



# MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

P.O. Box 972-60200 – Meru-Kenya.

Tel: +254 (0)799529958, +254 (0)799529959, +254 (0)712524293

Website: [www.must.ac.ke](http://www.must.ac.ke) Email: [info@must.ac.ke](mailto:info@must.ac.ke)

---

## University Examinations 2023/2024

SECOND YEAR, FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE CHEMISTRY, BACHELOR OF SCIENCE IN EDUCATION SCIENCE

### SCH 3201: PHYSICAL CHEMISTRY II

DATE: DECEMBER 2023

TIME: 2 HOURS

---

**INSTRUCTIONS:** *answer question one and any other two questions*

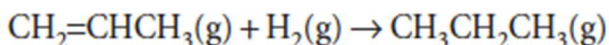
---

#### QUESTION ONE (30 MARKS)

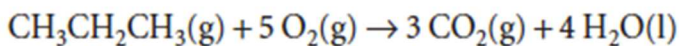
- (a) Define the joule in terms of SI base units. (2 marks)
- (b) Describe a simple bomb calorimeter. What measurements are needed to determine the heat of reaction? (3 marks)
- (c) State the first Law of thermodynamics according to:
- Energy and its conservation (3 marks)
  - Internal energy of a system (3 marks)
- (d) Write the formulas for the following basic concepts as used in thermodynamics
- Expansion against constant pressure (3 marks)
  - Isothermal reversible expansion (3 marks)
- (e) Write the van der Waals equation and explain the terms in it (6 marks)
- (f) Using the following definition of reduced variables, explain the principle of corresponding states. (4 marks)

$$V_r = \frac{V_m}{V_c} \quad p_r = \frac{p}{p_c} \quad T_r = \frac{T}{T_c}$$

- (g) The standard reaction enthalpy for the hydrogenation of propene



is  $-124 \text{ kJ mol}^{-1}$ . The standard reaction enthalpy for the combustion of propane



is  $-2220 \text{ kJ mol}^{-1}$ . Calculate the standard enthalpy of combustion of propene.

(3 marks)

## QUESTION TWO

(a) Define/explain the following terms

- i. Heat capacity (C) (4 marks)
- ii. Standard heat of formation (3 marks)

(b) The change in molar internal energy when  $\text{CaCO}_3(\text{s})$  as calcite converts to another form, aragonite, is  $+0.21 \text{ kJ mol}^{-1}$ . Calculate the difference between the molar enthalpy and internal energy changes when the pressure is  $1.0 \times 10^5 \text{ Pa}$  given that the densities of the calcite and aragonite are  $2.71 \text{ g cm}^{-3}$  and  $2.93 \text{ g cm}^{-3}$ , respectively. (5 marks)

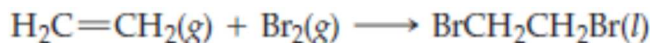
(c) Calculate the work in kilojoules done during a reaction in which the volume expands from 12.0 L to 14.5 L against an external pressure of 5.0 atm. (4 marks)

(d) Which of the following reactions are spontaneous under standard conditions at  $25^\circ\text{C}$ , and which are nonspontaneous? Explain (4 marks)

- i.  $\text{AgNO}_3(\text{aq}) + \text{NaCl}(\text{aq}) \rightarrow \text{AgCl}(\text{s}) + \text{NaNO}_3(\text{aq}) \quad \Delta G^\circ = -55.7 \text{ kJ}$
- ii.  $2 \text{C}(\text{s}) + 2 \text{H}_2(\text{g}) \rightarrow \text{C}_2\text{H}_4(\text{g}) \quad \Delta G^\circ = 68.1 \text{ kJ}$

## QUESTION THREE (20 MARKS)

(a) Predict (and explain) whether  $\Delta S^\circ$  is likely to be positive or negative for each of the following reactions: (6 marks)



- (b) A chemical reaction takes place in a container of cross-sectional area  $50.0 \text{ cm}^2$ . As a result of the reaction, a piston is pushed out through  $15 \text{ cm}$  against an external pressure of  $121000 \text{ Pa}$ . Calculate the work done by the system. (6 marks)
- (c) Aqueous silver ion reacts with aqueous chloride ion to yield a white precipitate of solid silver chloride  $\text{Ag}^+ (\text{aq}) + \text{Cl}^- (\text{aq}) \rightarrow \text{AgCl} (\text{s})$ . When  $10.0 \text{ mL}$  of  $1.00 \text{ M AgNO}_3$  solution is added to  $10.0 \text{ mL}$  of  $1.00 \text{ M NaCl}$  solution at  $25 \text{ }^\circ\text{C}$  in a calorimeter, a white precipitate of  $\text{AgCl}$  forms and the temperature of the aqueous mixture increases to  $32.6 \text{ }^\circ\text{C}$ . Assuming that the specific heat of the aqueous mixture is  $4.18 \text{ J}/(\text{g}\cdot^\circ\text{C})$ , that the density of the mixture is  $1.00 \text{ g/mL}$ , calculate  $\Delta H$  in  $\text{kJ}$  for the reaction. [8 marks]

#### QUESTION FOUR

- (a) State Hess's law of heat summation (3 marks)
- (b) We can show that by definition, enthalpy is defined as  $H = U + pV$  and implies that the change in enthalpy is equal to the energy supplied as heat ( $q$ ) at constant pressure (provided the system does no additional work): thus  $dH = dq$  (heat transferred at constant pressure). Show the justification proof. (11 marks)
- (c) Define the following terms
- Compression factor (2 marks)
  - Virial coefficients (2 marks)
  - Condensation (2 marks)