ABE 303 – Applications of Physical Chemistry to Biological Processes
Homework 3– Fall 2017
TOTAL = 100 points
Deadline Thursday September 28

Problem 1

The thermal conductivity of a biomaterial can be measured using a steady state method as the one illustrated in Lecture 3. The biomaterial samples are cut into rectangular geometries with area of 305mmx305mm and thickness of 15mm. The temperature difference between the hot and cold surfaces was kept to 4^{o}C and the measured heat rate was 10 Watts. Calculate the thermal conductivity of the sample.

[10 marks]

Problem 2

A cheese manufacturer has developed a new product consisting of grated cheddar cheese packed in a waxed cardboard box with dimensions of 100mmx100mmx150mm. Boxes of grated cheese will be chilled (**no frozen**) to 3^{o}C and maintained at this temperature until purchased by the consumer. It is necessary **to know chilling time** so that the refrigeration unit can be properly designed. The calculation requires a value of the thermal diffusivity of the packaged cheese (in addition to other data).

(a) Using the data given below, calculate **the thermal diffusivity** of the packaged cheese given a packing weight of 0.6 kg of cheese per box. Assume the box contains a random mixture of cheese pieces and air. Cheddar cheese itself is non-porous. The packaging material does not need be considered since it represents part of the external resistance to heat transfer.

(b) If the bulk porosity in the box is changed from the value it had in (a) [it has to be calculated] to a value of 0.5 what will be the new packing weight?

(c) For the new bulk porosity of 0.5, calculate a new value of thermal diffusivity. Compare this value with that calculated in (a); are the values significantly different (i.e. by 5% or more) or are the same? Comment on the result of this comparison and any possible implication in the chilling process.

DATA (Watch Out Units)

Substance Density of cheddar cheese:	= 1055 kg/m^3
Thermal Conductivity of cheddar cheese:	= 0.306 W/m.K
Thermal conductivity of air:	= 0.025 W/m.K
Specific heat of cheddar cheese	= 3.41 kJ/kg.K

[40 marks]

Problem 3

In what direction will the water activity of a liquid food change (higher, lower, or virtually (unaltered) if the following changes are done? Please assume all other factors constant. In each case, give a brief explanation.

1. Addition of sodium chloride
2. Addition of native starch (granules)
3. Heating the food with starch and cooling again to the original temperature without loss of water
4. Enzymatic hydrolysis of the protein present
5. Freezing part of the water

[10 points]

Problem 4

Sorption isotherms for Corn-syrup, sucrose and NaCl at room temperature are given in the table below. Plot the moisture isotherms and determine the models that better fit them:

Corn-syrups		NaCl		Sucrose	
a_w	m (dry weight)	a_w	m (dry weight)	a_w	m (dry weight)
0.11	1.77	0.11	0.13	0.11	0.02
0.33	2.45	0.33	0.12	0.33	0.02
0.44	6.57	0.44	0.12	0.44	0.03
0.52	10.00	0.52	0.12	0.52	0.03
0.68	18.53	0.68	0.13	0.75	0.24
0.75	23.77	0.75	6.44	0.85	5.38
0.85	37.42	0.85	391.46	0.88	49.62
0.88	44.24	0.88	473.15	0.91	73.72
0.91	94.07	0.91	600.31	0.97	211.28
0.97	196.95	0.97	1037.31		

[40 points]