Montogue

GATE Food Technology (XE-G):

◆20 Practice Questions

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Here's a set of 20 fully solved problems for applicants to the GATE Food Technology (XE-G) sub-exam. Problems were taken from past question papers and a carefully researched assortment of textbooks. All problems are solved step by step. Enjoy! ■

→ **Problems 1 – 10 are one-mark problems.**
→ **Problems 11 – 20 are two-mark problems.**

Problems marked wlth a red square (■) are taken from past exams. The remaining problems were specifically devised for this quiz.

PROBLEMS

Problem 1. Regarding food lipid oxidation, which of the following is **false**?
(A) Vacuum packaging reduces interactions between oxygen and the lipid, thereby delaying oxidation.
(B) Exposure to light promotes lipid oxidation.
(C) Metal ions such as iron and copper may act as catalysts for lipid oxidation.
(D) Fatty acids with several unsaturated bonds are less susceptible to oxidation than saturated fats.

Problem 2. A batch fryer that holds 600 kg of oil can process 0.96 metric tonnes of food product per hour. If the product absorbs 7.5% oil (by mass) during frying, what is the oil turnover rate?
(A) 6 h
(B) 6.33 h
(C) 8.33 h
(D) 9 h

■ **Problem 3.** The type of casein protein most responsible for the stability of micelles in milk is:
(A) α_{s1}-Casein
(B) α_{s2}-Casein
(C) κ-Casein
(D) β-Casein

■ **Problem 4.** Spoilage of milk involves a well-defined succession of:

P → *Lactobacillus*
Q → Yeasts and molds
R → *Lactococcus lactis*
S → Protein-digesting bacteria

The correct order of succession is:
(A) S → Q → R → P
(B) S → R → Q → P
(C) Q → S → P → R
(D) R → P → Q → S

Problem 5. The primary structure of a protein is:
(A) Related to interactions between the *R* groups of the amino acids that make up the protein.
(B) The sequence of amino acids in the polypeptide chain.
(C) The sequence of monosaccharides in the polypeptide chain.
(D) The specific arrangement of α-helix along a horizontal axis.

■ **Problem 6.** Match the enzymes in Group I with the corresponding functions in Group II.

Group I	Group II
P. Amylase	**1.** Conversion of sucrose to glucose and fructose
Q. Invertase	**2.** Effectiveness of pasteurization
R. Protease	**3.** Softening of dough
S. Phosphatase	**4.** Conversion of starch to maltose

(A) P.4; Q.1; R.3; S.2
(B) P.4; Q.1; R.2; S.3
(C) P.1; Q.2; R.4; S.3
(D) P.1; Q.4; R.3; S.2

Problem 7. How much juice flavor concentrate (28% total solids) should be added to 40 kg of apple juice (10% T.S.) to obtain a product with 13% T.S.?
(A) 1.8 kg
(B) 2.5 kg
(C) 5 kg
(D) 8 kg

Problem 8. The Lineweaver-Burk plot for an enzymatic reaction in a souring food was shown to yield a maximum reaction velocity of 150 μmol/L·min and a slope of 0.4 min. What is the velocity of the reaction, in μmol/L·min, for a substrate concentration of 32 μmol/L?
(A) 52.1
(B) 60.5
(C) 64.1
(D) 72.0

Problem 9. The variation of viscosity with temperature for a clarified peach juice is given by the Arrhenius-like equation

$$\eta = 8\times 10^{-11}\exp\left(\frac{7400}{T}\right)$$

where *T* is temperature in K and η is the dynamic viscosity in Pa·s. It is known that a peach juice production plant uses a plate heat exchanger that only allows fluids with viscosity lower than 1650 mPa·s to pass through. Accordingly, the minimum temperature required to process a clarified peach juice in this heat exchanger is __________ (◆ kelvins, *rounded to one decimal place*).

Problem 10. Suppose that a bacterial population in the exponential growth phase doubles every 6 hours. If the initial population is 500 individuals, the time required for the population to increase to 45,000 is ________ (◆ hours, *rounded to one decimal place*).

