Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

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

Course: Combustion and Reaction Fronts **Semester: II**
Program: M.Tech CFD **Time 03 hrs.**
Course Code: ASEG 7027 **Max. Marks: 100**

Instructions: Enthalpy of Formation Tables can be used

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Explain the effect of turbulence on flame propagation in jet engine combustion chamber.	**4**	**CO 3**
Q 2	Explain about Webber number, based on this non-dimensional number comment on process of atomization in gas turbines.	**4**	**CO 1**
Q 3	How does particulates form in combustion system. What is the method used to reduce particulate emission from combustion system?	**4**	**CO2**
Q 4	Explain about Rate of reaction using Gibb's free energy equation and how to estimate Kp using the Gibbs Free energy equation.	**4**	**CO 1**
Q 5	Explain about Electronegativity, and its significance in selection of fuels and oxidizers with the examples. Define Hess's Law. Describe the use of Hess's Law for analysis of chemical reactions.	**4**	**CO 2**

SECTION B
(4Qx10M= 40 Marks)

Q 6	Consider the combustion of hyrdocarbon fuel, Cn Hm, with excess theoretical air and incomplete combustion according to the chemical reaction as follows: $C_nH_m + (1+B)A_{th}(O_2 + 3.76N_2) \rightarrow DCO_2 + ECO + FH_2O + GO_2 + JN_2$ Where Ath is the theoritical O2 required for this fuel and B is excess amount of air in decimal form. If a is the fraction of carbon in the fuel converted to carbon dioxied and b is the reminaing fraction converted to carbon monoxied,		**CO2**

	determine the coefficients Ath, D, E, F, G and J for a fixed B amount of excess air. Write the coefficients D, E, F G, and J as function of n, m, a, b, B, and Ath in the simplest correct forms.		
Q 7	Derive the Rankine-Huguenot Relations for the Down stream velocity at non- Chapman-Jouguet Points and wave speed of the Chapman-Jouguet Detonations?		**CO 3**
Q 8	Explain the difference between diffusion flames and Premixed flames, describe the practical examples? What is the influence of Turbulence on the flame structure?		**CO1**
Q 9	In a closed Vessel, the oxygen molecules at 2000 K and 0.1 MPa is dissociated to oxygen by the following reaction $O_2 \leftrightarrow 2O$ (a). Estimate Equilibrium composition, If the vessel pressure is increased to 0.5 MPa, Determine its composition? (OR) Explain the procedure for calculating equilibrium composition; also determine equilibrium constant for each of the reaction independent of others		**CO 3**
SECTION-C **(2Qx20M=40 Marks)**			
Q 10	Describe the Species Transport Model using with the governing equations. Discuss the importance of (a). Mass Diffusion in Laminar Flows (b). Mass Diffusion in Turbulent Flows (c).Laminar Finite Rate Model (d). Eddy Dissipation Model	**20**	**CO 4**
Q 11	Derive the Schvab- Zeldovich formulation using conservation quations, Express the non-linear chemical source term after elimination of reaction term.? (OR) Find the Adiabatic Flame temperature of the products of combustion of hydrogen and oxygen whose composition and average specific heats are given in the table below. The reactants enter the adiabatic combustion chamber at 250 K, In this table, $\overline{C_{PP}}$ is the average molar specific heat of the component	**20**	**CO5**

between 298 K and the flame temperature, $\overline{C_{Pr}}$ is the average molar specific heat of the component between 250 K and 298 K, and $\overline{h_f^0}$ is the heat of formation at 298 K in KJ/Kmol. (20 Marks)

Component	Moles	$\overline{C_{PP}}$	C_{Pr}	Q_f
O_2	0.1008	36.3	32.3	0
H_2	0.3170	32.9	29.6	0
O	0.054	20.9	--	+245, 143
H	0.109	20.9	---	+216,093
OH	0.233	33.5	---	+41,870
H_2O	1.512	48.27	----	-241,827

Enthalpy of Formation

$\bar{h}_f^\circ$ and $\bar{g}_f^\circ$ (kJ/kmol), $\bar{s}^\circ$ (kJ/kmol•K)

Substance	Formula	$\bar{h}_f^\circ$	$\bar{g}_f^\circ$	$\bar{s}^\circ$
Carbon	$C(s)$	0	0	5.74
Hydrogen	$H_2(g)$	0	0	130.57
Nitrogen	$N_2(g)$	0	0	191.50
Oxygen	$O_2(g)$	0	0	205.03
Carbon monoxide	$CO(g)$	−110,530	−137,150	197.54
Carbon dioxide	$CO_2(g)$	−393,520	−394,380	213.69
Water	$H_2O(g)$	−241,820	−228,590	188.72
	$H_2O(l)$	−285,830	−237,180	69.95
Hydrogen peroxide	$H_2O_2(g)$	−136,310	−105,600	232.63
Ammonia	$NH_3(g)$	−46,190	−16,590	192.33
Oxygen	$O(g)$	249,170	231,770	160.95
Hydrogen	$H(g)$	218,000	203,290	114.61
Nitrogen	$N(g)$	472,680	455,510	153.19
Hydroxyl	$OH(g)$	39,460	34,280	183.75
Methane	$CH_4(g)$	−74,850	−50,790	186.16
Acetylene	$C_2H_2(g)$	226,730	209,170	200.85
Ethylene	$C_2H_4(g)$	52,280	68,120	219.83
Ethane	$C_2H_6(g)$	−84,680	−32,890	229.49
Propylene	$C_3H_6(g)$	20,410	62,720	266.94
Propane	$C_3H_8(g)$	−103,850	−23,490	269.91
Butane	$C_4H_{10}(g)$	−126,150	−15,710	310.03
Pentane	$C_5H_{12}(g)$	−146,440	−8,200	348.40
Octane	$C_8H_{18}(g)$	−208,450	17,320	463.67
	$C_8H_{18}(l)$	−249,910	6,610	360.79
Benzene	$C_6H_6(g)$	82,930	129,660	269.20
Methyl alcohol	$CH_3OH(g)$	−200,890	−162,140	239.70
	$CH_3OH(l)$	−238,810	−166,290	126.80
Ethyl alcohol	$C_2H_5OH(g)$	−235,310	−168,570	282.59
	$C_2H_5OH(l)$	−277,690	174,890	160.70

Heating Values of Hydrocarbons

		Higher Value[a]		Lower Value[b]	
Hydrocarbon	**Formula**	**Liquid Fuel**	**Gas. Fuel**	**Liquid Fuel**	**Gas. Fuel**
Methane	CH_4	—	55,496	—	50,010
Ethane	C_2H_6	—	51,875	—	47,484
Propane	C_3H_8	49,973	50,343	45,982	46,352
n-Butane	C_4H_{10}	49,130	49,500	45,344	45,714
n-Octane	C_8H_{18}	47,893	48,256	44,425	44,788
n-Dodecane	$C_{12}H_{26}$	47,470	47,828	44,109	44,467
Methanol	CH_3OH	22,657	23,840	19,910	21,093
Ethanol	C_3H_5OH	29,676	30,596	26,811	27,731

[a] H_2O liquid in the products.

[b] H_2O vapor in the products.