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National Exams December 2011

04-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 a CLOSED BOOK EXAM.
A Casio or Sharp approved calculator is permitted.
3. FOUR (4) problems constitute a complete exam paper.
The first five problems as they appear in the answer book will be marked.
4. Each problem is of equal value.
5. Note that the questions (a), (b), (c), (d), (e), (f) or (g) of each problem can be treated independently.
6. Most questions require an answer in essay format. Clarity and organization of the answer are important. Some of the questions require calculations please show all your steps.

Problem 1 (25 marks)

- 5
- (a) What is the meaning of the total acid number for a crude oil?
- (b) Gas composition analysis was conducted on the flue gas from the steam boiler of a petroleum refinery. The following result was reported on dry-basis (i.e., moisture free basis): 20% CO₂; 5% CO; 3% O₂.
- 9
- (i) Calculate the amount of excess air used.
- 5
- (ii) What is the weight ratio of hydrogen to carbon in the fuel?
- (c) What are the most common leading features used for the specification of the following petroleum products:
- i. Gasoline
 - ii. Naphtha and kerosene
 - iii. Gas oils
 - iv. Fuel oils
 - v. Lubricating oils
 - vi. Asphalts
- 6

Problem 2 (25 marks)

- 5
- (a) Explain graphically why petroleum greases are considered to be plastic non-Newtonian. Hint: Viscosity curve.
- 4
- (b) List four of the physical and physico-chemical properties of lubricating oils.
- 4
- (c) Describe two processes that are used to produce aromatics.
- 3
- (d) List three factors that determine the relative economics of these processes used for the production of aromatics.
- 9
- (e) If you have a 15 lb of carbon dioxide in a 30 ft³ tank at 35 °C. What will the pressure gauge on the tank read? Hint: assume carbon dioxide to be an ideal gas.

Problem 3 (25 marks)

(a) Explain briefly and concisely the meaning of the following terms:

(i) Flash point

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(ii) Pour point

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(b) Consider two distillation columns operating in series as shown below. A 250 kg/h feed mixture (F) containing 50% benzene, 25% xylene and 25% toluene is fed to a distillation column (DC1). The distillate (D1) from DC1 is almost pure in benzene; it contains 95% benzene and only 5% toluene. The residue (R1) from DC1 is fed to a second distillation column (DC2) from which a distillate (D2) of composition 90% toluene, 5% benzene and 5% xylene and a residue (R2) of composition 8% toluene and 92% xylene are obtained.

i. Determine the mass flow rates of the three final streams (D1, D2 and R2) from the system.

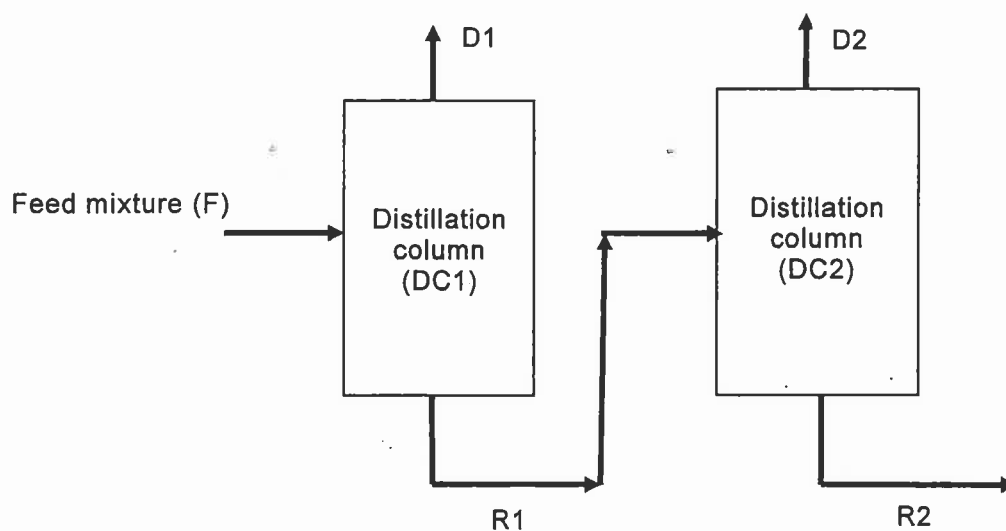
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ii. Find the mass flow rate of the intermediate stream R1.

