National Exams May 2017

04-Agric-A6, Physical Properties of Biological Materials and Food Products

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, to the point and concise.

Marking Scheme

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

1. (a) 4 marks, (b) 4 marks, (c) 4 marks, (d) 8 marks
2. 20 marks total
3. 20 marks total
4. 20 marks total
5. 20 marks total
6. (a) 10 marks, (b) 5 marks, (c) 5 marks
7. (a) 15 marks, (b) 5 marks
8. 20 marks total
9. (a) 6 marks, (b) 2 marks, (c) 2 marks, (d) 6 marks, (e) 4 marks

Do any 5 questions

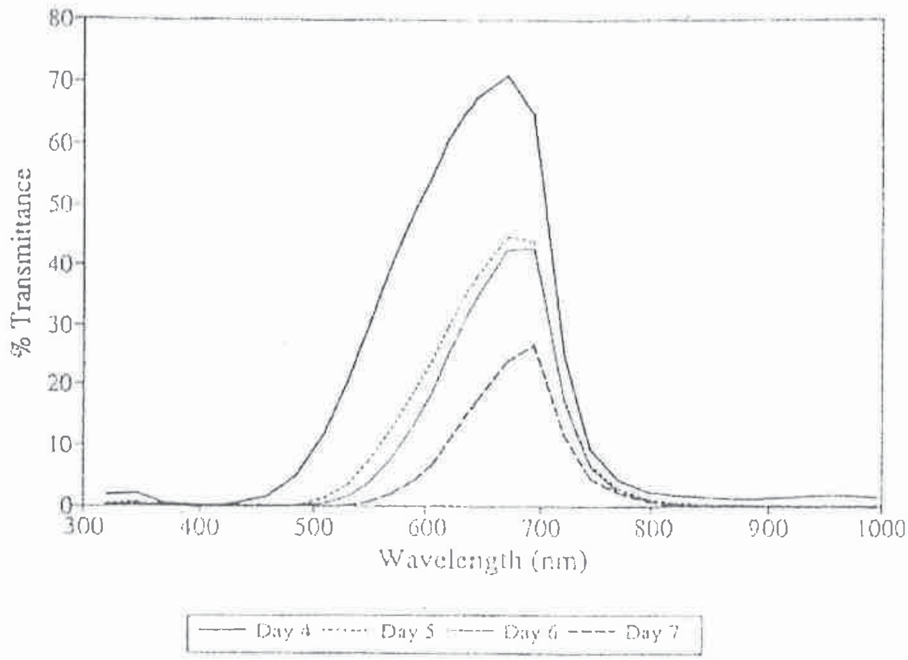
1. (a) Why are thermal properties important in engineering design? (4 marks)

   (b) Explain relationship behind specific heat (Cp) and enthalpy (H) conceptually and thermodynamically? (4 marks)

   (c) What is the most important component of a food w.r.t. its influence on thermal conductivity (k)? (4 marks)

   (d) Define heat transfer coefficient (h) conceptually and mathematically. What are the factors affecting h? When h can be neglected in heat transfer calculations? (8 marks)

2. Figure below is a plot of % transmittance at different wavelengths of light through a fat (oil) used for food frying for 4 to 7 days. Why % transmittance has decreased with time of oil use? Why % transmittance has peaked at a certain wavelength? What you conclude from this plot? How this information can be used to develop an online sensor to measure frying oil quality? Using a spectrophotometer how other optical properties such as Aabsorbance≅ and Aphotometric colour index≅ of the fat can be measured or calculated? (20 marks)



Percentage transmittance as a function of wavelength for fat taken from day 4 to day 7 of frying.

3. A rotational wide gap viscometer (like Brookfield make), was used to evaluate the apparent viscosity of tomato catsup. One spindle (No. 4) gave readings within the measuring scale of the instrument at 4 rotational speeds. The viscometer constant was 7187 dynes/cm full scale. The torque readings at various rotational speeds in rpm are as follows:

Rotational speed (rpm)	2	4	10	20
Viscometer indicator reading (% full scale)	53.5	67	80.5	97

Evaluate the flow behaviour index (n) for this food. Use log-log graph paper or ordinary graph provided. (20 marks)

4. Physical properties influence the composition and processing of fabricated food products. Select a liquid or solid food product and describe it carefully. Then indicate how specific properties such as pH, water activity (a_w), surface tension (γ), moisture diffusivity (D_m), thermal diffusivity (α), rheological properties (viscosity (μ), flow behaviour index, consistency coefficient, yield stress), specific heat (c_p), thermal conductivity (k), textural attributes influence its formulation and processing. Be specific. (20 marks)

5. A thin cylindrical probe with a heater wire and thermocouple is used to measure the thermal conductivity of a peanut butter. The resistance of the heater wire is 17.1 Ω/m, current applied to the heater wire is 0.1958 A, probe correction factor is 0.309 A.m, and heater wire length is 3.94 cm. The following time- temperature data are recorded:

Time, s	0	3	6	9	12	15	18	21
Temperature, °C	26.2	30.9	34.4	36.5	37.8	38.7	39.4	40.0

Calculate the thermal conductivity of the peanut butter in W/(m.K). Use regular graph paper provided. (20 marks)

6. (a) In a textural profile analysis (TPA, two cycle compression with constant strain) test, what will be the effect of sample size (cylindrical shape, diameter to height ratio) on the TPA parameters B hardness-1 (N/m^2), cohesiveness and elasticity (cm)? Will the rate of sample compression affect these parameters? (10 marks)

(b) Explain Maxwell model to analyse stress relaxation behaviour data of a food product. (5 marks)