Problem 11. A fluid food product with constant viscosity of 12 cP and density of 1090 kg/m^3 is to be pasteurized in a continuous system that heats the food to 75°C. followed by holding in a 76.2-mm diameter sanitary pipe from which it leaves at 70°C. The process is designed to achieve a 12 decimal reduction of *Staphylococcus aureus*, which has a *D*-value at 75°C close to 0.0092 min. Calculate the length of the holding tube if the flow rate is 25 L/min.
(A) 0.6 m
(B) 1.2 m
(C) 1.8 m
(D) 2.4 m

Problem 12. High-pressure inactivation of *S. cerevisiae* ascospores in grape juice at 24°C yielded two different *D*-values at two different pressures, as shown below:

Pressure (MPa)	*D* value (min)
250	4.8
400	0.9

What is the pressure-based *z*-value for this operation?
(A) 44 MPa
(B) 80 MPa
(C) 146 MPa
(D) 206 MPa

Problem 13. Associate the fermented product in Group I with the base material in Group II.

Group I	Group II
P. Cachaça	**I.** Milk
Q. Kvass	**II.** Sugarcane
R. Chhurpi	**III.** Rice
S. Sake	**IV.** Rye

(A) P.II; Q.IV; R.III; S.I
(B) P.II; Q.IV; R.I; S.III
(C) P.IV; Q.III; R.I; S.III
(D) P.II; Q.I; R.III; S.IV

■ **Problem 14.** The gradual decrease in viscosity of tomato paste during storage can be prevented by quickly heating it to 82°C, because:
(A) Water-soluble pectin interacts with calcium.
(B) Hemicellulose prevents decrease in viscosity.
(C) Pectin methylesterase is deactivated.
(D) Lignin prevents decrease in viscosity.

Problem 15. A ketchup sample may be assumed to behave like a power-law fluid with rheological parameters $K = 2.02$ Pa·s^n and $n = 0.85$. This fluid is pumped at a velocity of 1 m/s through a pipe of internal diameter equal to 15 mm and length of 1.8 m. Assuming laminar flow and no entry effects, what is the pressure drop for this system?
(A) 105.3 kPa
(B) 201.6 kPa
(C) 280.0 kPa
(D) 315.1 kPa

Problem 16. A crushing device fed at a rate of 1 ton per hour is used to comminute spherical grains from 5 mm diameter to 2.4 mm. The crusher requires 1.25 kWh to carry out this operation. Using von Rittinger's law, find the power required to crush 5-mm grains to 1.2 mm using the same crusher at the same feeding rate.
(A) 2.08 kW
(B) 2.58 kW
(C) 3.65 kW
(D) 4.81 kW

Problem 17. The wall of a baking oven consists of two metal sheets with insulation in between. The temperature of the inner wall surface is 80°C and that of the outer surface is 40°C. The thickness of each metal sheet is 10 mm and the thickness of the insulation is 12 mm. The thermal conductivities of the metal and insulation are 5 W/m·K and 1 W/m·K, respectively. Given these data, the heat transfer loss through the wall per m^2 of wall area is _____ (◆watts, *no decimal places*).

Problem 18. In a process used to obtain powdered milk, an atomization stage is used. Drops of milk shaped like spheres of 0.85 mm diameter fall in the atomized chamber, where air circulates at 125°C. The drops and the air circulate in countercurrent with a relative velocity of 28 m/s. Assuming that the surface temperature of the drop is 50°C and that the mass diffusivity of water vapor in air at the temperature of interest is 3.5×10^{-5} m^2/s, the corresponding convective mass transfer coefficient is ___________ (◆m/s, *rounded to one decimal place*). Use the correlation $Sh = 2.0 + 0.95(Re)^{0.5}(Sc)^{1/3}$. Take 1.0 kg/m^3 and 0.03 mPa·s as the density and viscosity of air, respectively.

Problem 19. In a batch soaking and steaming unit, raw paddy with an initial moisture content of 0.14 (dry basis) is soaked at 58°C under isothermal conditions. If the initial moisture gain for this paddy at 58°C is 0.05 and the value of k_m for use in the hydration equation is given as 2.4×10^{-3}, the time required to attain a moisture content of 43% (dry basis) is ___________ (◆hours, *rounded to one decimal place*).

