ABE 303 – Applications of Physical Chemistry to Biological – Fall 2017
Homework 2 – 100 marks
Deadline Thursday September 14

Problem 1

Prepacked ready meals are to be cooled to a chill storage temperature of -1.5°C following in-pack microwave pasteurization. The meals leave the pasteurizer at 90°C. Each meal consists of:

Potato	250 g
Peas	180 g
Pork	150 g
Butter	30 g
Total	610 g

The compositions of the four meal components are as follows:

	Potato	Peas	Pork	Butter
Water (%)	80	75	45	12
Fat (%)	0	0	29	88
SNF (%)	20	25	26	0

The freezing points of all four components are all less than -1.5°C.
Using the data given below, calculate how much energy (in MJ/day) the chilling system must be capable of removing from the meals if they are being produced at the rate of 900 per day.

Hint: unless a meal is considered as one composite material, this problem will take a long time to solve.

DATA

Specific heat of water = 4.2 kJ/kg.K

Enthalpy data for butterfat and port fat:

	Enthalpy, h (kJ kg), relative to h=0 at - 50°C	
Temperature (°C)	**Butter Fat**	**Pork Fat**
-5	86.3	77.1
0	101.7	86.15
10	141.4	112.9
30	223.9	182.6
60	294.2	301.0
90	355.3	361.5

For a fatty material containing more than one type of fat:

$$\Delta h_{fatty\,material} = x_{non\_fat}\Delta h_{non\_fat} + x_{fat\_1}\Delta h_{fat\_1} + \ldots.. + x_{fat\_n}\Delta h_{fat\_n}$$

where:

$$x_{non-fat} + x_{fat\_1} + \ldots.. + x_{fat\_n} = 1$$

[50 marks]

Problem 2

A non-fatty protein based biomaterial has the following composition (%w/w):

Water 82%
Protein 16.5%
Salt (NaCl) 1.5%

Mass fraction of solids non-fat includes the salt and the protein, so it is 18%. The biomaterial has to be cooled from room temperature 25°C to -2.5°C to slow chemical and microbiological deterioration. In addition of affecting the quality of the biomaterial freezing is an expensive process so it needs to be avoided. The freezing point of the biomaterial is -1°C, so more salt has to be added to depress its freezing point to -3.5°C and the biomaterial can be cooled at -2.5°C without freezing.

(a) Calculate the mass of salt (in kg) per kg of biomaterial to add to have an initial freezing point of -3.5°C. To facilitate your calculations, you could use 1 kg (or 100 g) of the biomaterial as a basis for your calculation.
(b) Calculate the new composition of the salted biomaterial in terms of percentage of water and percent solids non-fat (SNF)
(c) Calculate the additional (i.e. difference between salted and non-salted biomaterial) energy removal (in kJ/kg) that would be required to cool the biomaterial to -3.5°C if salt was not added. Assume no bound water.
(d) Explain briefly why this additional energy removal would be necessary.

DATA

Specific heat of water = 4.2 kJ/kg.K
Specific heat of SNF (protein plus salt) = 1.9 kJ/kg.K
Specific heat of ice = 2.1 kJ/kg.K
Latent heat of fusion of water = 331 kJ/kg

Freezing point data for salt solutions

Salt concentration in the brine solution (%)	Freezing Point °C
1.7	-1.0°C
3.3	-2.0°C
5.2	-3.0°C
6.8	-4.5°C

[50 marks]

OFFICE HOURS 9-13-2017 1

Problem)

Food

$m_p = 250\ g$

$m_{pea} = 180$

$m_{pk} = 150$

$m_B = 30\ g$

$m_T = 610\ g$

$X_p = \frac{m_p}{m_T}$ [FRACTION OF P.

$X_{pea} = \frac{m_{pea}}{m_T}$

$X_w = X_p \times 0.8 + \cancel{X}_{peas.} \times 0.75 + X_{pk} \times 0.45 + X_B \times 0.12$

Problem 2 (2)

BIOMATERIAL 25°C

Case 1

NO SALT ADDED

$\Delta h_{-1°C-25}$

$\Delta h_{-2.5-25} = \Delta h_{-1-25} + \Delta h_{-1\to-2.5}$

FREEZING POINT $-1°C$

$-2.5°C$

$\Delta h_{-2.5\to-1.5}$

Below Freezing Point

Above FP

Below FP.

CASE 2

ADD SALT

25

$\Delta h_{-2.5-25}$

$-2.5°C$

Freezing point -3.5

From Interpolation in the table

$X_{salt} = 5.5\%$

82 % water
16.5 protein
1.5 % salt. salt } SNF 18 %

$-1.0\,°C$

Check !!

interpolate salt 5.5 %

1 Kg = 1000 g.

0.82 g water
0.165 protein.
x salt.

$$\frac{X}{0.82+0.165+X} \times 100 = 5.5 \Longrightarrow X$$

Salt to add $= X - 1.5$

Units in Problem 1

(4)

$$\text{Result } \frac{KJ}{\cancel{Kg}} \times 900 \frac{\cancel{meals}}{day} \times \frac{0.610\ \cancel{Kg}}{\cancel{meal}} = \frac{\cancel{KJ}}{day} \times \frac{1MJ}{10^3 \cancel{KJ}}$$

$$\frac{KJ}{Kg} \xrightarrow{\%} 1000 \times 900 \times 0.610 \qquad \boxed{\frac{MJ}{dog\ day}}$$