

NATIONAL EXAMS MAY 2007

2004-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).

2004-CHEM-B6 Exam:

Question 1 (20 marks):

- (a) Sketch a typical True Boiling Point curve for crude oil, and indicate the relative locations on the curve of the following fractions: residuum, light vacuum gas oil, kerosene, light atmospheric gas oil, naphtha, heavy vacuum gas oil, light atmospheric gas oil, heavy atmospheric gas oil. Identify which fractions are drawn from the Atmospheric distillation column, and which are drawn from the Vacuum distillation column.

5

- (b) Use your True Boiling Point curve from part (a) to answer the following question. Suppose that I increase the drawrate for the light vacuum gas oil product. Which of the crude oil fractions listed in part (a) will be affected by the increased drawrate? Please explain your answer.

3

- (c) In an Atmospheric distillation column, a sidestream is often drawn, passed through heat exchangers to recover heat, and then returned to the Atmospheric column. What is this stream called, and why is it used?

4

- (d) Sketch the flowsheet of a typical refinery containing an atmospheric and vacuum distillation unit, fluid catalytic cracking unit, naphtha reformer, isomerization unit, light ends separation unit, alkylation unit and visbreaker. 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

8

Question 2 (20 marks):

- (a) How is the catalyst disengaged from the hydrocarbon vapour in a Fluidized Catalytic Cracking Unit? Where does this disengagement take place?

3

- (b) What is the definition of "weight hourly space velocity"? How is weight hourly space velocity (WHSV) related to catalyst residence time in the reactor ("t"), and catalyst/oil ratio ("C/O")? How should WHSV be changed if we wish to *increase* conversion?

4

- (c) Sketch the layout of a typical Fluidized Catalytic Cracking Unit (FCCU), indicating the major pieces of process equipment and their function.

6

- (d) Provide a brief description, using a sketch of the flowsheet, of an alkylation unit. What are the two standard catalysts that are used for alkylation units? What are the typical feedstocks to the alkylation unit?

7

Question 3 (20 marks):

- (a) RON is used to characterize gasoline. What does the acronym RON stand for, and how is it defined?

4

- (b) Naphtha Reforming units and Isomerization units are both used to produce blendstock for gasoline blending. Both processes use catalytic reactors to convert naphtha range feedstocks and enhance their octane rating. Compare the types of reactions that occur in Naphtha Reforming to those that occur in Isomerization. You might want to consider, for example, the extent to which cyclic compounds are produced.

4

- (c) What is the Reid Vapour Pressure (RVP), and how is it defined? Which product uses RVP as a specification, and why is it necessary to adjust RVP from Summer to Winter? Please explain your answer clearly.

4

- (d) A regular gasoline is to be blended using the four components listed in the table below. The target RON specification is 90. We want to blend using all the volume available of Straight Run Naphtha, Alkylate and Reformate, and we can use up to 3000 barrels of Isomerate. How much Isomerate will be required to produce a regular gasoline that will meet the blending specification?

5

Blending Indices and Volumes

Component	Volume (barrels)	RON	MON
Isomerate	<3000	92.4	90.3
Straight Run Naphtha	4000	78.2	76.3
Alkylate	2000	91.8	90.1
Reformate	4000	98.2	93.1

- (e) What is the pour point of a petroleum product? Provide an example of a product for which pour point is measured.

3

Question 4 (20 marks):

(a) The naphtha cracking process is frequently used to produce light olefins (e.g., ethylene, propylene, butylene) which represent major petrochemical feedstocks.

(i) What happens to the yield of light olefins when temperature is increased in a naphtha cracker?

2

(ii) What is added to the hydrocarbon stream in a naphtha cracker to reduce coking?

2

(b) For which polymer are adipic acid and hexamethylene diamine two intermediate reactants?

2

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

3

(d) There are two common processes for producing vinyl chloride monomer: the direct oxidation process, and the oxychlorination process. Briefly describe each process, identifying the feedstocks involved, the main intermediate and final product chemical species, the general reaction conditions (e.g., liquid vs. gas-phase), and the types of catalysts involved (e.g., platinum).

8

(e) How is ethylene glycol obtained from ethylene using the oxidation route? Identify any feedstock(s) required, and the general reaction conditions required (e.g., liquid vs. gas-phase).

3

Question 5 (20 marks):

(a) 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?

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(b) What is the definition of API gravity? Does a lighter crude oil have a lower or higher API gravity? Please explain.

4

(c) What is DEA, and what is it used for in a refinery?

3

(d) What is a PONA analysis of a crude oil fraction?

2

(e) Identify three sources of process water streams requiring treatment.

3

(e) What is an API skimmer, and in which refinery unit is it found?

3

Question 6 (20 marks):

(a) Name two types of Naphtha Reformer processes.

2

(b) Identify the three beneficial types of reactions occurring in a Naphtha Reformer. Briefly describe the chemical change associated with each type of reaction, and the type of hydrocarbon typically involved.

6

(c) How is coking suppressed in a Naphtha Reformer?

2

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

6

(e) What type of catalyst is used in a Naphtha Reformer?

2

(f) Is the Naphtha Reformer a net consumer or producer of hydrogen in a refinery?

2

TOTAL MARKS: 100

---- END OF EXAMINATION ----