Problem 20. (Long problem) A pizza is being frozen in an air-blast freezer. The pizza has average thickness equal to 1.5 cm, frozen thermal conductivity equal to 1.4 W/m·K, and density of 900 kg/m^3. The specific heat capacity is 2.9 kJ/kg·K unfrozen and 1.92 kJ/kg·K frozen, and the latent heat of freezing is 300 kJ/kg. Cooling air is at −35°C and the pizza, which has an initial freezing point of −3°C, enters the freezer at 10°C and leaves it at −12°C. The convective heat transfer coefficient for the cold air-pizza system may be taken as 18 W/m^2·K. Using the Pham model, the freezing time for the pizza in hours is ______ (◆hours, *rounded to two decimal places*). Assume that the pizza is a homogeneous product and take E = 1 as the shape parameter.

ANSWER KEY

Problem	Answer	Problem	Answer
1	D	11	B
2	C	12	D
3	C	13	B
4	D	14	C
5	B	15	B
6	A	16	C
7	D	17	2500
8	A	18	1.13
9	311.6	19	2.78
10	39.0	20	1.35

SOLUTIONS

1 ➡ D

Fatty acids with more double bonds are generally more susceptible to oxidation than saturated fats.

2 ➡ C

Oil that is absorbed by the food is periodically replaced with fresh oil in the fryer. The 'oil turnover' represents the time needed to completely replace the oil in a fryer:

$$\text{Oil turnover} = \frac{\text{Weight of oil in a fryer}}{\text{Weight of oil added per hour}}$$

In the case at hand,

$$\text{Oil Turnover} = \frac{600}{960\times0.075} = \boxed{8.33\text{ h}}$$

3 ➡ C

κ-casein is responsible for the micelle-stabilizing effect mentioned in the statement. The crucial role of κ-casein in micelle stabilization has been corroborated by researchers, who've reported, for instance, that κ-caseindeficient mice did not lactate because of destabilization of micelles in the lumina of the mammary gland.

4 ➡ D

Lactococcus lactis is normally the first kind of bacteria observed in souring milk. It is followed by the development of lactobacilli, which, like their predecessors, metabolize lactose and release lactic acid, causing the milk to coagulate. Afterwards, yeasts and molds populate the acid environment left by the bacilli. Lastly, protein-digesting bacteria consume the few remaining nutrients in the milk culture.

5 ➡ B

The primary structure is related to the linear sequence of amino acids within a protein. Option (D), which speaks of the 'specific arrangement of α-helix along a horizontal axis', is related to *secondary* structure. Option (A), which speaks of 'interactions between the *R* groups of amino acids,' is related to the *tertiary* structure of proteins.

6 ➡ A

Invertase is an enzyme that catalyzes the hydrolysis of sucrose dimer into fructose and glucose. Amylase is an enzyme that catalyzes the hydrolysis of starch polymer into sugar. Alkaline phosphatase is an enzyme that is naturally present in milk, but is destroyed at a temperature close to the pasteurization temperature; in view of this feature, the so-called 'alkaline phosphatase test' can be used to indicate whether milk has been adequately pasteurized or has been contaminated with raw milk after pasteurization. Proteases are used on a large commercial scale in the production of bread, baked goods, crackers, and waffles.

7 ➡ D

The feed juice is labeled *F*; the concentrate is labeled *C*; the product is labeled *P*. Writing a mass balance on the total amount of material in the system, we have

$$\text{Mass of feed juice} + \text{Mass of concentrate} = \text{Mass of juice product}$$
$$40 + C = P \quad (\text{I})$$

Now, a mass balance on the amount of solids gives

$$\begin{bmatrix}\text{Mass of solids}\\ \text{initial food}\end{bmatrix} + \begin{bmatrix}\text{Mass of solids}\\ \text{in concentrate}\end{bmatrix} = \begin{bmatrix}\text{Mass of solids}\\ \text{in juice product}\end{bmatrix}$$

$$\therefore 0.10F + 0.28C = 0.13P$$
$$\therefore 0.10 \times 40 + 0.28C = 0.13P$$
$$\therefore 4.0 + 0.28C = 0.13P$$
$$\therefore P = 30.77 + 2.154C$$

Substituting in (I) and solving for *C*, we get

$$40 + C = 30.77 + 2.154C$$
$$\therefore 40 - 30.77 = 1.154C$$
$$\therefore \boxed{C = 8.0\text{ kg}}$$

That is to say, a mass of 8 kg of concentrate should be added to the initial product.

