THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

SECOND SEMESTER EXAMINATION – 2021

CH221– ADVANCED PHYSICAL CHEMISTRY

FRIDAY 29th OCTOBER - 12:50 PM

TIME ALLOWED: 2 HOURS

INFORMATION FOR CANDIDATES:

1. You will have 10 minutes to read the question paper. You **MUST NOT** begin writing in the answer book during this time.
2. **ANSWER ALL QUESTIONS.**
3. All answers **MUST** be written on the answer book provided.
4. Calculators are permitted in the examination room. Lecture notes, notebooks, plain papers, and textbooks are **NOT** allowed.
5. Mobile phones are not allowed. **SWITCH OFF THE MOBILE PHONES.**
6. Show all working and calculations in the answer book.
7. **DRAW any FIGURES** clearly and visibly.
8. Write your name and number clearly on the front page of the answer book. **DO IT NOW.**

MARKING SCHEME: [TOTAL 50 MARKS]

1. (a) To evaluate the change in enthalpy for a particular temperature change from T_1 to T_2, we often use the thermodynamic expression below:

$$\int_{H(T_1)}^{H(T2)} dH = \int_{T1}^{T2} CpdT$$

Given that $C_{p,m} = 28.6 + 3.8 \times 10^{-3} T - 5 \times 10^{4} T^{-2}$ J/mol/K for N_2, calculate the change in molar enthalpy for N_2 from 25.0°C to 100.0°C.

(b) What will be the change in Entropy for N_2 from 25.0°C to 100.0°C?

(TOTAL: 10 Marks)

2. A Physical Chemist provided the following experimental data for vapour pressure (p) and temperature (T) for Benzene and Toluene, two hazardous organic compounds:

Toluene				**Benzene**			
T/K	p (mm Hg)	ln p	1/T (K^{-1})	T/K	p (mm Hg)	ln p	1/T (K^{-1})
312.55	54.6			287.75	54.6		
322.55	90.0			316.45	191		
357.15	314			333.15	403		
384.65	854			357.15	854		

(i) Complete the ln p and 1/T portions in the Table for Toluene and Benzene in the Answer Booklet provided.

[2 marks]

(ii) Using the graph paper provided, and on the same graph paper, plot ln p on the vertical axis and 1/T on the horizontal axis for Toluene and Benzene.

[6 marks]

(iii) Using the Clausius-Clapeyron equation, $\ln p = -\frac{\Delta H_{vap}}{RT}$, and your graphs in 2 (ii) above, determine the enthalpy of vaporization for Toluene and Benzene. [R = 8.314 J/mol/K]

[5 marks]

(iv) From your results in 2 (iii) above, which of the two compounds is more volatile, and why?

[2 marks]

(TOTAL: 15 Marks)

3. Gibbs fourth fundamental equation in chemical thermodynamics is expressed as: $dG = -SdT + Vdp$

(a) Using the equation provided above, show that for an ideal gas

$$\left(\frac{\partial G}{\partial V}\right)_T = -\frac{nRT}{V}$$

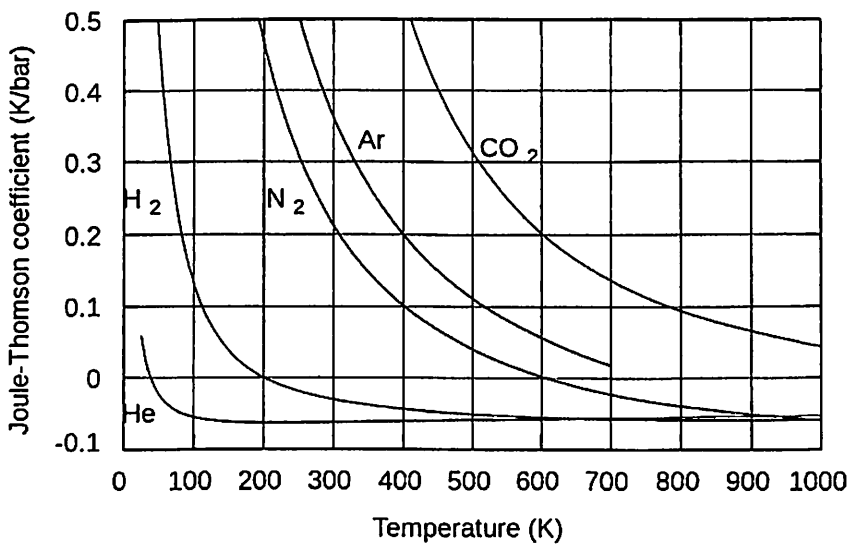
(b) 2.50 mol of an ideal gas expands isothermally at 500 K from a container of volume 5 dm^3 into a container of volume 15 dm^3, calculate the change in Free Energy, ΔG^o, for the process. [R = 8.314 J/mol/K]

(TOTAL: 15 Marks)

4. (a) Write a mathematical expression for the Joule-Thomson coefficient, $\mu_{J.T}$, in terms of the appropriate thermodynamic variables.

[2 marks]

(b) Using the graph below, answer the questions that follow:



(i) At room temperature (25°C), name gases that will cool on expansion.

[4 marks]

(ii) At 200 K, what gas will exhibit ideal behavior?

[2 marks]

(iii) What are the inversion temperatures for H_2, and N_2?

[2 marks]

(TOTAL: 10 MARKS)

----------THE END – MERRY CHRISTMAS TO YOU----------