

## National Exams December 2018

### 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. Questions are 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.
5. Questions 1-3 require answers in essay format. Clarity and organization of the answer are important.

**Question Number I (10 Marks)**

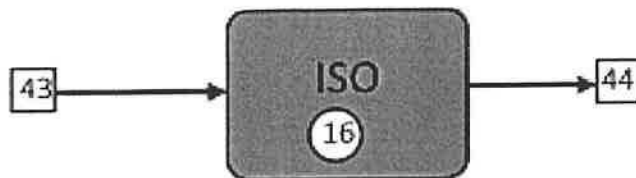
- a) Define briefly and concisely the following terms that are commonly used in petroleum refining:
- i. Reid vapor pressure
  - ii. Antiknock
  - iii. Boiling range
  - iv. RON
  - v. API gravity
  - vi. TAN
  - vii. Watson characterization factor
- b) The terms hydrotreating, hydroprocessing, hydrocracking and hydrodesulfurization are used rather loosely in petroleum refinery industry. Define briefly and concisely these terms, and provide the typical operating conditions (i.e., pressure and temperature) for each?

**Question Number II (10 Marks)**

- a) Petroleum coke (petcoke) is a by-product generated upon processing crude oil in the refinery. There are several types of petcoke that can be produced depending upon feedstock properties, process which is used, and the operating conditions.
- i. Briefly and concisely, describe the three types of petcoke?
  - ii. Name five different applications for petcoke?
  - iii. List three drawbacks for petcoke?
- b) Hydrogen is an important ingredient for the petrochemical industry.
- i. Describe briefly the main methods used to produce hydrogen from hydrocarbons?
  - ii. List the impurities that can be formed during hydrogen production?
  - iii. What processes would you use to remove these impurities to obtain purified hydrogen?

**Question Number III (10 Marks)**

The following sketch shows the “black box” of the isomerization unit in a typical refinery.



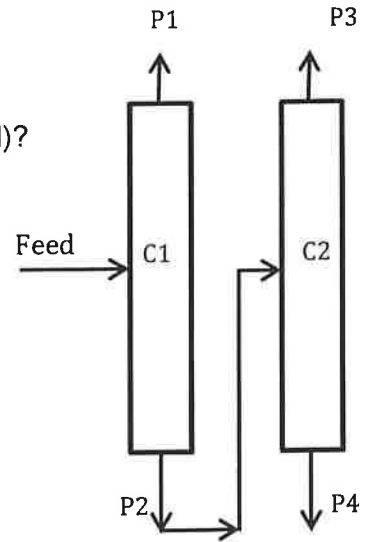
Answer the followings:

- What is the main functional role of this unit?
- What is the typical operating temperature and pressure in this unit?
- What is the type of catalyst that is typically used in this process?
- What is the impact of contact time, reactor temperature and catalyst activity on the isomerization reaction?
- Name the feed (stream 43) and the generated products (stream 44)?
- What is the destination for stream 44?

**Question Number IV (10 Marks)**

500 moles/s of liquid hydrocarbon mixture containing, by moles, 20% methane, 40% propane and 40% normal butane is to be separated in two distillation columns, as per the diagram below. The product P1 contains all the methane, and it is 96% pure methane and 1% n-butane. The product P3 is 99% pure propane and P4 is 92% pure n-butane.

- Calculate the flow rates of streams P1 through P4?
- Determine the composition for P2?
- What are the key components for each column?
- Calculate the split fractions and split ratios for the light keys?
- What is the recovery for n-butane (based on the process feed)?



**Question Number V (10 Marks)**

A hydrocarbon stream has a molecular mass 300 kg/kmol and a specific gravity of 0.9 at 60 °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 °C
- d) The crude density in kg/m<sup>3</sup> at standard conditions
- e) Pseudo critical temperature (K) and pressure (kPa)
- f) The heat capacity in kJ/kg at 100 °C and 101 kPa
- g) The absolute viscosity in cP at 80 °C and 101 kPa