

University of Ruhuna- Faculty of Technology
Bachelor of Biosystems Technology Honours Degree
Level 1 (Semester I) Examination, June/July 2023
Academic year 2021/2022

Course Unit: BST 1181 Thermodynamics (Theory) Duration: 1 ½ hours

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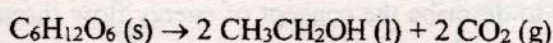
Instruction for candidate:

- 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) = $8.314 \text{ J k}^{-1} \text{ mol}^{-1}$

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. $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}_2(\text{g})$ (1 marks x 3 = 3 marks)

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



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

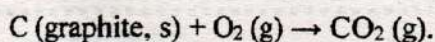
	$\Delta H_f^\circ / \text{kJ mol}^{-1}$	$S^\circ / \text{J K}^{-1} \text{ mol}^{-1}$
$\text{C}_6\text{H}_{12}\text{O}_6 (\text{s})$	-1273.3	212.13
$\text{CH}_3\text{CH}_2\text{OH} (\text{l})$	-269.29	160
$\text{CO}_2 (\text{g})$	-393.5	213.79

- i. Calculate the standard enthalpy change of the reaction. (3 marks)
- ii. Calculate the standard entropy change of the reaction. (3 marks)
- iii. Calculate the standard Gibbs free energy change of the reaction. (2 marks)
- iv. State whether reaction is spontaneous or non-spontaneous. Explain your answer. (2 marks)

- v. Predict and state whether the reaction is spontaneous or non-spontaneous at lower temperature (less than 25°C) and higher temperature (higher than 25°C).

(2marks)

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



The reaction is conducted at 298 K and 1.0 atm, $\Delta H = -393.5 \text{ kJ/mol}$. The molar volume of graphite is 0.0053 L. If the universal gas constant (R) is $8.314 \text{ J k}^{-1} \text{ mol}^{-1}$ Calculate the ΔU for the reaction? (5 marks)

2. Answer all parts.

- a) A thermos flask is a device that designed to slow down all forms of heat transfer.
- Write the methods of heat transfer. (1.5 marks)
 - Discuss the designed features of thermos flask that involved in minimize the heat lose. (3 marks)
- b) A teapot equipped with a 1200 W electric heating element and it has filled 1.2 kg of liquid water initially at 15°C is to be heated to 95°C . The teapot is 0.5 kg and has an average specific heat of $0.7 \text{ kJ/kg} \cdot ^{\circ}\text{C}$. The specific heat of water is $4.18 \text{ kJ/kg} \cdot ^{\circ}\text{C}$.
- Calculate the total heat energy to complete the process. (6.5 marks)
 - Calculate the time take for the water to be heated by disregarding heat loss of from the teapot. (3 marks)
- c) Scientists use the term bioenergetics to describe the concept of energy flow through living systems, such as cells.
- Explain the difference between anabolic reaction and catabolic reaction.
 - Discuss the importance of coupled reactions in bio systems.

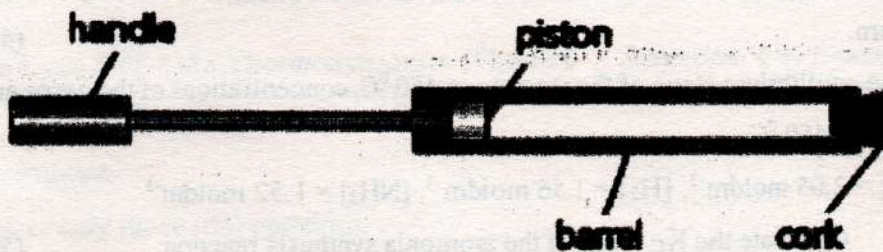
(3 marks x 2 = 6 marks)

3. Answer all parts.

- a) i. Explain the function of a refrigerator according to concepts in thermodynamics.
ii. Discuss the temperature change of closed room which located refrigerator with open door. (3 marks x 2 = 6 marks)
- b) A gas is filled in container and initially has 2000 joules of internal energy. 500 joules of heat energy is transferred into the container and the internal energy of the gas increases to 2200 joules. Calculate the work done on or by the gas.

