



CRAWFORD UNIVERSITY  
COLLEGE OF NATURAL AND APPLIED SCIENCES  
DEPARTMENT OF PHYSICAL AND EARTH SCIENCES  
INDUSTRIAL CHEMISTRY PROGRAMME 2013/2014 SESSION

COURSE CODE: ICH 323

COURSE TITLE: HEAT TRANSFER

3 UNITS

TIME ALLOWED: 2½Hrs.

DATE: FEBRUARY, 2013.

INSTRUCTION: Answer any Three (3) Questions.

1. (a) Show that the heat flux  $Q$  can be defined by;

$$Q = \frac{K(t_1 - t_2)}{\Delta}$$

- (b) Define the parameters in the equation in (a) above

- (c) A 10.5cm thick side wall of an oven is primarily made of an insulator whose thermal conductivity is 0.64W/MK. Conditions on the inside wall fix the temperature on that side at 426K. The electric coils within the oven dissipate 86.5 watts of electrical energy to make up for the heat loss through the wall. Calculate the wall surface area perpendicular to heat flow so that temperature on the other side of the wall does not exceed 370K.

2. (a) Differentiate with examples, the two types of convection in heat transfer.

- (b) An oil cooler in a high performance engine has an outside surface area of 0.22m<sup>2</sup> and a surface temperature of 65°C. The air rushes over the surface of the cooler at a temperature of 30°C and gives rise to a surface coefficient of heat transfer equal to 35.1W/m<sup>2</sup>K. Calculate the heat transfer rate from the cooler.

- (c) A wire, 20cm long and 2.0mm in diameter is held between two conducting supports in a water tank. A controlled amount of current is made to pass through the wire until the temperature of the water became 120°C and it started to boil. Calculate the steady temperature of the wire if 23.8 watts of electric power is used. (Corrective heat transfer coefficient = 5000W/m<sup>2</sup>deg).

3. (a) Describe the distinct phases involved in the mechanism of heat flow by radiation

- (b) A radiator in a domestic heating system operates at a surface temperature of 60°C.

Calculate the heat flux at the surface of the radiator using the Stefan-Boltzmann law assuming that it behaves like a black body. (Take  $\delta_b = 5.67 \times 10^{-8} \text{W/m}^2/\text{K}^4$ )

- (c) A cylindrical rod 1.8m long and 2.5cm in diameter is heated electrically and placed in a vacuum furnace having interior walls at 860K temperature. A controlled amount of current is passed through the rod and its surface is maintained at 1200K. Calculate the power supplied to the heating rod if its surface has an emissivity of 0.90.
4. (a) Describe the process of heat conduction along a metal rod using thermometers and a heat source.  
(b) How does heat transfer differ from thermodynamics?  
(c) To effect a bond between two metal plates, 2.5cm and 15cm thick, heat is uniformly applied through the thinner plate by a radiant heat source. The bonding epoxy must be held at 320K for a short period of time. At heat of  $43.5 \text{KW/m}^2$ , a thermocouple installed on the side of the thinner plate close to the source indicated 345K. Calculate the temperature gradient for heat conduction through the thinner plate and the thermal conductivity of its material.
5. (a) Differentiate between steady and unsteady state heat transfer. Give two examples of each.  
(b) Distinguish between the modes of heat transfer by conduction, convection and radiation.  
(c) A 5.0cm diameter steel pipe maintained at a temperature of  $60^\circ\text{C}$  is kept in a large room where the air and wall temperatures are  $25^\circ\text{C}$ . If the surface emissivity of the steel is 0.7, calculate the total heat loss per unit length of pipe if convective heat transfer coefficient is  $6.5 \text{W/m}^2\text{deg}^-$ .

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