

**2026/FYUG/EVEN/SEM/
CHMDSC251T/120**

FYUG Even Semester Exam., 2026

**CHEMISTRY
(4th Semester)**

Paper Code : CHMDSC251T

**[Physical Chemistry—II
(Chemical Thermodynamics of Equilibrium)]**

Full Marks : 70

Pass Marks : 28

Time : 3 hours

*The figures in the margin indicate full marks
for the questions.*

UNIT—I

1. Answer any two questions : 2×2=4

(a) State and write the mathematical statement for first law of thermodynamics.

(b) 1 mol of He gas is compressed from 50 L to 5 L isothermally at 27 °C in infinite number of steps. Calculate the work done by the gas.

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(Turn Over)



- (c) Compare isothermal and adiabatic expansion of an ideal gas and prove that

$$P_{\text{ad}} < P_{\text{iso}}$$

where P indicates final pressure.

2. Answer either (a) or (b) : 10

- (a) (i) Derive thermodynamically

$$C_P - C_V = R$$

for 1 mol of an ideal gas. 4

- (ii) Calculate q , ΔU , w and ΔH for expansion of 1 mol of an ideal gas ($C_V = 1.5R$) reversibly and adiabatically from volume 10 dm^3 to 20 dm^3 at 27°C . 4

- (iii) What are exact and inexact differential? Explain giving suitable example. 2

- (b) (i) Calculate the bond enthalpy of C—H bond in CH_4 if heat of formation of CH_4 is -75 kJ , heat of sublimation of carbon is 720 kJ and bond enthalpy of H_2 gas is 435 kJ . 4

- (ii) Deduce Kirchhoff's equations. 3

- (iii) Derive a relation between pressure (P) and volume (V) for an ideal gas in an adiabatic and reversible process.

3

UNIT—II

3. Answer any *two* questions :

2×2=4

- (a) Mention two limitations of first law of thermodynamics.
- (b) State Kelvin and Planck's statements for the second law of thermodynamics.
- (c) Explain the significance of entropy.

4. Answer *either* (a) or (b) :

10

- (a) (i) Derive the mathematical statement for the second law of thermodynamics and show that two engines working between the same two temperatures will have the same efficiency.

4+2=6

- (ii) Calculate the efficiency of a Carnot engine working between ice point and steam point. It is desired to increase the efficiency of the engine by 20% keeping the temperature of the source constant. Calculate the change in temperature of the sink.

1+3=4

(b) (i) Show the following :

2×2=4

$$(1) \left(\frac{\partial G}{\partial T} \right)_P = \left(\frac{\partial A}{\partial T} \right)_V$$

$$(2) - \left(\frac{\partial S}{\partial P} \right)_T = \left(\frac{\partial V}{\partial T} \right)_P$$

(ii) Derive the second thermodynamic equation of state using Maxwell relations.

2

(iii) Derive expression for Joule-Thomson coefficient for an ideal gas.

2

(iv) The van der Waals' constants a and b for H_2 in dm^3 atm units are 0.246 and 0.0267 respectively. Calculate the inversion temperature of H_2 .

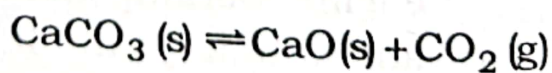
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UNIT—III

5. Answer any two questions :

2×2=4

(a) Calculate the number of components, phases and degrees of freedom in the following equilibrium :



(b) Distinguish between true and meta-stable equilibrium.

(c) What is a condensed system? Write the reduced phase rule equation.

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(Continued)

6. Answer either (a) or (b) : 10

(a) (i) Deduce Clausius-Clapeyron equation for liquid-vapour equilibrium. 4

(ii) What are the significance differences between the phase diagram of water and carbon dioxide? Explain giving phase diagrams. 6

(b) (i) Explain the concept of activity and fugacity. 2

(ii) Draw the phase diagram of Ag-Pb system. Write the salient features and explain eutectic point. 3+3=6

(iii) Discuss on triangular plots. 2

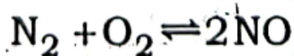
UNIT—IV

7. Answer any two questions : 2×2=4

(a) Elaborate the phenomena of 'coupled reaction' with a suitable example.

(b) Differentiate between exo-ergic and endo-ergic reactions.

(c) At 2000 K, ΔG° for the reaction



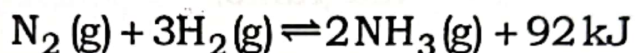
is $92048 - 10.46T$ J. Calculate K_p for the reaction.

8. Answer either (a) or (b) : 10

(a) (i) Deduce Van't Hoff reaction isotherm. 4

(ii) Explain the physical significance of chemical potential. 2

(iii) State Le Châtelier's principle and apply it on the following equilibrium reaction : 4



(b) (i) Derive Van't Hoff equation for the temperature dependence of equilibrium constant. 4

(ii) Study the equilibrium of the reaction $\text{PCl}_5 \rightleftharpoons \text{PCl}_3 + \text{Cl}_2$ and explain, in detail, in terms of K_c and K_p . 3+3=6

UNIT—V

9. Answer any two questions : 2×2=4

(a) Define pOH. Calculate pOH of 10^{-4} M NaOH.

(b) Write two applications of buffers in industry.

(c) Explain on selection of indicators and their limitations.

10. Answer either (a) or (b) : 10

(a) (i) Derive Henderson's equation for a basic buffer. 4

(ii) Deduce the expression for hydrolysis constant, degree of hydrolysis and pH for a salt of strong acid and weak base. $2+2+2=6$

(b) (i) Explain the theory of acid-base indicators taking methyl orange as an example. 3

(ii) Draw acid-base titration curves for titration of a strong acid against a strong base and explain, in detail, regarding change in pH. 3

(iii) 25 mL of 0.1 M HCl is titrated against 0.1 M NaOH solution. Calculate the pH value of the titrate solution after the addition of 20 mL NaOH solution. 3

(iv) Why is aqueous solution of CuSO_4 acidic in nature? 1

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