(7 marks)

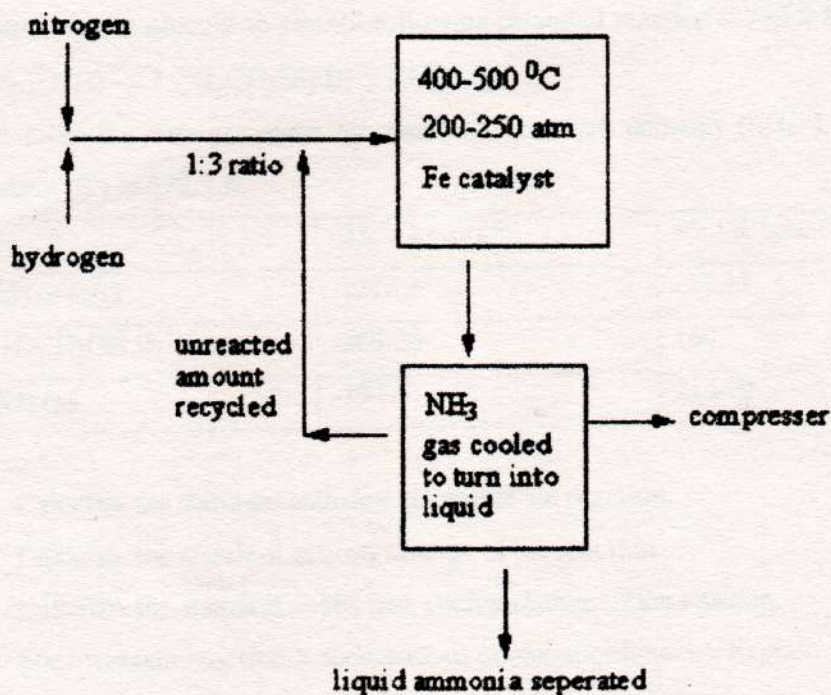
- c) a) The following figure is displayed child's 'pop' gun in which a piston is pushed quickly along the barrel, compressing the air in the barrel.



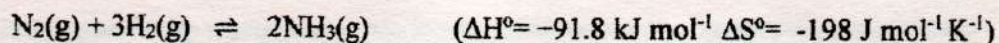
The air in the barrel is at a pressure of 1.0×10^5 Pa, a temperature of 290 K and the volume is 2.1×10^{-5} m³. The volume of air in the barrel at the instant the cork is expelled is 1.2×10^{-5} m³.

- i. The air compresses adiabatically and work needed to expel the cork is 1.4 J. Calculate the internal energy change of the air during compression. (4 marks)
- ii. Explain how adiabatic processes occur. (3 marks)

4. The Haber Process combines nitrogen from the air with hydrogen derived mainly from natural gas (methane) into ammonia as shown in the following figure.



The chemical reaction is:



- a) Explain the effect/s on the equilibrium when increase temperature and pressure of the system. (4 marks)
- b) At the equilibrium stage of the reaction at 450°C , concentrations of the gases are given below at 450°C .
 $[\text{N}_2] = 2.05 \text{ moldm}^{-3}$, $[\text{H}_2] = 1.56 \text{ moldm}^{-3}$, $[\text{NH}_3] = 1.52 \text{ moldm}^{-3}$
- Calculate the K_C value of the ammonia synthesis reaction. (5 marks)
 - Calculate the K_p value of the ammonia synthesis reaction. (5 marks)
- c) If concentrations of gases changed to $[\text{N}_2] = 2.52 \text{ moldm}^{-3}$, $[\text{H}_2] = 1.22 \text{ moldm}^{-3}$ and $[\text{NH}_3] = 3.22 \text{ moldm}^{-3}$,
- Calculate the quotient of the reaction. (4 marks)
 - State the direction of reaction that is more favorable. Explain your answer. (2 marks)

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