National Exams May 2016

04-Agric-A6, Physical Properties of Biological Materials

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is a CLOSED BOOK EXAM. Approved calculator is permitted. One aid sheet allowed written on both sides.

3. FIVE (5) questions constitute a complete exam paper. The first five questions as they appear in the answer book will be marked.

4. Marks for each question are given.

5. Some questions require an answer in essay format. Clarity and organization of the answer are important. Be brief, too the point and concise.

Marking Scheme

Five questions out of nine (all questions carry 20 marks)

1. 20 marks total
2. (a) 10 marks, (b) 10 marks
3. 20 marks total
4. (a) 6 marks, (b) 6 marks, (c) 8 marks
5. (a) 10 marks, (b) 10 marks
6. (a) 10 marks, (b) 5 marks, (c) 5 marks
7. (a) 12 marks, (b) 8 marks
8. (a) 4 marks, (b) 6 marks, (c) 3 marks, (d) 7 marks
9. (a) 4.5 marks, (b) 4,5 marks, (c) 3 marks, (d) 5 marks, (e) 3 marks

Do any 5 questions

1. The specific heat of a 12% moisture yellow-dent corn was determined using a thermos bottle as a calorimeter. The mass of the thermos was 54.5 g and the mass of the grain sample was 90 g. The thermos and corn were first heated to 73°C and then 255 g of water at 21°C was poured into the thermos. When the system was sealed and at equilibrium its temperature was 30°C. If the specific heat of the thermos was 0.946 kJ/(kg K) and of water was 4.187 kJ/(kg K), determine the specific heat of the corn using the method of mixtures. (20 marks)

2. Using bench scale laboratory tests, or batch equipment tests, how would you determine or estimate the following:

(a) The thermal conductivity and diffusivity of a food product. (10 marks)
(b) The maximum tolerable freezing rate in terms of some frozen product quality attributes. (10 marks)

3. A rotational narrow gap viscometer, with a spring constant equivalent to 7187 dynes/cm full scale reading on the indicator, is used on a viscometer with 1 cm outside diameter (OD) for the inner cylinder and 1.5 cm inside diameter (ID) for the outer cylinder. The cylinders are 6 cm high. Assume that end effects are negligible. The following readings, as a percentage of full scale on the indicator, were obtained at various spindle speeds for a food product. Determine the flow behaviour index (n) and consistency coefficient (b) of the fod.

Speed (N), rpm	2	4	10	20
Torque indicated (% full scale)	15	26	53	93

Use log-log graph paper or ordinary graph provided. (20 marks)

4. (a) Sketch the recovery of fluid viscosity vs. time during agitation at a very low shear rate following rapid agitation. Distinguish between fluids that recover consistency and those that do not. (6 marks)

(b) What is the rate of strain ($d\varepsilon/dt$, ε is strain and t is time)? Is it dimensionally similar to $\Delta v/\Delta y$ (shear rate for viscosity, v is velocity and y is displacement)? Why? (6 marks)

(c) The proportionality constants between stress and strain are called moduli (M), i.e. M = stress/strain. Define in words and then in symbols, the following moduli: modulus of rigidity, modulus of elasticity, bulk modulus and modulus of compressibility. (8 marks)

5. (a) Sketch a typical General Food Textural Profile curve for a food product which also shows adhesiveness. Label the curve with the primary textural parameters and areas under the curve. Define in formula form cohesiveness, gumminess and chewiness. (10 marks)

(b) Sketch a force-deformation curve for 2 cycles compression for a small strain, i.e. 10%. Assume all plastic changes have vanished after the first compression cycle. Start the curve for the second compression cycle at the end of the displacement for the first cycle. Label the stress at 10% compression, the degree of elasticity, the mechanical hysteresis loss and the secant modulus of deformability and elasticity. (10 marks)

6. (a) What would be the non-Newtonian class of a bio-material in a laminar flow pipeline if the pressure drop/pipe length versus pipe length were (a) linearly decreasing, (b) exponentially increasing, and (c) exponentially decaying? (10 marks)

(b) Explain Kelvin model to analyse creep behaviour data of a food product. (5 marks)

(c) Sketch a shear stress vs. shear rate diagram for a pseudoplastic fluid over a range from creeping flow to very high shear rates. Show when a Newtonian-like behavior is to be expected. Briefly explain why? (5 marks)

