Assignment 5

1. Hydrazine (N_2H_4) at a temperature of 25°C is decomposed in a catalytic bed in a monopropellant thruster using activated iridium adsorbed in alumina. The catalyst bed is designed to give 30% dissociation of the ammonia (NH_3). Determine the following:

i. Heat release per kg of hydrazine
ii. Temperature of the products of decomposition
iii. Molecular mass of the products
iv. Characteristic velocity of the monopropellant rocket.

The following data is to be used:

Property	Hydrazine (liquid)	Ammonia (vapor)	Hydrogen (gas)	Nitrogen (gas)
Standard heats of formation ΔH^o_f in kJ/mole	+ 55	- 46	--	--
Average specific heat C_p in $\frac{kJ}{moleK}$	-------	0.04	0.03	0.035

2. Determine the diameter of the catalyst bed of a monopropellant hydrazine rocket to provide a thrust of 11 N given that the bed loading, based on the permeability of the alumina granules, is specified as 2 $\frac{g}{cm^2\, s}$. The specific impulse is 2000 Ns/kg. What would be the through-put of hydrazine for which the bed needs to be designed if the total duration of operation of the rocket is 6 hours.

3. Hydrogen peroxide monopropellant rockets have been used in the early satellites. Considering the environmental-friendly nature of hydrogen peroxide, interest continues in the development of the hydrogen peroxide monopropellant rockets.
A belt with a stabilization device in which a hydrogen peroxide monopropellant thruster is integrated is known as a “bell rocket belt”. It is worn by people for being propelled in air. The “bell rocket belt” has been used to fly individuals during the opening ceremonies of some Olympic games.

Determine the specific impulse of a monopropellant thruster assuming no dissociation of the products when pure hydrogen peroxide is injected into a catalyst chamber at a temperature of 25°C. The chamber pressure is 0.5 MPa and the nozzle is designed to expand the combustion products to the ambient pressure of 0.1 MPa.

4. The catalyst bed of a hydrazine monopropellant rocket gives the degree of dissociation of ammonia to be 0.2. Determine the proportion of ammonia, nitrogen and hydrogen in the products of dissociation and the heat liberated per kg of hydrazine. The standard heats of formation of hydrazine and ammonia are +50.3 kJ/mole and -45.9 kJ/mole respectively. You can assume the hydrazine to be injected into the catalyst bed at the standard state of 25°C.

What is the characteristic velocity corresponding to the above degree of decomposition of 0.2. You can take the specific heats of ammonia, hydrogen and nitrogen as 0.04, 0.03 and 0.035 $\frac{kJ}{mole\ K}$ respectively.

5. A hydrogen peroxide (H_2O_2) rocket is made by the decomposition of H_2O_2 at a pressure of 0.5 MPa using heated silver wire-mesh as the catalyst. Assuming that H_2O_2 is injected into the catalyst chamber at a temperature of 298 K and is decomposed by the catalyst to steam and oxygen, determine the characteristic velocity of the H_2O_2 rocket. You can use the following data:

Standard heat of formation of H_2O_2 = - 188 $\frac{kJ}{mole}$

Standard heat of formation of H_2O = - 286 $\frac{kJ}{mole}$

Specific heat of water = 90 $\frac{J}{mole\,K}$

Specific heat of steam = 58 $\frac{J}{mole\,K}$

Boiling temperature of water = 150^oC

Latent heat of steam = 38 $\frac{kJ}{mole}$