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University Examinations 2024/2025

SECOND YEAR FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE AND BACHELOR OF SCIENCES

SCH 3201: PHYSICAL CHEMISTRY II

DATE: JANUARY 2025

TIME: 2 HOURS

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

QUESTION ONE (30 MARKS)

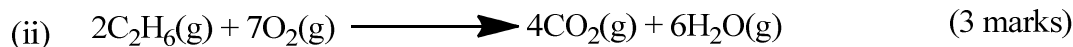
- a) State the first Law of thermodynamics according to:
- Energy and its conservation (2 marks)
 - Internal energy of a system (2 marks)
- b) Write the formulas for the following basic concepts as used in thermodynamics
- Expansion against constant pressure (3 marks)
 - Enthalpy (2 marks)
- c) Define/explain the following terms
- Heat capacity (C) (4 marks)
 - Standard heat of formation (3 marks)
 - The Joule - Thomson effect (3 marks)
- d) 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. (5 marks)

Predict whether ΔS° is likely to be positive or negative for each of the following reactions:

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Page 1

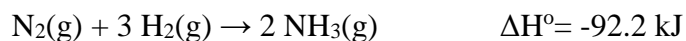


QUESTION TWO (20 MARKS)

- a) Calculate the work needed for a bird of mass 120 g to fly to a height of 50 m from the surface of the Earth. (8 marks)
- b) A chemical reaction takes place in a container of cross-sectional area 50.0 cm^2 . As a result of the reaction, a piston is pushed out through 15 cm against an external pressure of 121000 Pa. Calculate the work done by the system. (6 marks)
- (c) A sample of 4.50 g of methane occupies 12.7 L at 310 K.
- (i) Calculate the work done when the gas expands isothermally against a constant external pressure of 200 Torr until its volume has increased by 3.3 L. (3 marks)
- (ii) Calculate the work that would be done if the same expansion occurred reversibly. (3 marks)

QUESTION THREE (20 MARKS)

- a) Discuss the molecular interpretation of the Joule-Thomson effect (6 marks)
- b) The reaction of nitrogen with hydrogen to make ammonia has $\Delta H^\circ = -92.2 \text{ kJ}$. What is the value of ΔE in kilojoules if the reaction is carried out at a constant pressure of 40.0 atm and the volume change is -1.12 L ? (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 mL of 1.00 M AgNO_3 solution is added to 10.0 mL of 1.00 M NaCl solution at 25°C in a calorimeter, a white precipitate of AgCl forms and the temperature of the aqueous mixture increases to 32.6°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 g/mL , calculate ΔH in kJ for the reaction. [8 marks]

QUESTION FOUR (20 MARKS)

- a) Write the van der Waals equation and explain the terms in it (6 marks)
- b) Predict the sign of entropy in the system for each of the following processes (8 marks):
- (i) $\text{CO}_2(\text{s}) \rightarrow \text{CO}_2(\text{g})$ (sublimation of dry ice)
 - (ii) $\text{CaSO}_4(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{SO}_3(\text{g})$
 - (iii) $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$
 - (iv) $\text{I}_2(\text{s}) \rightarrow \text{I}_2(\text{aq})$ (dissolution of iodine in water)
- c) Explain the significance of a physical observable being a state function and compile a list of four state functions you can identify (6 marks)