES 60 MARKS. DRAW NEAT DIAGRAMS WHEREVER NECESSARY.

Heat Capacity for water	C_p	$= 4.2 \times 10^3$ kJ K^{-1}
Latent Heat of Fusion for ice	H_f	$= 334$ kJ kg^{-1}
Latent Heat of Vapourization	H_v	$= 2.3 \times 10^3$ kJ kg^{-1}

Section A

1. (a) Give the four general classes into which equipment is classified. Draw a generalized diagram. [4]

(b) State the principle of optimum sloppiness and successive approximation. [4]

(c) You are working in a physics laboratory. You are required to prepare 10 acid accumulators and two power supplies giving 12 V at 150 mA. Submit your budget to the chairman within ten minutes. [4]

(d) Why is there interest in the DSC when there already exists the solid state silica solar cell? [2]

(e) What are the advantages of using the semiconductor TiO_2 as compared to silicon in photo Voltaic applications? [2]

(f) What is a thin film? Explain how a thin film differs from bulk material. [4]

(g) Reduce the following equation to two approximate expressions for the path of the ray through the atmosphere.

$$\frac{d^2h}{ds^2} - \left(\frac{2}{R+h} + \frac{1}{n}\frac{dn}{dh}\right)\left(\frac{dh}{ds}\right)^2 - \left(\frac{R+h}{R}\right)^2\left(\frac{1}{R+h} + \frac{1}{n}\frac{dn}{dh}\right) = 0 \quad [6]$$

(h) Explain why the radar uses the microwave section of the EM spectrum to detect weather. [2]

(i) Give three parameters measured by a conventional radar [3]

(j) Explain how 'second trip 'echos' confuse the interpretation of the radar picture and how the echo can be eliminated. [5]

(k) On what factors does the number of thin film grain boundaries depend on? [4]

SECTION B

2. (a) Explain the terms:
   (i) NPSH
   (ii) Similitude and changing conditions
   (iii) Rules of thumb for optimization. [6]

(b) You are working as an engineer at Wankie colliery. You are provided with a 100 cm diameter and 45 cm aerofoil single stage axial flow fan that runs at 450 rpm and delivers 2000 $dm^3\ s^{-1}$ of a gas at static pressure 0.75 cm of water. The power required to drive the fan is 0.75 kW. This fan has to be used for the flow rate of 1500 $dm^3\ s^{-1}$ of the same gas. Suggest the method of achieving this result. Calculate other relevant parameters for the system. [8]

(c) In ZIMCHEM you are required to vacuum convey polyethylene pallets. Assuming the design value for the solid loading as 10-kg/kg calculate
   (i) the gas flow rate and
   (ii) the diameter of the pipe for a pressure operation at 100 kPa. You may assume conveying design velocity to be 20 m s^{-1} and the density of the gas = 1.24 kg m^{-3}. Draw a neat diagram of the system. [6]

3. (a) List various types of thermal exchange devices used in industry. Which of these devices are used in ZESA and ZISCO? Give reasons for the choice. [4]

(b) What is the important parameter in designing cooling towers? Give four different variations on design of cooling towers. [8]

(c) A cooling tower is to cool 1800 kg s^{-1} of water from 321 K to 304 K. The local wet bulb temperature is 299.8 K. Rough size the cooling tower based on experience. [8]

4. (a) Calculate the length of the pipe of 7.5-cm diameter to have pressure loss of two velocity heads. The friction factor is 0.08. [4]

(b) The heat transfer coefficient for a system is 3 kW $m^{-2}K^{-1}$. How does this value change if we increase the total flow rate through the tube side by 20% and we have to plug off 3% of the tubes? [4]

(c) Describe various types of furnaces. [4]

(d) A stream of 150-kmol h^{-1} is heated up from 290 K to 373K. This steam is a mixture of a number of components. During this process 10 $kmolh^{-1}$ evaporates at 303 K to create a vapour whose is 30 kJ $mol^{-1}K^{-1}$ and 10 kmol h^{-1} of liquid components react at 343 K. This reaction is endothermic and requires 200 MJ $mol^{-1}$of A reactant. If stream initially contains 10 mol h^{-1} of A and \ 10 kmol h^{-1} of B, calculate the heat load. [8]

5. (a) Make use of a sketch of cross section of the dye - sensitized solar cell to explain how it functions. [10]

(b) List 3 sources of dark currents in the dye sensitized solar cell. [3]

(c) Give three parameters measured by a conventional radar [2]

(b) Explain how 'second trip echos' confuse the interpretation of the radar picture and how the echo can be eliminated. [5]

6. (a) List the probes used in the characterization of materials. [5]

(b) Describe the physical vapour deposition process. [8]

(c) Compare the evaporation and sputtering methods of thin film deposition. [7]

7. Write explanatory notes on applications of lasers in industry. In your explanation include

(I) Laser welding
(II) Laser cutting
(III) Surface hardening
(IV) Semiconductor processing
(V) Micromachining and
(VI) Drilling, scribing and marking [20]