(c) What could cause Abrittle≅ behaviour besides fracture in a food product? (5 marks)

7a. Given the following size analysis of a food sample, calculate mean volume surface, mean surface and length mean diameters. D_p = mean particle diameter, N = number of particles. (15 marks)

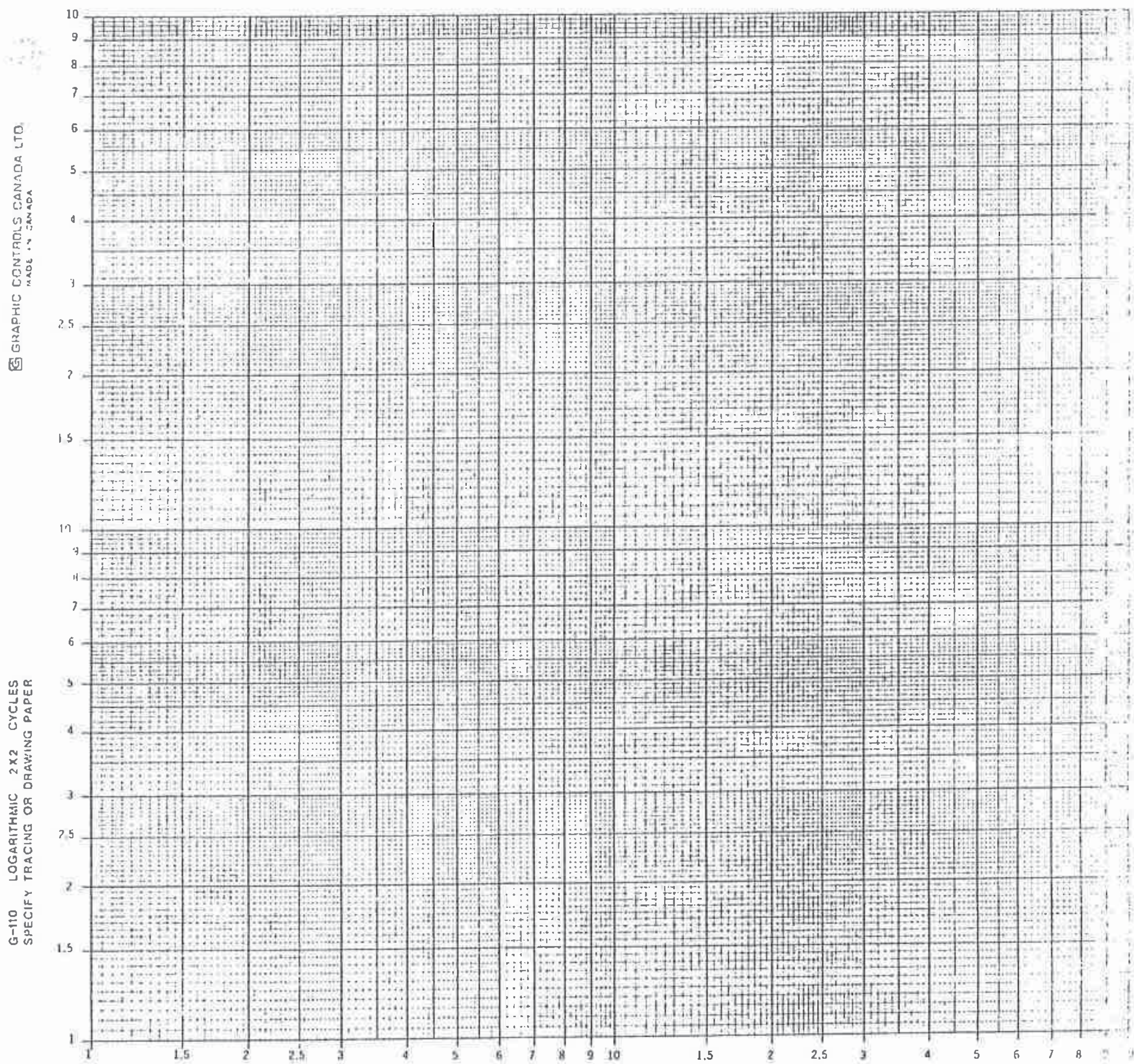
D_{pi}, cm	N_i
0.2	3
0.3	12
0.4	20
0.5	8
0.6	2

7b. Calculate the sphericity of a cube whose length of a side is = W. Note: Calculate equivalent D_p (particle diameter) by equating the volume of a sphere having diameter D_p with the cube volume. (5 marks)

8. Let us consider how we mechanically Aload≅ food products and sense their mechanical properties in a number of different situations. Describe the process in a sentence or two. Then indicate (i) whether the strain is small, medium or large, (ii) whether the rate of strain is slow, medium or fast, (iii) briefly describe how this test could be simulated mechanically in the laboratory.

(a) How does a shopper sense the quality of a ripe tomato?
(b) How does a consumer sense the ripeness of a melon by thumping it?
(c) How does a consumer sense the consistency of a milk shake?
(d) How does a consumer sense the texture of an apple by chewing?
(e) How does a consumer sense the texture of a potato chip or a cheese puff? (20 marks)

9. (a) Define rheology. Why is rheology important in process design? What is shear stress? (6 marks)
(b) What characteristics of a liquid do viscosity measure? (2 marks)
(c) What is the effect of temperature on viscosity? (2 marks)
(d) Define Bingham plastic, pseudoplastic and dilatant foods. (6 marks)
(e) What is the effect of temperature on flow behaviour index and consistency coefficient? (4 marks)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