

THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY
SECOND SEMESTER EXAMINATION
CH221 – ADVANCED PHYSICAL CHEMISTRY
FRIDAY 28th OCTOBER, 2022 – 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 workings and calculations in the answer book.
7. **DRAW the STRUCTURES** clear and visible.
8. **DO NOT** overwrite.
9. Write your name and number clearly on the front page. **DO IT NOW.**

MARKING SCHEME:

Total 50 marks

1. Relating to Kinetic Theory of gases:

(a) List THREE postulates of the kinetic theory of gases.

[3 marks]

(b) Under what physical conditions do gases deviate from the ideal behaviour?

[2 marks]

(Total = 5 marks)

2. Relating to Maxwell Boltzmann Distribution:

(a) Elaborate on the influence of temperature and molar mass on the speed of gases.

[4 marks]

(b) Calculate the root mean square (rms) speed, average speed and the most probable speed (mps) of hydrogen gas at 300 K.

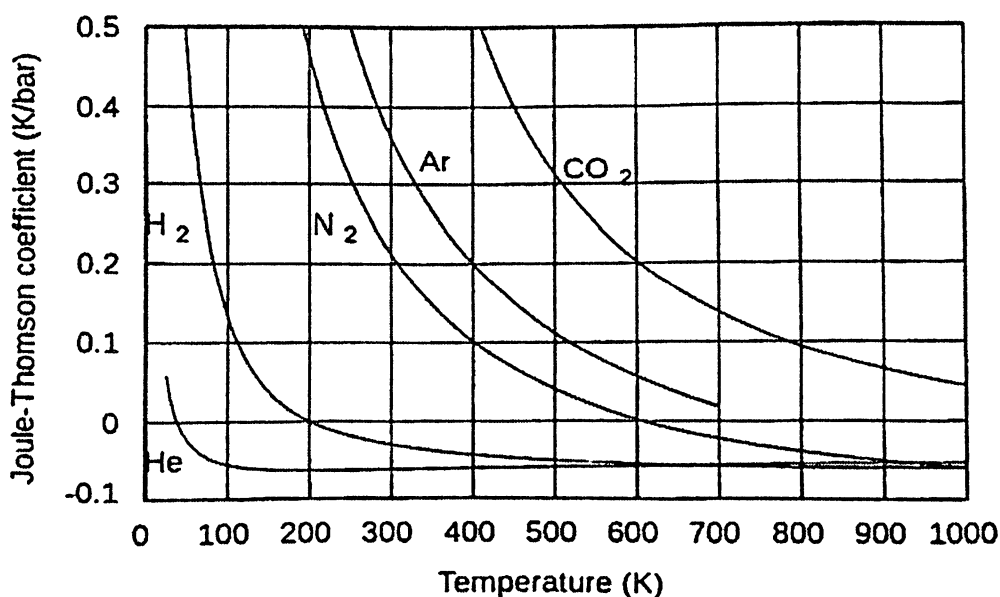
[3 marks]

(Total = 7 marks)

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

[2 marks]

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



(i) At 200 K, which gas exhibits ideal behaviour?

[2 marks]

(ii) Name the gases that will cool on expansion at room temperature (25°C).

[4 marks]

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

[2 marks]

(Total = 10 marks)

4. A sample of gas has changed in volume from 4.00 L to 6.00 L against an external pressure of 1.50 atm, and simultaneously absorbs 1000 J of heat.

a. Calculate the heat absorbed.

[1 mark]

b. Calculate the work done.

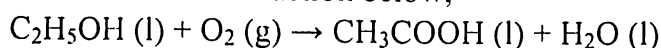
[3 marks]

c. Calculate the change in the internal energy of the system?