8 ➡ A

A Lineweaver-Burk plot is a line given by

$$\frac{1}{V} = \frac{k_m}{V_{\max}} \frac{1}{[\mathrm{S}]} + \frac{1}{V_{\max}}$$

Substituting V_{max} = 150 μmol/L·min, [*S*] = 32 μmol/L, and the given slope k_m/V_{max} = 0.4 min, we obtain

$$\frac{1}{V} = 0.4 \times \frac{1}{32} + \frac{1}{150} = 0.0192 \frac{\mathrm{L \cdot min}}{\mu\mathrm{mol}}$$

The velocity we aim for is the reciprocal of this result, or

$$V = \frac{1}{0.0192} = \boxed{52.1\ \frac{\mu\text{mol}}{\text{L}\cdot\text{min}}}$$

9 ➡ 300 – 320

The minimum temperature can be found by substituting η = 1.65 Pa·s into the equation we were given and solving for T:

$$\eta_{\max} = 8\times10^{-11}\exp\left(\frac{7400}{T_{\min}}\right) \;\rightarrow\; 1.65 = 8\times10^{-11}\exp\left(\frac{7400}{T_{\min}}\right)$$

$$\therefore 2.06\times10^{10} = \exp\left(\frac{7400}{T_{\min}}\right)$$

$$\therefore 23.75 = \frac{7400}{T_{\min}}$$

$$\therefore T_{\min} = \frac{7400}{23.75} = \boxed{311.6\text{ K}}$$

In order to use the heat exchanger, the clarified peach juice must be at a temperature no lower than 311.6 K ≈ 38.5°C.

10 ➡ 38 – 40

With an initial population P_0 = 500 and a doubling time D = 6 h, the population evolves with the exponential law

$$P(t) = 500\times2^{(t/6)}$$

Substituting P = 45,000 and applying logarithms, we obtain

$$P(t) = 500\times2^{(t/6)} \;\rightarrow\; 45{,}000 = 500\times2^{(t/6)}$$

$$\therefore 90 = 2^{(t/6)}$$

$$\therefore \log_2 90 = \log_2 2^{(t/6)}$$

$$\therefore 6.492 = \frac{t}{6}$$

$$\therefore t = 6\times6.492 = \boxed{39.0\text{ h}}$$

The bacterial population will reach 45,000 within approximately 39 hours.

11 ➡ B

The average velocity of flow in the tube is

$$\overline{V} = \frac{q}{\left(\pi d^2/4\right)} = \frac{(25/60)\times10^{-3}}{\pi\times0.0762^2/4} = 0.0914\text{ m/s}$$

The corresponding Reynolds number is

$$\text{Re}_d = \frac{\rho\overline{V}d}{\mu} = \frac{1090\times0.0914\times0.0762}{12\times10^{-3}} = 633$$

But the holding length is usually calculated on the basis of *maximum* velocity, which for Hagen-Poiseuille flow equals twice the average velocity, or

$$V_{\max} = 2\overline{V} = 2\times0.0914 = 0.183\text{ m/s}$$

(The problem statement says nothing about using the average or maximum velocity, but one assumes that, if this type of question were to appear in a GATE exam, the student would be told which velocity to use.) The F-value is the required process time, and must be equal to the residence time in the tube for the fastest flowing particle. For a decimal reduction S = 12, we have $F = t_{min} = S \times D$ = 12 × 0.0092 = 0.110 min. The corresponding tube length then becomes

$$t_{\min} = \frac{L}{V_{\max}} \;\rightarrow\; L = V_{\max}t_{\min}$$

$$\therefore L = 0.183\times(0.110\times60) = \boxed{1.21\text{ m}}$$

12 ➡ D

The equation to use is

$$D = D_1 \times 10^{\left(\frac{p_1 - p}{z_p}\right)}$$

which is the high-pressure inactivation equivalent of high-temperature inactivation kinetics. Substituting D = 0.9 min, P = 400 MPa, D_1 = 4.8 min, and P_1 = 250 MPa and solving for z_P, we have

$$D = D_1 \times 10^{\left(\frac{p_1 - p}{z_p}\right)} \rightarrow 0.9 = 4.8 \times 10^{\left(\frac{250-400}{z_p}\right)}$$

