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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:

i. Energy and its conservation (2 marks)

ii. Internal energy of a system (2 marks)

b) Write the formulas for the following basic concepts as used in thermodynamics

(i) Expansion against constant pressure (3 marks)

(ii) Enthalpy (2 marks)

c) Define/explain the following terms

i. Heat capacity (C) (4 marks)

ii. Standard heat of formation (3 marks)

iii. 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^o is likely to be positive or negative for each of the following reactions:

(i) $H_2C{=}{=}CH_2(g) + Br_2(g) \longrightarrow BrCH_2CH_2Br(l)$ (3 marks)

(ii) $2C_2H_6(g) + 7O_2(g) \longrightarrow 4CO_2(g) + 6H_2O(g)$ (3 marks)

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 ΔH^o = -92.2 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)

$N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$ ΔH^o= -92.2 kJ

c) Aqueous silver ion reacts with aqueous chloride ion to yield a white precipitate of solid silver chloride Ag+ (aq) + Cl- (aq) →AgCl (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 J/(g. °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) $CO_2(s) \rightarrow CO_2(g)$ (sublimation of dry ice)

(ii) $CaSO_4(s) \rightarrow CaO(s) + SO_3(g)$

(iii) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

(iv) $I_2(s) \rightarrow I_2(aq)$ (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)