

NATIONAL EXAMS DECEMBER 2003

98-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. Candidates may use one of two calculators, the Casio or Sharp approved models. This is a Closed Book exam, however candidates are permitted to bring in one (1) aid sheet, 8.5x11" (both sides) which can contain notes and formulae.
3. Any five questions constitute a complete paper. Only the first five questions as they appear in your answer book will be marked.
4. All questions are of equal value (as indicated).

Question 1 (20 marks):

- (a) Which of the following two classes of hydrocarbon molecules is a better octane blending component for gasoline: normal paraffins vs. naphthenes?
2
- (b) Which is likely to be a better gasoline blendstock: the catalytic gasoline stream from the fluid-bed catalytic cracking unit, or reformat? Please explain your answer.
3
- (c) Give one reason why gasoline blends are adjusted seasonally (i.e., summer versus winter)? Please explain your answer.
3
- (d) Butane is typically an inexpensive blendstock for gasoline. Which property particularly limits the amount of butane that can be blended into gasoline? How is this usually characterized?
2
- (e) A premium gasoline is to be blended using the components and quantities listed in the table below. Using the information provided, determine whether the blended gasoline product will meet the minimum 92 RON product specification.
4

Blending Indices and Volumes

Component	Volume (barrels)	RON	API Gravity
i-C ₅	200	93.2	95.0
Alkylate	800	94	78.6
Reformat	300	98	43.1

- (f) What is the cloud point of a petroleum product? Provide an example of a product for which cloud point is measured.
3
- (g) Which product is characterized by the cetane number? Briefly state how the cetane number is defined.
3

Question 2 (20 marks):

- (a) What is the typical 95% point (expressed as a temperature) for the naphtha feedstock to the naphtha reformer??

3

- (b) For each molecular type listed below, identify the types of beneficial reactions that occur in a naphtha reformer that lead to an improvement in gasoline blending properties:

- olefins
- paraffins
- naphthenes

Now identify two types of undesirable reactions that decrease gasoline blending properties.

5

- (c) What is a cyclic naphtha reformer? Briefly describe this type of naphtha reformer.

3

- (d) Sketch a typical flowsheet for the Naphtha Reformer. Indicate the essential reaction, heating, and separation equipment.

6

- (e) What is an "Isomerization Unit", and why is it used?

3

Question 3 (20 marks):

- (a) Which two components are reacted to form Nylon6/6? What role does benzene play in the formation of Nylon 6/6?

3

- (b) How is styrene obtained from ethylene?). Identify any additional feedstock(s) required, and the general reaction conditions (e.g., liquid vs. gas-phase).

3

- (c) Briefly describe how vinyl acetate can be produced using ethylene. Identify any additional feedstock(s) required, and the general reaction conditions (e.g., liquid vs. gas-phase).

3

- (d) How does Nylon 6 differ from Nylon 6/6?

2

- (e) The naphtha cracking process is frequently used to produce light olefins (e.g., ethylene, propylene, butylene) which represent major petrochemical feedstocks.
- (i) Briefly describe the separation sequence required to retrieve the individual light olefins from the cracker product.
5
- (ii) How would you increase the yield of light olefins in a naphtha cracker?
2
- (f) Identify a feedstock other than naphtha that is used in cracking furnaces to produce ethylene.
2

Question 4 (20 marks):

- (a) Which refinery product stream is treated with a solvent dewaxer? Why is dewaxing performed? Identify one solvent that is used for solvent dewaxing.
3
- (b) How does hydrogen sulphide arise in refinery operation? Using a sketch, briefly describe the amine treating unit for a refinery gas stream. How does the refinery dispose of the hydrogen sulphide?
5
- (c) Briefly describe the primary steps in waste water treatment for a refinery or petrochemical complex.
6
- (d) Identify two types of compounds removed in the hydrotreating of fuel oils.
2
- (e) What is the Udex extraction process used for?
2
- (f) Identify a refinery unit that is a net producer of hydrogen, and a refinery unit that is a net consumer of hydrogen.
2

Question 5 (20 marks):

- (a) What is the difference between an Equilibrium Flash Vapourization curve and a True Boiling Point curve?
2
- (b) Sketch a typical True Boiling Point curve for crude oil, and indicate the relative locations on the curve of the following fractions: light vacuum gas oil, diesel, light atmospheric gas oil, naphtha.
3
- (c) What quantities would you consider to assess the degree of overlap between two adjacent petroleum fractions?
2
- (e) Identify the four main types of hydrocarbon molecules present in crude oil. Provide an example of each type, including the molecular structure.
6
- (e) Sketch the flowsheet of a typical refinery containing an atmospheric and vacuum distillation unit, fluid catalytic cracking unit, naphtha reformer, alkylation unit, light ends separation unit, and delayed coker. It isn't necessary to sketch the details of the individual units; rather, provide a sketch that shows the typical material pathways and sequence of the various units
7

Question 6 (20 marks):

- (a) Sketch the layout of a typical Fluidized Catalytic Cracking Unit (FCCU), indicating the major pieces of process equipment and their function.
7
- (b) The conversion in an FCCU needs to be increased. How should the weight hourly space velocity be adjusted? Please explain your answer.
3
- (c) What do "full burn" and "partial burn" modes refer to in catalytic cracker operation?
3
- (d) Briefly describe the effect of catalyst/oil ratio and reactor temperature on FCCU operation.
3
- (e) What are the typical feedstocks for an alkylation unit? What are the two standard catalysts for alkylation units?
4

TOTAL MARKS: 100

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---- END OF EXAMINATION ----