Combustion in Air-breathing Aero Engines
Assignment No. 2

July 20, 2017

Release Date:

Date of Submission:

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: Classify the following reactions into chain initiation, chain branching, chain carrying, and chain termination reactions

(a) $H + O_2 = OH + O$

(b) $CH_4 + OH = CH_3 + H_2O$

(c) $H + O_2 + M = HO_2 + M$

(d) $CH_4 + O_2 = CH_3 + HO_2$

Choose the correct answer from the following choices:

1. a-Chain branching, b-Chain Carrying, c-Chain termination, and d-Chain initiation

2. a-Chain Carrying, b-Chain branching, c-Chain termination, and d-Chain initiation

3. a-Chain termination, b-Chain initiation, c-Chain branching, and d-Chain Carrying

4. a-Chain branching, b-Chain termination, c-Chain initiation, and d-Chain Carrying

Ans: The correct choice is 1.

Q2: Consider a hypothetical reaction $A + B \rightarrow C + D$ and is exothermic. Which of the following statement is true with respect to this reaction.
Choose the correct answer from the following choices:

1. Activation energy of exothermic forward reaction is higher relative to the backward reaction

2. Activation energy of exothermic forward reaction is lesser relative to the backward reaction

3. Both forward and backward reactions have same activation energy

4. Both forward and backward reactions have zero activation energy

Ans: The correct choice is 2.

Q3: Consider a unimolecular reaction. The rate coefficient of this reaction is a function of

(a) Pressure at low pressure conditions

(b) Temperature at low pressure conditions

(c) Independent of pressure at high pressure conditions

(d) Independent of pressure at both low and high pressure conditions

Choose the correct answer from the following choices:

1. only (a)

2. Both (a) and (c)

3. Only (b)

4. Only (d)

Ans: The correct choice is 2.

Q4: Consider the explosion limit curve for H_2-O_2 system consisting of three zones. Which of the following is the dominant termination reaction in the zone - I.

(a) $H \rightarrow$ wall destruction

(b) $H + O_2 + M = HO_2 + M$

(c) $HO_2 + HO_2 + M = H_2O_2 + O_2 + M$

Choose the correct answer from the following choices:

1. only (b)

2. Both (b) and (c)

3. Only (a)

4. Only (c)

Ans: The correct choice is 3.
Reason : Diffusivity of H radical is inversely proportion to pressure. At low pressure, the H radical diffuse at a faster rate and collide with the walls and terminate the reaction.

Q5: Identify the key elementary reaction from the following choices in which CO is converted to CO_2.
Choose the correct answer from the following choices:

1. $CO + O_2 = CO_2 + O_2$

2. $CO + OH = CO_2 + H$

3. $CO + HO_2 = CO_2 + OH$

4. $CO + O_2 = CO_2 + \frac{1}{2}O_2$

Ans: The correct choice is 2.

Q6: Consider the explosion limits (P-T curve) for higher chain hydrocarbon fuel. Here, a peculiar phenomena called *negative temperature coefficient* (NTC) is observed in the temperature range of 300-400°C. Identify the phenomena that causes NTC with respect to the below reactions where R represents the radical species.

(a) $R + O_2(+M) = RO_2(+M)$ (R1)

(b) $R + O_2(+M) = RO_2H(+M)$ (R2)

(c) $R + O_2 = olefin + HO_2$ (R3)

(d) $RO_2 + RH = RO_2H + R$ (R4)

(e) $RO_2H(+M) = RO + OH(+M)$ (R5)

(f) $RH + OH = R + H_2O(+M)$ (R6)

(g) $RO_2(+M) = ROOH(+M)$ (R7)

where reactions R1 to R7 (except R3) represent the chain branching path and R3 is the termination reaction. Choose the correct answer from the following choices:

1. Chain branching is less competitive than chain termination reaction

2. Chain branching is more competitive than chain termination reaction

3. Both, chain branching and chain termination reactions are equally competitive

4. Due to the H_2-O_2 chemistry and none of the above reactions play a role

Ans: The correct choice is 1.
Reason: As the branching path become less competitive, RO_2 decomposes to R and O_2.

Q7: Consider the n-butyl radical (C_4H_9). From the β-scission rule identify which of the following reactions are most likely to occur.
Choose the correct answer from the following choices:

1. CH_3-CH_2-CH_2-CH_2(+M)$\rightarrow$ C_2H_5 + C_2H_4(+M)

2. CH_3-CH_2-CH_2-CH_2(+M)$\rightarrow$ CH_5 + C_3H_4(+M)

3. CH_3-CH_2-CH_2-CH_2(+M)$\rightarrow$ C_3H_5 + CH_4(+M)

4. CH_3-CH_2-CH_2-CH_2(+M)$\rightarrow$ CH_3 + CH_2 + C_2H_4(+M)

Ans: The correct choice is 1.
Reason: β_2 (C-C) bond is the weakest with the lowest bond energy.

Q8: Identify the best sequence of steps that explains the formation of soot
Choose the correct answer from the following choices:

1. PAH formation $\rightarrow$ UHC $\rightarrow$ Mass growth of particles $\rightarrow$ Formation of 3D structures of PAH $\rightarrow$ Particle aggregation

2. UHC $\rightarrow$ PAH formation $\rightarrow$ Formation of 3D structures of PAH $\rightarrow$ Mass growth of particles $\rightarrow$ Particle aggregation

3. PAH formation $\rightarrow$ UHC $\rightarrow$ Formation of 3D structures of PAH $\rightarrow$ Particle aggregation $\rightarrow$ Mass growth of particles

4. UHC $\rightarrow$ Mass growth of particles $\rightarrow$ Particle aggregation $\rightarrow$ PAH formation $\rightarrow$ Formation of 3D structures of PAH

where, UHC is unburnt hydrocarbons and PAH is polycyclic aromatic hydrocarbons
Ans: The correct choice is 2.