**ABE 303 – Fall 2017**

**Example Problems**

**How Much Energy is required?**

**Example 1**

Kiwifruit juice (a non-fatty food), extracted from the fresh fruit at 20oC, is to be cooled to

a temperature some degrees below its initial freezing point to cause some of the water in

the juice to turn into ice. The ice crystals are then to be mechanically separated from the

mixture leaving a concentrated juice (***this process is called freeze concentration***). The

initial mass composition of the juice is:

Water: 86.5%

Total solids (SNF): 13.5%

It is desired to concentrate the juice to 60% total solids by weight. All the water in

the juice is freezable, i.e. none is bound.

(a) Calculate at what temperature the juice will have to be cooled to achieve the desired

concentration. Hint: use 1 kg of unfrozen juice as the basis of the mass balance to

estimate that temperature.

(b) Calculate how much heat energy (in kJ/kg) will have to be removed from the fresh

juice during the freeze concentration process.

**DATA**

Initial Freezing point of fresh kiwifruit juice = -1.3C

Specific heat of kiwifruit dry solids = 1.50 kJ/kgK

Specific heat of water = 4.18 kJ/kgK

Specific heat of ice = 2.11 kJ/kgK

Latent heat of fusion of water = 320 kJ/kg

**How Fast the Energy is transferred – problem to predict thermal conductivity of a complex material - ice cream. It has many components plus ice and air.**

**Example 2**

A liquid ice cream mix is pasteurized and then cooled in continuous heat exchangers prior to whipping and freezing. Values of the **density**, **specific heat** and **thermal conductivity** of the mix are required for use in heat exchanger design calculations. Predict such values using the data and equations given below.

The mix may be thought of as a random dispersion of milk fat globules in a continuous aqueous phase which itself consists of a random dispersion of non-fat milk solids in a 16.7% sucrose solution. The mix is non-porous.

**Hint**: volume fractions used at any state of your calculations must be fractions of the part of the mix under consideration at that state.

**DATA**

Mass composition of mix

Water 60%

Sucrose 12%

Non-fat milk solids 10%

Milk fat 18%

Thermophysical properties

Substance density of 16.7% sucrose solution = 1070 kg/m3

Substance density of non-fat milk solids = 1380 kg/m3

Density of milk fat = 930 kg/ m3

Thermal conductivity of 16.7% sucrose solution = 0.55 W/ m.K

Thermal conductivity of non-fat milk solids = 0.20 W / m.K

Thermal conductivity of milk fat = 0.19 W / m.K

Specific heat of 16.7% sucrose solution = 3.77 kJ / m.K

Specific heat of non-fat milk solids = 1.70 kJ / m.K

Specific heat of milk fat = 2.95 kJ / m.K