



UNIVERSITY EXAMINATIONS

FIRST SEMESTER 2025/2026 ACADEMIC YEAR

**THIRD YEAR EXAMINATION FOR THE DEGREE OF
BACHELOR OF SCIENCE (GENERAL) AND BACHELOR OF
EDUCATION (SCIENCE)**

CHEM 311: CHEMICAL THERMODYNAMICS

STREAM: BSc (Gen) AND BEd (Sci)

TIME: 2HRS

DAY: WEDNESDAY [14.30 – 16.30 P.M]

DATE: 28/01/2026

THIS QUESTION PAPER CONSISTS OF THREE (3) PAGES

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Attempt Question All questions. Question ONE carries 30 marks while Question Two and Three carry 20 marks each.

QUESTION ONE (30 MARKS)

a) Define the following terms as used in physical chemistry

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|------|-----------------------|----------|
| i. | Thermochemistry | (1 Mark) |
| ii. | State function | (1 Mark) |
| iii. | Isochoric process | (1 Mark) |
| iv. | Entropy | (1 Mark) |
| v. | Joule-Thompson effect | (1 Mark) |

b) Distinguish between

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|------|--|-----------|
| i. | Isolated and closed systems | (2 Marks) |
| ii. | Work and heat | (2 Marks) |
| iii. | State Trouton's law and name two substances, that show a positive deviation from the law | (2 Marks) |

c)

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|------|---|-----------|
| i. | Write a mathematical expression of the first law of thermodynamics | (2 Marks) |
| ii. | How is the Joule-Thompson Effect different for an ideal gas vs. real gas? | (3 Marks) |
| iii. | State three criteria for spontaneity. | (3 Marks) |

d) i. Calculate the change in entropy in the Haber process for the production of ammonia from nitrogen and hydrogen gas.

Given that at standard temperature of 298 K.

$$S^0(\text{NH}_3) = 192.5 \text{ J/mol K}$$

$$S^0(\text{N}_2) = 191.5 \text{ J/mol K}$$

$$S^0(\text{H}_2) = 130.6 \text{ J/mol K} \quad (3 \text{ Marks})$$

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|-----|--|-----------|
| ii. | Which of the following are not extensive properties, (Length, density, pressure, volume) | (2 Marks) |
|-----|--|-----------|

- iii. Determine the number of components, number of phases and degrees of freedom in the system: $\text{CaCO}_3(\text{s}) \rightleftharpoons \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$ (3 Marks)
- iv. Find the work done when one mole of a gas expands reversibly and isothermally from 5 atm to 1 atm at 25° C (3 Marks)

QUESTION TWO (20 MARKS)

- a) Draw the phase diagram for water and describe the curves, regions and triple point of intersection. (9 Marks)
- b) Calculate the entropy change involved in the thermodynamic expansion of 2 moles of an ideal gas from a volume of 1 litre to a volume of 10 litres at a constant temperature (5 Marks)
- c) The vapour pressure of benzene is 53333 Pa at 7.6 ° C and 5330 Pa at 60.6°C. Calculate the heat of vaporization of benzene and its boiling point. (6 Marks)

QUESTION THREE (20 MARKS)

- a) Find, ΔE , q and w if 2 moles of hydrogen at 3 atm pressure expand isothermally at 50° C and reversibly to a pressure of 1 atm. (6 Marks)
- b) Two moles of H_2 gas are compressed adiabatically from STP conditions to occupy a volume of 4.48 litres. Calculate the final temperature. (γ for $\text{H}_2 = 1.41$) (7 Marks)
- c)
- What is the thermodynamic basis of Hess's Law (2 Marks)
 - From the following data, determine the enthalpy of formation. $\Delta_f H^\ominus$ for $\text{FeCl}_3(\text{s})$ from the following two-step process that occurs under standard state conditions (5 Marks)