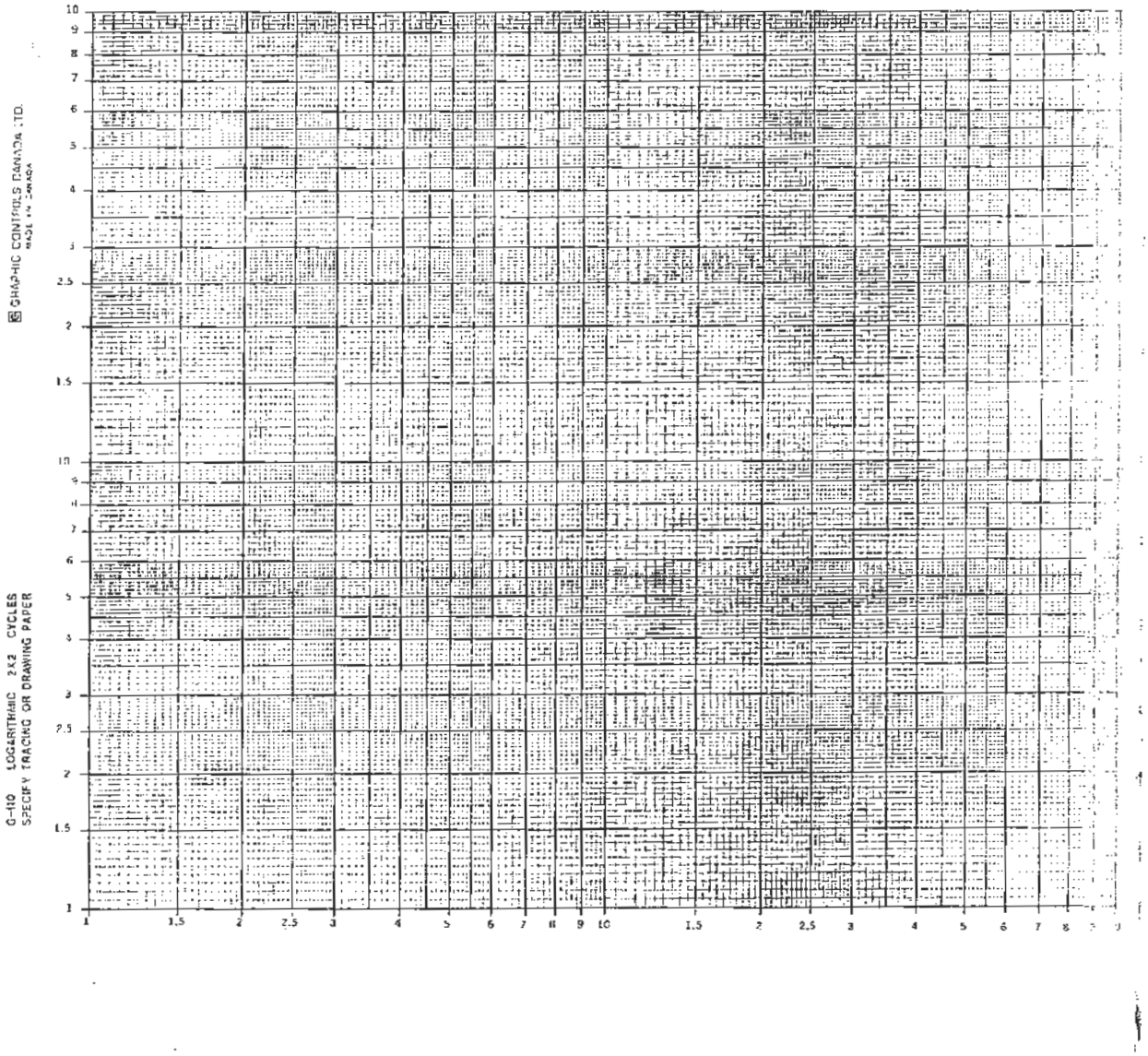
7a. Given the following size analysis of a sample, calculate length mean particle diameter, and volume mean particle diameter. D_p = mean particle diameter, N = number of particles. (12 marks)

D_{pi}, µm	N_i	N_iD_{pi}	$N_iD_{pi}^2$	$N_iD_{pi}^3$
2	30			
6	40			
10	90			
14	100			
18	120			
22	80			
26	65			
30	15			

7b. Define drag coefficient, frictional drag and terminal velocity in aerodynamic characteristics of particles. (8 marks)

8. (a) Define the surface and interfacial tension of liquid foods. (4 marks)
(b) Define the work of cohesion and adhesion, and spreading coefficient of liquid foods. (6 marks)
(c) What is the effect of temperature on surface tension of a liquid food? (3 marks)
(d) Explain capillary pull (du Nouy surface tension balance) method of measuring surface tension of a liquid food. (7 marks)

9. (a) List 3 methods of measuring volume of a fruit product. (4.5 marks)
(b) List 3 methods of porosity measurement of a fried food product. (4.5 marks)
(c) List 2 methods of measuring surface area of a vegetable product. (3 marks)
(d) How could you use a freezing point depression to monitor the solids concentration of a beverage? (5 marks)
(e) Give a conceptual view of why the addition of a solute in a liquid lowers its vapour pressure. (3 marks)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