National Exams May 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. This is an OPEN BOOK exam. 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.

5. Questions 1-4 require answers in essay format. Clarity and organization of the answer are important.

Question Number I *(10 Marks)*

a) Define briefly and concisely the following terms that are commonly used in petroleum refining:
   i. Asphaltenes
   ii. Petroleum coke
   iii. Watson characterization factor
   iv. Reid vapour pressure
   v. Olefins
   vi. Fire point
   vii. Total Acid Number
   viii. Visbreaking
   ix. API gravity

b) Consider 1000 barrels of 30° API gas oil are blended with 5000 barrels of 15° API fuel oil. What would be the density of the mixture in the following units, assuming that the volumes are additive?
   i. Lb/ft^3
   ii. Lb/US Gallon

Question Number II *(10 Marks)*

a) Explain briefly and concisely what is a hydrocracking unit, and what are the unit feedstock and desired products?

b) Describe briefly and in a concise manner the typical flow sheet of an alkylation unit in a typical refinery. Indicate the main reactions and equipment used?

c) Draw the relationship between the theoretical number of stages in a distillation column and the reflux ratio? Show, on the graph, the optimum reflux ratio, the minimum reflux and the minimum number of stages.

d) Explain the main reason of having a crude oil desalting unit in the refinery? Describe briefly and concisely how the desalting process is performed?

Question Number III *(10 Marks)*

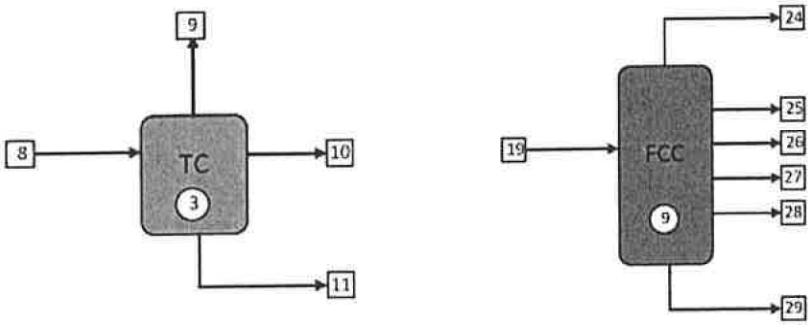
Octane number is an important property for many intermediate streams that undergo blending later on to produce automotive gasoline, diesel, et.

a) What are the two types of octane numbers for gasoline engine? Explain the difference between them, if any?

b) High octane numbers can be obtained from low quality oil by isomerization, dehydrocyclisation and catalytic cracking.
   a. Briefly and concisely, describe the three methods?
   b. Provide one example reaction for each?
   c. All three methods involve the use of catalysts, what type of catalyst is used for each method?

Question Number IV *(10 Marks)*

The following sketches show the "black boxes" of thermal (TC) and catalytic cracking (FCC) processes, respectively, in a typical refinery.



Answer the followings:

a) What is the main functional role of each process?
b) What is the typical operating temperature and pressure in each process?
c) What is the type of catalyst that is typically used in the FCC process?
d) What is the impact of contact time, reactor temperature and catalyst activity on the cracking reaction in the FCC process?
e) Name the feed (streams 8 and 19) and the generated products (streams 9, 10, 11, 24 to 29)?
f) What is the destination for streams 10 and 11 in the TC process?
g) What is the destination of streams 24 and 29 in the FCC process?

Question Number IV *(10 Marks)*

Consider 200 mol/min of a hydrocarbon mixture is distilled in a sequence of two distillation columns. The feed composition, on a molar basis, is 20% (A), 65% (B) and the balance is (C). C has the highest molecular weight followed by B and then A. The distillate from the first column is 95% pure A with 99% recovery. The split fraction for B in the top product of the second column is 0.88 and the purity of B is 98%.

a) Estimate the rates of the product streams?
b) What is the purity of C in the bottom of the second column?
c) Draw a schematic diagram of this process and identify the composition of A, B, C at each stream?