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iii. Determine the composition of R1.

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Problem 4 (25 marks)

(a) Two types of reforming may be used in the petrochemical industry: Thermal and catalytic reforming.

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i. Describe briefly what is reforming for this industry.

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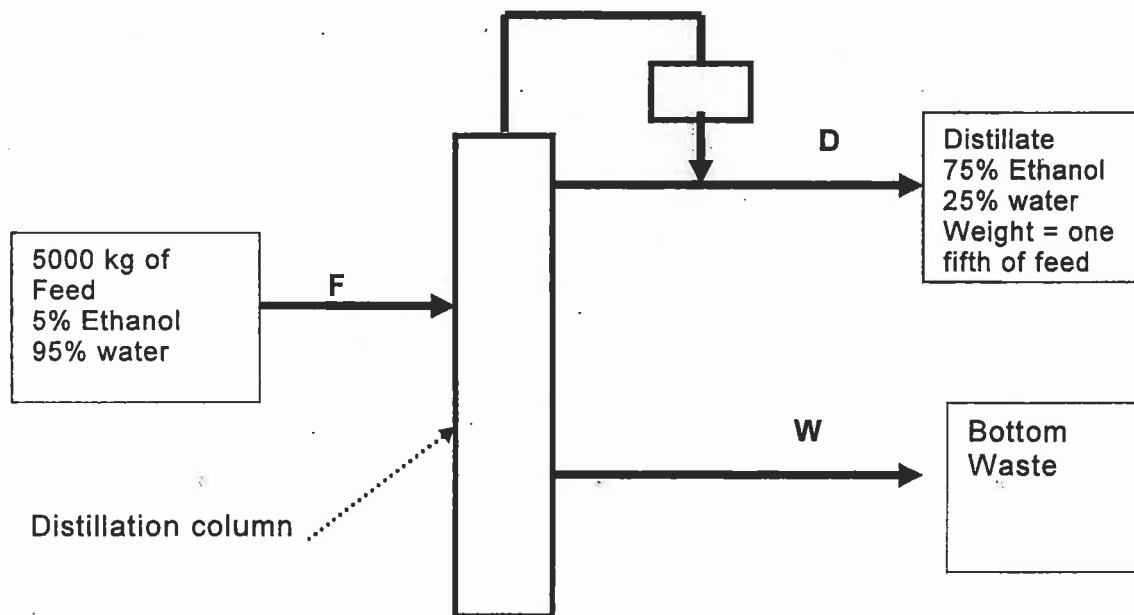
ii. Explain the major differences between thermal and catalytic reforming

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iii. Write the reforming reactions using the methane steam reaction for example.

(b) A distillation column in a petroleum refinery is shown in the diagram below with all known information on the feed and distillate. Calculate the amount of alcohol lost in the bottom.

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Problem 5 (25 marks)

(a) In a refinery gases, hydrogen sulphide, carbon dioxide and low aliphatic mercaptans need to be removed from product streams. Describe briefly how these gases are removed.

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- (b) Provide a concise definition of API gravity and show how it relates to specific gravity.

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- (c) Does a heavier crude oil have a lower or higher API gravity?

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- (d) 8000 barrels of 26° API gas oil are blended with 20,000 barrels of 16° API fuel oil. What is the density of the mixture in Lb per US Gallon

Note: Assume that the volumes are additive.

1 barrel = 42 US gallons

The density of water at 60 °F is 0.999 g/cm³.

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