$$\therefore \log_{10} 0.9 = \log_{10} 4.8 + \log_{10} 10^{\left(\frac{250-400}{z_p}\right)}$$

$$\therefore -0.0458 = 0.681 + \frac{250-400}{z_p}$$

$$\therefore -0.727 = \frac{-150}{z_p}$$

$$\therefore z_p = \frac{150}{0.727} = \boxed{206.3\ \text{MPa}}$$

13 ➡ D

Cachaça is a Brazilian fermented beverage produced from sugarcane. Kvass is a Northern European beverage made from processed rye bread or rye flour. Chhurpi is a traditional cheese consumed in Tibet. Sake is a Japanese fermented beverage made from rice.

14 ➡ C

It is well-known that the viscosity of tomato paste is directly related to the activity of pectin methylesterase (PME) and polygalacturonase (PG), which can cause the degradation of cell wall pectin. Pectin methylesterase decreases the esterification degree of the pectins and polygalacturonase transforms them into smaller soluble compounds, influencing the charge of the cell wall and decreasing cell-to-cell adhesion; the final macroscopic effect is a decrease in viscosity.

15 ➡ B

The pressure drop is given by the Poiseuille equation, in this case modified for power-law fluids:

$$\Delta p = \left(\frac{4KL}{D}\right)\left(\frac{8u}{D}\right)^n = \left(\frac{4 \times 2.02 \times 1.8}{0.015}\right) \times \left(\frac{8 \times 1}{0.015}\right)^{0.85} = 201{,}600\ \text{Pa}$$

$$\therefore \boxed{\Delta p = 201.6\ \text{kPa}}$$

16 ➡ C

Substituting data for the initial operation, we have

$$W_1 = K_{VR}\left(\frac{1}{P_1} - \frac{1}{F_1}\right) \rightarrow 1.25 = K_{VR}\left(\frac{1}{2.4} - \frac{1}{5.0}\right) \text{(I)}$$

Substituting data for the second operation, we have

$$W_2 = K_{VR}\left(\frac{1}{P_2} - \frac{1}{F_2}\right) \rightarrow W_2 = K_{VR}\left(\frac{1}{1.2} - \frac{1}{5.0}\right) \text{(II)}$$

The von Rittinger work index K_{VR} is unknown, but we can solve for W_2 without determining it if we divide (II) by (I), giving

$$\frac{W_2}{1.25} = \frac{\cancel{K_{VR}}\left(\frac{1}{1.2} - \frac{1}{5.0}\right)}{\cancel{K_{VR}}\left(\frac{1}{2.4} - \frac{1}{5.0}\right)}$$

$$\therefore \frac{W_2}{1.25} = \frac{0.633}{0.217}$$

$$\therefore W_2 = 3.65\ \text{kWh/t}$$

For a feed rate of 1 ton/hr, the corresponding power is

$$\Pi = 3.65\times 1.0 = \boxed{3.65\text{ kW}}$$

17 ➡ 2500

We basically have three thermal resistances connected in series. The resistance offered by either the inner *(R_1)* or the outer (R_3) steel wall is:

$$R_1 = R_3 = \frac{\Delta x}{k_{\text{steel}}A} = \frac{0.01}{5\times 1} = 2.0\times 10^{-3}\ ^{\text{o}}\text{C/W}$$

In turn, the resistance of the insulation is

$$R_2 = \frac{\Delta x}{k_{\text{ins}}A} = \frac{0.012}{1\times 1} = 12.0\times 10^{-3}\ ^{\text{o}}\text{C/W}$$

The equivalent resistance then becomes

$$\Sigma R = R_1 + R_2 + R_3 = \left(2.0+12.0+2.0\right)\times 10^{-3}$$

$$\therefore \Sigma R = 16\times 10^{-3}\ ^{\text{o}}\text{C/W}$$

The heat transfer through the wall follows as

$$q = \frac{\Delta T}{\Sigma R} = \frac{80-40}{16\times 10^{-3}} = \boxed{2500\text{ W}}$$

18 ➡ 1.0 – 1.3

The first step is to compute the Reynolds number:

$$\text{Re} = \frac{\rho u d}{\mu} = \frac{1.0\times 28\times\left(0.85\times 10^{-3}\right)}{0.03\times 10^{-3}} = 793$$

