Example Answers

International Master's Programs of Chemical Engineering in the Graduate School of Engineering, Kyushu University (Academic Year from October, 2025)

Subject：Biochemical Engineering（1 heet）

1.

(1.1)

The Crabtree effect is a metabolic phenomenon in which aerobic organisms, particularly yeasts such as *Saccharomyces cerevisiae*, preferentially ferment rather than respirate when exposed to high concentrations of glucose, even in the presence of sufficient oxygen.

The glucose effect, also known as catabolite repression, is a regulatory mechanism whereby the presence of glucose represses the expression of genes involved in the metabolism of alternative carbon sources. In bacteria such as *Escherichia coli*, high glucose levels inhibit the transcription of operons such as the lac operon, thereby prioritizing glucose metabolism over other sugars.

(1.2)

SDS-PAGE (Sodium Dodecyl Sulfate–Polyacrylamide Gel Electrophoresis) separates proteins based on their molecular weight. Sodium dodecyl sulfate (SDS), a detergent, binds to proteins, denatures them, and gives them a uniform negative charge proportional to their length. When an electric field is applied, proteins migrate through a polyacrylamide gel matrix—smaller proteins move faster and farther than larger ones.

Other methods: Size-Exclusion Chromatography (Gel Filtration), Mass Spectrometry (e.g., MALDI-TOF, ESI-MS), Analytical Ultracentrifugation, etc.

(1.3)

Density gradient centrifugation, especially using a cesium chloride (CsCl) gradient in the presence of ethidium bromide (EtBr), is a classic method for separating plasmid DNA from genomic DNA. During ultracentrifugation, CsCl forms a continuous density gradient. When EtBr is added, it intercalates into DNA and reduces its buoyant density. The degree of intercalation depends on the DNA structure—supercoiled plasmid DNA binds less EtBr than linear or relaxed DNA, resulting in different equilibrium densities.

2.

(2.1) $$\boldsymbol{t} = \int_{C_{\mathrm{S0}}}^{C_{\mathrm{S}}} \frac{\mathrm{d}C_{\mathrm{S}}}{r_{\mathrm{S}}} = \frac{K_{\mathrm{m}}}{V_{\max}} \ln\frac{C_{\mathrm{S0}}}{C_{\mathrm{S}}} + \frac{C_{\mathrm{S0}}-C_{\mathrm{S}}}{V_{\max}} = \frac{5.0}{1.0}\ln\frac{100}{5.0} + \frac{100-5.0}{1.0} = \mathbf{110\ \ s}$$

(2.2) $$\tau = \frac{C_{\mathrm{S0}}-C_{\mathrm{S}}}{-r_{\mathrm{S}}} = \frac{C_{\mathrm{S0}}-C_{\mathrm{S}}}{\frac{V_{\max}C_{\mathrm{S}}}{K_{\mathrm{m}}+C_{\mathrm{S}}}} = \frac{(C_{\mathrm{S0}}-C_{\mathrm{S}})(K_{\mathrm{m}}+C_{\mathrm{S}})}{V_{\max}C_{\mathrm{S}}}$$

$$\boldsymbol{D} \equiv \frac{1}{\tau} = \frac{V_{\max}C_{\mathrm{S}}}{(C_{\mathrm{S0}}-C_{\mathrm{S}})(K_{\mathrm{m}}+C_{\mathrm{S}})} = \frac{1.0\times5.0}{(100-5)(5.0+1.0)} = \mathbf{5.3\times10^{-3}\ \ s^{-1}}$$

(2.3) $$(1-\varepsilon)\tau = \frac{(C_{\mathrm{S0}}-C_{\mathrm{S}})(K_{\mathrm{m}}+C_{\mathrm{S}})}{\eta V_{\max}C_{\mathrm{S}}}$$

$$\frac{\boldsymbol{\eta}\times(1-\boldsymbol{\varepsilon})}{\boldsymbol{D}} = \frac{(\boldsymbol{C}_{\mathbf{S0}}-\boldsymbol{C}_{\mathbf{S}})(\boldsymbol{K}_{\mathbf{m}}+\boldsymbol{C}_{\mathbf{S}})}{\boldsymbol{V}_{\mathbf{max}}\boldsymbol{C}_{\mathbf{S}}}$$