THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

SECOND SEMESTER EXAMINATION

CH224 – ADVANCED PHYSICAL CHEMISTRY

TUESDAY 27TH OCTOBER 2020 - 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, IF NECESSARY. 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. **DO NOT** over write
9. Write your name and number clearly on the front page of the answer book. **DO IT NOW.**

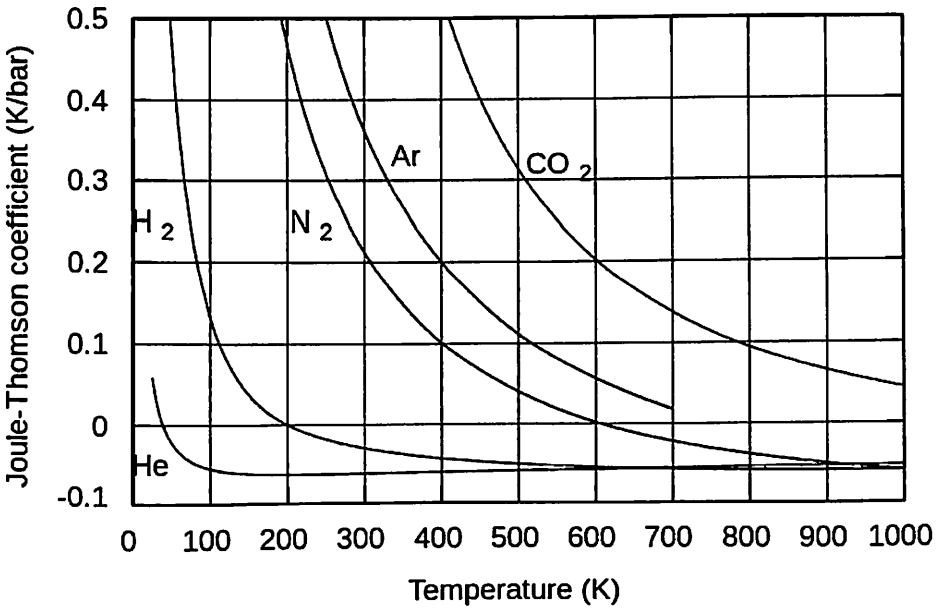
MARKING SCHEME: [TOTAL 50 MARKS]

CH224

1. (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 exhibits ideal behavior? [2 marks]

(iii) What are the inversion temperatures for H_2, and N_2? [2 marks]

(TOTAL = 10 MARKS)

2. The Table below is the vapour pressure (p) and temperature (T) data for solid palladium metal.

p/atm	T (K)
0.00285	1294
0.00419	1308
0.00687	1322
0.00790	1333
0.0108	1350
0.0323	1396
0.0629	1426
0.1165	1459
0.2211	1488

Using the Clausius-Clapeyron equation given as

$$\ln p = -\frac{\Delta_{sub}H_m}{R}\left(\frac{1}{T}\right) + \text{constant}$$

(a) Plot a graph of **ln p** on the vertical axis versus **1/T** on the horizontal axis.

Try and cover the entire area on the graph sheet. [7 marks]

(b) Calculate the slope of the line. [3 marks]

(c) From 2(b) above, calculate the enthalpy change of sublimation for palladium Given that R = 8.314 J/mol/K. [2 marks]

(TOTAL = 12 MARKS)

3. The heat capacity, $C_{p,m}$, of a substance from 298 K to 1234 K is given by the relationship: $C_{p,m} = 21 + 9 \times 10^{-3}T + 1.5 \times 10^{5}\ T^{-2}$

   where T is the Kelvin Temperature. Given the following relationship,

$$\left(\frac{\partial S_m}{\partial T}\right)_p = \frac{C_{p,m}}{T}$$

   Calculate ΔS_m for heating the sample from 298 K to 1000 K.

(TOTAL = 8 MARKS)

4. Given that Gibbs Free Energy, G, is a function of p and T, then,
   G = f (p, T), therefore, $dG = \left(\frac{\partial G}{\partial p}\right)_T dp + \left(\frac{\partial G}{\partial T}\right)_p dT$

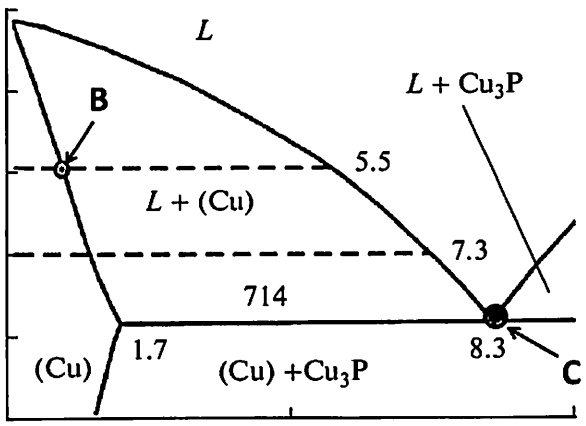
   But $\left(\frac{\partial G}{\partial p}\right)_T = V$

$$\int dG = \Delta G = \int_{p_1}^{p_2} \left(\frac{\partial G}{\partial p}\right)_T dp + \int_{T_1}^{T_2} \left(\frac{\partial G}{\partial T}\right)_p dT$$

From the information provided above, calculate ΔG for the isothermal expansion of 2.5 mole of an ideal gas at T = 300 K from p_1 = 0.100 MPa to p_2 = 0.200 MPa. [PV = nRT; R = 8.314 J mol^{-1} K^{-1}].

(TOTAL = 10 MARKS)

5. Use the phase diagram below to answer the following questions:



(i) At point B on the phase diagram, how many degrees of freedom will be available for thermodynamic consideration?

(ii) At point C on the diagram, how many degrees of freedom will be available for thermodynamic consideration?

[Given: Phase equation: $f = C - P + 2$]

(TOTAL: 10 MARKS)

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