University of Ruhuna- Faculty of Technology
Bachelor of Biosystems Technology Honours Degree
Level 1 (Semester I) Examination, December 2025
Academic year 2023/2024

Course Unit: BST 1181 Thermodynamics (written) (Old) **Duration: 1and 1/2 hour**

Instruction for candidate:

- Answer only **three** (03) questions.
- Use a separate book for answering the questions.
- Each question should be started with a new page.
- Universal gas constant (R) = 8.314 J k^{-1} mol^{-1}

1. Gibbs free energy change, ΔG° describes the spontaneity of the reaction. This is dependent on the standard enthalpy and entropy changes, and the temperature.

   a) State and explain whether the following processes will lead to an increase or decrease in entropy.

      i. Converting solid I_2 to I_2 vapor.

      ii. The conversion of graphite to diamond.

      iii. $2NO(g)+O_2(g) \rightarrow 2NO_2(g)$ (15 marks)

   b) Yeasts convert glucose to ethanol following chemical reaction at 298.2 K.

      $C_6H_{12}O_6$ (s) $\rightarrow$ 2 CH_3CH_2OH (l) + 2 CO_2 (g)

      The following data are given for standard formation enthalpy (ΔH_f°) and Standard entropy (S°) at 298.2 K.

	ΔH_f°/ kJ mol^{-1}	S°/ J K^{-1} mol^{-1}
$C_6H_{12}O_6$ (s)	-1273.3	212.13
CH_3CH_2OH (l)	-269.29	160
CO_2 (g)	-393.5	213.79

      i. Calculate the standard enthalpy change of the reaction. (10 marks)

      ii. Calculate the standard entropy change of the reaction. (10 marks)

      iii. Calculate the standard Gibbs free energy change of the reaction. (10 marks)

      iv. State whether reaction is spontaneous or non-spontaneous. Explain your answer. (10 marks)

c) The combustion of graphite to produce carbon dioxide is given by the following equation.

C (graphite, s) + O_2 (g) → CO_2 (g).

The reaction is conducted at 298 K and 1.0 atm, $\Delta H = -393.5$ kJ/mol. The molar volume of graphite is 0.0053 L. Calculate the ΔU for the reaction?

(45 marks)

[Total-100 marks]

2. Answer all parts.

a) Compare **conduction**, **convection**, and **radiation** with examples from biological systems. (20 marks)

b) Describe the working principle of an **alcohol bulb thermometer**. (20 marks)

c) An aluminum pot (mass 0.5 kg) contains 1.2 kg of water initially at 15 °C. It is heated to 95°C using a 2 kW electric heater. (specific heat capacity of Al and water are 900 J/kg.K and 4200 J/kg.K respectively)

i. Calculate the energy required to heat the water. (15 marks)

ii. Calculate the energy required to heat the pot. (15 marks)

iii. Find the total energy input needed. (10 marks)

iv. Determine the time (in minutes) required for the heating process. (20 marks)

[Total- 100 marks]

3. The Haber process to manufacture ammonia using nitrogen and hydrogen is given by the equation below:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ ($\Delta H^o = -95$kJ and $\Delta S^o = -190 JK^{-1}$)

a) If temperature of the equilibrated system increases, which direction of the reaction is more favorable?

(10 marks)

b) Explain your answer in part (a).

(20 marks)

c) Explain briefly why entropy change of the reaction is negative value.

(20 marks)

d) Assuming ΔH° and ΔS° for the reaction do not change with temperature, calculate minimum temperature that the reaction is no longer spontaneous.

(50 marks)

[Total-100 marks]

4. Given the reactions:

$\text{Glucose} + \text{Pi} \rightarrow \text{Glucose-6-phosphate} + H_2$ ($\Delta G^\circ = +13.8$ kJ/mol)

$\text{ATP} + H_2O \rightarrow \text{ADP} + \text{Pi}$ ($\Delta G^\circ = -30.5$ kJ/mol)

a) Calculate ΔG° for the coupled reaction:

$\text{Glucose} + \text{ATP} \rightarrow \text{Glucose-6-phosphate} + \text{ADP}$

(40 marks)

b) Explain why this coupling is biologically important. (10 marks)

c) For the hydrolysis reactions:

$\text{Creatine phosphate} + H_2O \rightarrow \text{Creatine} + \text{Pi}$ ($\Delta G^\circ = -43.1$ kJ/mol)

$\text{ADP} + \text{Pi} \rightarrow \text{ATP} + H_2O$ ($\Delta G^\circ = +30.5$ kJ/mol)

i. Calculate ΔG° for the synthesis of ATP from creatine phosphate.

(40 marks)

ii. Is this eaction thermodynamically favorable? (10 marks)

[Total-100 marks]

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