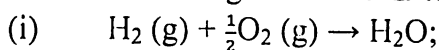
[3 marks]

(Total = 7 marks)

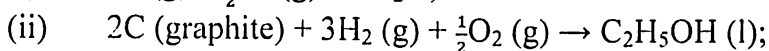
5. Use the chemical reaction below;



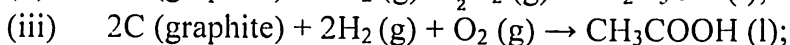
and the following data at 25 °C to answer the questions below.



$$\Delta G^\circ = -238 \text{ kJ}$$



$$\Delta G^\circ = -176 \text{ kJ}$$



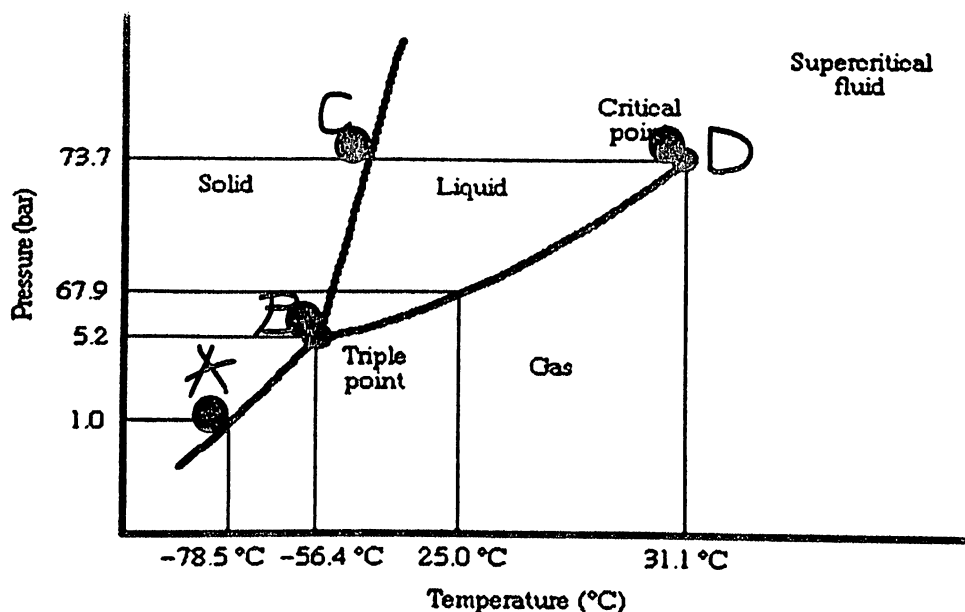
$$\Delta G^\circ = -394 \text{ kJ}$$

a. Use the data provided to calculate the Gibbs free energy change ($\Delta_{\text{rxn}}G^\circ$) for the chemical reaction above.

[Hint: $\Delta_{\text{rxn}}G^\circ = \sum \Delta G^\circ$]

(Total = 6 marks)

6. Use the phase diagram of CO_2 below to answer the following questions:



- (a) The diagram above shows a CO₂ component system. What are the TWO variables that describes the existence of the phases? [2 marks]
- (b) Describe the phenomenon that exist beyond the critical point of CO₂. [2 marks]
- (c) At point A on the phase diagram, how many degrees of freedom will be available for thermodynamic consideration?
[Hint: Phase equation: $F = C - P + 2$] [2 marks]
- (d) At point B on the phase diagram, how many degrees of freedom will be available for thermodynamic consideration?
[Hint: Phase equation: $F = C - P + 2$] [2 marks]
- (e) What is the phase of CO₂ at point B? Explain your answer. [4 marks]

(Total = 12 marks)

7. The heat of vaporization of water is 40.8 kJ mol⁻¹. The boiling point of water at a pressure of 1.00 atm is 100°C. What will the boiling point be at a pressure of 0.50 atm?

[Hint: $\ln \frac{p_2}{p_1} = \left(\frac{H_{va}}{R}\right) \left(\frac{1}{T_1} - \frac{1}{T_2}\right)$. $R = 8.314 \text{ J K}^{-1}$.]

(Total = 3 marks)