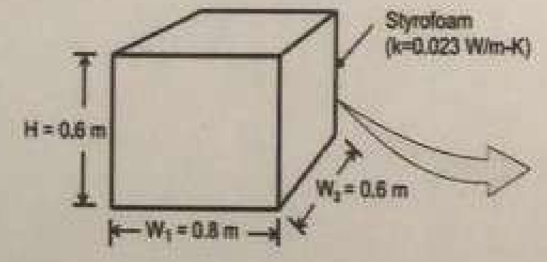
Question No 1: (20 minutes, 5 points)

An inexpensive food and beverage container is fabricated from 25-mm-thick polystyrene (k = 0.023 W/m. K) and has interior dimensions of 0.8 m x 0.6 m x 0.6 m. Under conditions for which an inner surface temperature of approximately 2 °C is maintained by an ice-water mixture and an outer surface temperature of 20 °C is maintained by the ambient.

1- What is the heat flux through the container wall?
2- Assuming negligible heat gain through the 0.8 m x 0.6 m base of the cooler, what is the total heat load for the prescribed conditions?



Question No 2: (20 minutes, 5 points)

The 6 mm thick bottom of a 200 mm diameter pan may be made from aluminum (k =250 W/m. K) or copper (k = 400 W/m. K). When used to boil water, the surface of the bottom exposed to the water is nominally at 120 °C. If heat is transferred from the stove to the pan at a rate of 7.5 kW.

What is the temperature of the surface in contact with the stove for each of the two materials?

K = 25

120

Question No 3: (25 minutes, 7 points)

The temperature distribution across a wall 0.3 m thick at a certain instant of time is: $T(x) = a + bx + cx^2$, where T is in degrees Celsius and x is in meters, a = 200 °C, b = -200 °C /m, and c = 30 °C /m^2. The wall has a thermal conductivity of 2 W/m.K.

1- On a unit surface area basis, determine the rate of heat transfer **into** and **out** of the wall and **the rate of change** of energy stored by the wall.

2- If the cold surface is exposed to a fluid at 110 °C, what is the convection coefficient?

Question No 4: (40 minutes, 11 points)

Spheres A and B are initially at 800 K, and they are simultaneously quenched in large constant temperature baths, each having a temperature of 320 K. The following parameters are associated with each of the spheres and their cooling processes.

	Sphere A	Sphere B
Diameter (mm)	300	30
Density (kg/m3)	1600	400
Specific heat (kJ/kg. K)	0.4	1.6
Thermal conductivity (W/m. K)	170	1.7
Convection coefficient ($W/m^2.K$)	5	567

1- Calculate the time required for the surface of each sphere to reach 415 K.

2- Determine the energy that has been gained by each of the baths during the process of the spheres cooling to 415 K.

Question No 5: (45 minutes, 12 points)

A shell-and-tube heat exchanger with 2-shell passes and 8-tube passes is used to heat ethyl alcohol (cp = 2670 J/kg.K) in the tubes from 25°C to 70°C at a rate of 2.1 kg/s. The heating is to be done by water (cp = 4190 J/kg.K) that enters the shell at 95°C and leaves at 60°C. If the overall heat transfer coefficient is 800 W/m².K,

Determine the heat transfer surface area of the heat exchanger using:

1. The LMTD method
2. The NTU method.
3. Conclude.