In turn, the Schmidt number is

$$\text{Sc} = \frac{\mu}{\rho D} = \frac{0.03\times 10^{-3}}{1.0\times\left(3.5\times 10^{-5}\right)} = 0.857$$

The Sherwood number can be established from the correlation we were given:

$$\text{Sh} = 2.0 + 0.95\left(\text{Re}\right)^{0.5}\left(\text{Sc}\right)^{1/3} = 2.0 + 0.95\times 793^{0.5}\times 0.857^{1/3}$$

$$\therefore \text{Sh} = 27.4$$

Finally, from the definition of *Sh*,

$$\text{Sh} = \frac{h_m d}{D} \rightarrow h_m = \frac{\text{Sh}\times D}{d}$$

$$\therefore h_m = \frac{27.4\times\left(3.5\times 10^{-5}\right)}{0.85\times 10^{-3}} = \boxed{1.13\text{ m/s}}$$

19 ➡ 2.6 – 3.0

The empirical hydration equation is

$$\left(\bar{x} - x_0\right) = \Delta x_i + k_m\sqrt{\theta}$$

where $\bar{x}$ is the average moisture content (d.b.) for a soaking period, x_0 is the initial moisture content (d.b.), Δx_i is the initial moisture gain, k_m is a proportionality constant, and θ is the soaking period. Solving for $\sqrt{\theta}$ and substituting the given data, we get

$$\sqrt{\theta} = \frac{\bar{x} - x_0 - \Delta x_i}{k_m} = \frac{0.43-0.14-0.05}{2.4\times 10^{-3}} = 100\text{ s}^{1/2}$$

Squaring both sides,

$$\sqrt{\theta} = 100\text{ s}^{1/2} \rightarrow \theta = 100^2 = 10{,}000\text{ s}$$

$$\therefore \boxed{\theta = 2.78\text{ h}}$$

The soaking period should be about 2 hours and 47 minutes.

20 ➡ 1.15 – 1.55

The equation to use is

$$t_f = \frac{1}{E}\left(\frac{\Delta H_1}{\Delta \theta_1} + \frac{\Delta H_2}{\Delta \theta_2}\right)\left(\frac{R}{h} + \frac{R^2}{2k_f}\right) \quad \text{(I)}$$

where

$$\Delta H_1 = \rho c_u \left(\theta_i - \theta_{fm}\right)$$

$$\Delta H_2 = \rho\lambda + \rho c_f \left(\theta_{fm} - \theta_{fin}\right)$$

$$\Delta\theta_1 = \frac{\left(\theta_i + \theta_{fm}\right)}{2} - \theta_a$$

$$\Delta\theta_2 = \theta_{fm} - \theta_a$$

$$\theta_{fm} = 1.8 + 0.263\theta_{\text{fin}} + 0.105\theta_a$$

$$\theta_{fm} = 1.8 + 0.263\times(-12) + 0.105\times(-35) = -5.03^\circ\text{C}$$

$$\Delta H_1 = 900\times 2900\times\left[20-(-5.03)\right] = 6.53\times 10^7 \text{ J/m}^3$$

$$\Delta\theta_1 = 0.5\times(10-5.03)-(-35) = 37.5^\circ\text{C}$$

$$\Delta H_2 = 900\times 333{,}000 + 860\times 1920\times\left[-5.03-(-12)\right] = 2.82\times 10^8 \text{ J/m}^3$$

$$\Delta\theta_2 = \theta_{fm} - \theta_a = -5.03-(-35) = 30.0^\circ\text{C}$$

We also have half-thickness R = 1.5/2 = 0.75 cm, convective heat transfer coefficient h = 18 W/m^2·K, and frozen-product thermal conductivity k_f = 1.4 W/m·K. Substituting in (I) brings to

$$t_f = \frac{1}{1.0}\times\left(\frac{6.53\times 10^7}{37.5} + \frac{2.82\times 10^8}{30.0}\right)\times\left(\frac{0.0075}{18} + \frac{0.0075^2}{2\times 1.4}\right) = 4870 \text{ s}$$

$$\therefore \boxed{t_f = 1.35 \text{ h}}$$

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