National Exams December 2019

16-Chem-B6, Petroleum Refining and Petrochemicals

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. OPEN BOOK. Any non-communicating calculator is permitted.

3. FIVE (5) questions constitute a complete exam paper.
   The first five questions as they appear in the answer book will be marked.

4. Each question is of equal value.

Question Number I *(10 Marks)*

a) Define briefly and concisely the following properties that are common and important of gasoline:
   i. Boiling range
   ii. Reid vapour pressure
   iii. Antiknock characteristics
   iv. Fire point

b) Consider 200 mol/h of a binary hydrocarbon mixture of A and B to be fractionated in a distillation column. The feed composition, on a molar basis, is 60% (A) and the balance is (B). The distillate is 90% pure A and the bottom is 85% B.
   i. Estimate the rates of the product streams?
   ii. Draw a schematic diagram of this process and identify the composition of A and B at each stream?

Question Number II *(10 Marks)*

a) API gravity is a property of crude oil. Define what is API? and explain briefly and concisely whether heavy crude oil has a lower or higher API gravity?

b) A salty water contains 10% salt at a flow rate of 100 mole/h. The salt to be concentrated to 35% using a single pass evaporator. The evaporator can achieve in one single pass 50% salt concentration. Thus, to get the desired product of 35%, a portion of the feed is made to by-pass the evaporator. Determine:

1. The water evaporation rate?
2. The fraction of the feed that by-passes the evaporator?
3. The production rate of the concentrated water?
4. Draw a schematic diagram of this process and identify the composition of at each stream?

Question Number III *(10 Marks)*
A hydrocarbon stream has a molecular mass 300 kg/kmol and a specific gravity of 0.9 at 60 ^{o}F. Use charts and/or correlations to estimate the following properties:

a) API gravity
b) Watson characterization factor
c) The mean average boiling point in ^{o}C
d) The crude density in kg/m$_3$ at standard conditions
e) Pseudo critical temperature (K) and pressure (kPa)
f) The heat capacity in kJ/kg at 100 ^{o}C and 101 kPa
g) The absolute viscosity in cP at 80 ^{o}C and 101 kPa

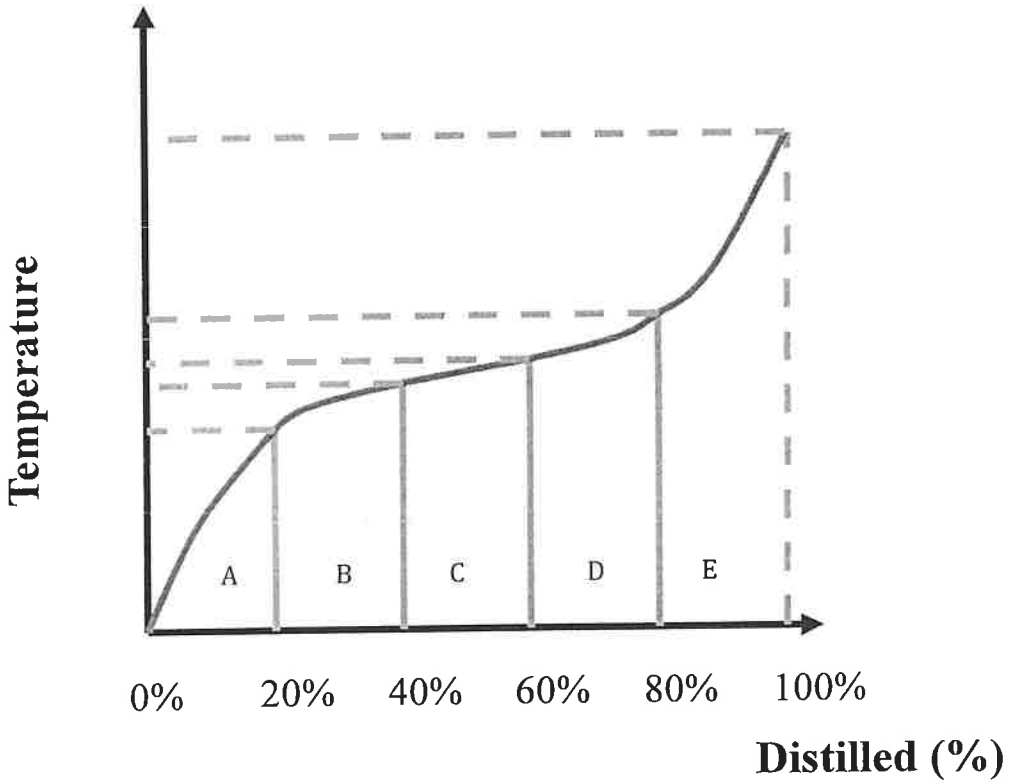
Question Number IV *(10 Marks)*

a) Below is a schematic representation of the TBP curve for a typical crude oil.

i. Name the pseudo-component products listed as A, B, C, D, and E?

ii. Show the IBP and the EP points of this crude?

iii. Show the cut points of product D?



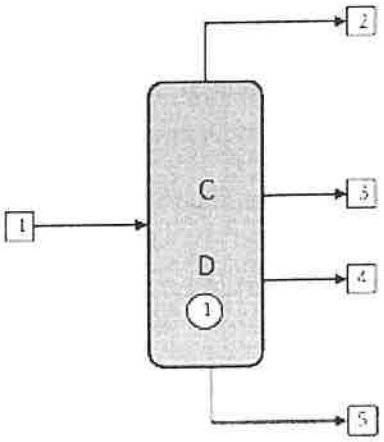
b) The following sketch shows the "black box" of the atmospheric distillation unit in a typical refinery. Answer the followings:

i. What is the main functional role of this unit?

ii. What is the typical operating temperature and pressure of the distillation column in this unit?

iii. Name the feed and the generated products?

iv. What is the destination for streams 2 and 5, and what are their functional roles?



Question Number IV *(10 Marks)*
The following processes are widely used in petroleum refining industry:

a) Catalytic Reforming
b) Catalytic Cracking.
c) Hydrocracking
d) Hydrotreating
e) Alkylation

1. State the main purposes of these processes?
2. What are their feedstocks?
3. State the possible desirable and undesirable chemical reactions that take place during these processes and their possible chemical reactions?