

Combustion in Air-breathing Aero Engines

Assignment No. 4

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This assignment contains 8 multiple choice questions with 4 possible answers to each. Only one of the choice is correct and so select the choice that best answers the question. Correct choice rewards you with 1 point for each question. Wrong answers will reward you with 0 points (no negative marking). The questionnaire contains both numerical and concept-based questions. All the best!!!

Q1: Consider a non premixed flame analysis in the limit of infinitely fast chemistry, the important factor that controls the combustion phenomena is (without any leakage of reactants)

Choose the correct answer from the following choices:

1. Chemical kinetics
2. Heat release rate
3. Diffusion of reactants
4. All of the above

Ans: The correct choice is 3.

Q2: Consider a 1D chambered flame in the limit of infinitely fast chemistry. Which of the following represent the location of the reaction sheet (\tilde{x}_f)

Choose the correct answer from the following choices:

1. $\frac{\phi^*}{1+\phi^*}$
2. $\frac{1+\phi^*}{\phi^*}$
3. $\frac{\phi^*-1}{\phi^*}$
4. $\frac{\phi^*}{\phi^*-1}$

Ans: The correct choice is 1.

Q3: Coupling function formulation is derived for a reactive flow system. Which of the following statements always hold true with respect to the coupling function

- (a) Coupling function eliminates the chemical aspect of the problem
- (b) Coupling functions are always conserved
- (c) Coupling functions simplify the problem
- (d) Coupling function relations hold in static or convective or $Le \neq 1$ mixtures
- (e) Coupling function relations hold in static or convective or $Le = 1$ mixtures

Choose the correct answer from the following choices:

1. All of the above

2. Both (b) and (e)
3. Both (a) and (e)
4. Both (c) and (e)

Ans: The correct choice is 4.

Q4: Calculate the evaporation constant (K) of a 1mm diameter propane (C₃H₈) droplet evaporating in a hot stagnant oxygen (O₂) at 950K and 1 atm.

Choose the correct answer from the following choices:

1. 1.225 m²/s
2. 1.225×10⁻² m²/s
3. 1.225×10⁻⁶ m²/s
4. 1.225×10⁻⁵ m²/s

Ans: The correct choice is 3.

Solution:

Evaporation rate constant is given by

$$K = \frac{8k_g}{\rho_l c_{p,g}} \ln(B_q + 1) \quad (1)$$

$$B_q = \frac{c_{p,g} (T_{\text{inf}} - T_{\text{boil}})}{h_{fg}} \quad (2)$$

where,

$$k_g = 0.4k_F(\bar{T}) + 0.6k_{\text{inf}}(\bar{T})\bar{T} = (T_{\text{inf}} + T_{\text{boil}}) 0.5c_{pg} = c_{pF}(\bar{T}) \quad (3)$$

T_{inf} = 950 K;

For propane,

T_{boil} = -42.1 C = 231 K, \bar{T} = 590.5

From Table B.1, B.2, and B.3 (Refer Combustion by Turns 3rd edition) c_{pg} = 127.54 kJ/kmol-K

k_F = 0.05346 W/m-K

h_{fg} = 425 kJ/kg, ρ_l = 500 kg/m³

k_g = 0.05 W/m-K

B_q = 0.2157 and K = 1.225×10⁻⁶ m²/s

Q5: Consider the solution of 1D chambered flame using the coupling function. Which of the following condition is representative of maximum burning.

Choose the correct answer from the following choices:

1. Y_{F,O} = Y_{O,ℓ} = 0.5
2. Y_{F,O} = Y_{O,ℓ} = 1.0
3. Y_{F,O} = 1.0 and Y_{O,ℓ} = 0.5
4. Y_{F,O} = 0.5 and Y_{O,ℓ} = 1.0

Ans: The correct choice is 2.

Q6: From the d² law of droplet burning, identify which of the following statement is true

Choose the correct answer from the following choices:

1. Droplet surface regression rate is constant
2. The reaction sheet standoff ratio is constant
3. Flame temperature (T_f) is adiabatic flame temperature and constant
4. All of the above

Ans: The correct choice is 4.

Q7: Over ventilated behavior of Burke-Schumann flame is because of

Choose the correct answer from the following choices:

1. Excess of air than fuel
2. Excess of fuel than air
3. Fuel and air are stoichiometric
4. Mixing of fuel and air

Ans: The correct choice is 1.

Q8: Mixture fraction formulation is not used in solving the premixed flame problems because
Choose the correct answer from the following choices:

1. There is no mixing phenomena
2. Mass fraction cannot be defined
3. Mixture fraction do not vary spatially
4. None of the above

Ans: The correct choice is 3.