Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2022

Course: Physical Chemistry II **Semester: II**
Program: B.Sc (H) Chemistry **Time: 03 hrs.**
Course Code: CHEM1006 **Max. Marks: 100**

Instructions: Read all the below mentioned instructions carefully and follow them strictly

1) Write your name and enrollment no. at the top of the question paper.
2) Do not write anything else on the question paper except your name and roll number.
3) Attempt all the parts of a question at one place only.
4) Internal choices are given for question number 9 and 11.
5) CO1, CO2, CO3 & CO4 in the last column stand for course outcomes and are for official use only.

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	The combustion of heptane C_7H_{16} in a constant volume calorimeter gave the value of internal energy = -4793 kJ at 25°C.What will be the enthalpy change of the process at 25°C? $C_7H_{16}(l) + 11O_2(g) = 7CO_2(g) + 8H_2O\ (l)$	**4**	**CO2**
Q 2	Using the standard heats of formation below, calculate the standard enthalpy change for the following reaction. $3Fe_2O_3(s) + H_2(g) \rightarrow 2\ Fe_3O_4(s) + H_2O(g)$ Compound ΔH_f^o (kJ/mol) $Fe_2O_3(s)$ –824.2 $Fe_3O_4(s)$ –1118.4 $H_2O(g)$ –241.8	**4**	**CO1**
Q 3	Derive the expression of Clausius inequality.	**4**	**CO1**
Q 4	One mole of ethane at 25C and one atm is heated to 1000C at constant pressure. Assuming the ideal behavior, calculate the change in enthalpy given that the molar heat capacity of ethane is given by $C_p = 0.06 + 2T + 8T^2 + 0.01T^3$	**4**	**CO1**
Q 5	Calculate the final volume of one mole of an ideal gas initially at 0°C and 1	**4**	**CO1**

	atm pressure if it absorbs 100 J of heat during a reversible isothermal expansion. (Given: R= 8.314 $JK^{-1}mole^{-1}$; Hints: use Avogadro's law to determine initial volume of the ideal gas)		
	SECTION B **(4Qx10M= 40 Marks)**		
Q 6	Derive the expression of entropy of mixing of two gases O_2 and N_2 assuming that both the gases behaves ideally.	**10**	**CO2**
Q 7	(i) Derive the expression of thermodynamic equation of state of $\left(\frac{\partial U}{\partial V}\right)_T$. (ii) Calculate $\left(\frac{\partial U}{\partial V}\right)_T$ for a real gas which follows equation of state (V-b)(P+a) = RT Where "a" and "b" are constants.	**5+5**	**CO2**
Q 8	Using thermodynamic square write down all the criteria of spontaneity in terms of S, P, T, V, U, H, A and G.		**CO2**
Q 9	Show that the chemical potential of a pure substance in two phases in equilibrium are equal. **OR** Determine the feasibility of formation of ethanol by calculating the standard Gibbs free energy at 25℃ as represented by the following equation $2C(graphite)+3H_2(g)+\frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l); \Delta H^0=500\frac{J}{mol}$ $Given\ that: S^0_{C_2H_5OH(l)}=160\ J\ K^{-1}mol^{-1}, S^0_{C(graphite)}=5.7\ J\ K^{-1}mol^{-1}, S^0_{H_2(g)}=130.$	**10**	**CO3**
	SECTION-C **(2Qx20M=40 Marks)**		
Q 10	(a) Write the statement of Planck's third law of entropy. Show using a graphical diagram of entropy vs T, when a solid at zero kelvin is heated to gas at T kelvin. (b) Calculate the third law entropy of a substance in the gas phase at 277°C. Given: (i) Heat capacity of substance in the solid phase follows a relation Cp (in Joule) = $0.1T^3$ from zero kelvin to its melting point 7°C (ii) $\Delta H_{fus,m}$ =11.68 kJ/mole at the melting point 7°C (iii) Heat capacity of substance in the liquid phase follows a relation Cp (in Joule) = 25+0.05T from 7°C to its boiling point 127°C (iv) $\Delta H_{vap,m}$ = 25.52 kJ/mol at the boiling point 127°C. (v) Heat capacity of substance in the gas phase follows a relation Cp (in Joule) = 10+0.2T from 127°C to 277°C	**10+10**	**CO3**

Q 11	(a) Derive the thermodynamic expression of freezing point of a solution. **OR** Derive the thermodynamic expression of boiling point of a solution. (b) Show that the value of Helmholtz free energy at constant temperature and volume decreases for a spontaneous process. **OR** Calculate the enthalpy of reaction for $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ at 450 K using the following crude guesses for the heat capacities: $C_P(N_2) = 3.5\ R$, C_P(H2) = 3.5 R, C_P(NH3) = 4R. It is known that $\Delta H_f^0(NH_3(g), 298\ K) = -45.72$ kJ/mol.	**10+10**	**CO3**