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UNIVERSITI KUALA LUMPUR
MALAYSIAN INSTITUTE OF CHEMICAL AND BIOENGINEERING TECHNOLOGY

FINAL EXAMINATION
OCTOBER 2025 SEMESTER

COURSE CODE	:	CCB41302
COURSE NAME	:	PETROCHEMICALS & PETROLEUM REFINING TECHNOLOGY
PROGRAMME NAME	:	BACHELOR OF CHEMICAL ENGINEERING WITH HONOURS
DATE	:	24 JANUARY 2026
TIME	:	2.00 PM – 5.00 PM
DURATION	:	3 HOURS

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper has information printed on both sides of the paper.
3. This question paper has FIVE (5) questions. Answer ALL questions.
4. Please WRITE your answers on the answer booklet provided.
5. Please answer all questions in English only.

THERE ARE 14 PAGES OF QUESTIONS AND APPENDICES EXCLUDING THIS PAGE.

INSTRUCTION

Answer ALL questions (Total: 100 marks)

Please use the answer booklet provided.

QUESTION 1

(a) The sample of crude oil from Hastings Field's Well, Texas was sent to Bartlesville's Laboratory for analysis before further process to obtain various petrochemical products.

i. Based on the crude petroleum analysis data sheets shown in Figure 1a and 1b, calculate the true boiling point (TBP) by using both graphical and formula methods.

(7 marks)

ii. Tabulate all the final data in a table and illustrate the TBP and gravity mid-percent curves (showing all the points on the same illustration for TBP and gravity mid-percent curves).

(6 marks)

(b) Calculate the correlation index for 2-methylpentane (*the boiling point is 140.47°F and the specific gravity (S.G) is 0.658 at 60°F*).

(2 marks)

(c) The percentage of oil distillation for every 20 minutes are tabulated in Table 1. Calculate the Universal Oil Products (UOP) *K* factor and conclude whether this oil is paraffinic, aromatic or naphtenic. (Given that the density of oil = 719.7 kgm^{-3}, density of water = 1000 kgm^{-3})

(5 marks)

Table 1: Percent of oil distilled over time

Time (minute)	Temperature (°C)	Percent Oil Distilled (%)
20	90	13
40	110	35
60	133	48
80	168	60
100	200	85

GENERAL CHARACTERISTICS

Gravity, specific, 0.867 Gravity, ° API, 31.7 Pour point, ° F., below 5
Sulfur, percent, 0.15 Color, brownish green
Viscosity, Saybolt Universal at 100° Nitrogen, percent,

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 751 mm. Hg
First drop, 84 ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum. percent	Sp. gr., 60/60° F.	° API, 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. visc., 100° F.	Cloud test, ° F.
1	122	0.8	0.8	0.673	78.8					
2	167	1.0	1.8	.685	75.1	15				
3	212	3.0	4.8	.725	63.7	24	1.39574	127.7		
4	257	3.4	8.2	.755	55.9	29	1.41756	128.6		
5	302	3.1	11.3	.777	50.6	32	1.42985	135.4		
6	347	3.9	15.2	.798	45.8	35	1.44192	137.8		
7	392	4.9	20.1	.817	41.7	38	1.45217	139.9		
8	437	6.8	26.9	.833	38.4	40	1.46057	140.3		
9	482	8.0	34.9	.848	35.4	41	1.46875	148.0		
10	527	10.9	45.8	.864	32.3	44	1.47679	149.8		
STAGE 2—Distillation continued at 40 mm. Hg										
11	392	7.3	53.1	0.873	30.6	45	1.48274	155.2	42	Below 5
12	437	7.8	60.9	.879	29.5	44	1.48474	156.2	50	do
13	482	6.2	67.1	.889	27.7	45	1.49058	152.7	71	do
14	527	5.7	72.8	.901	25.6	48			125	10
15	572	6.9	79.7	.916	28.0	52			280	20
Residuum	......	20.3	100.0	.945	18.2					

Carbon residue, Conradson: Residuum, 4.7 percent; crude, 1.0 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	4.8	0.708	68.4	
Total gasoline and naphtha	20.1	0.771	52.0	
Kerosine distillate	--	--	--	
Gas oil	36.9	0.858	33.4	
Nonviscous lubricating distillate	10.2	.879-.895	29.5-26.6	50-100

Figure 1a: Crude petroleum analysis obtained from Hastings Field's Well, Texas

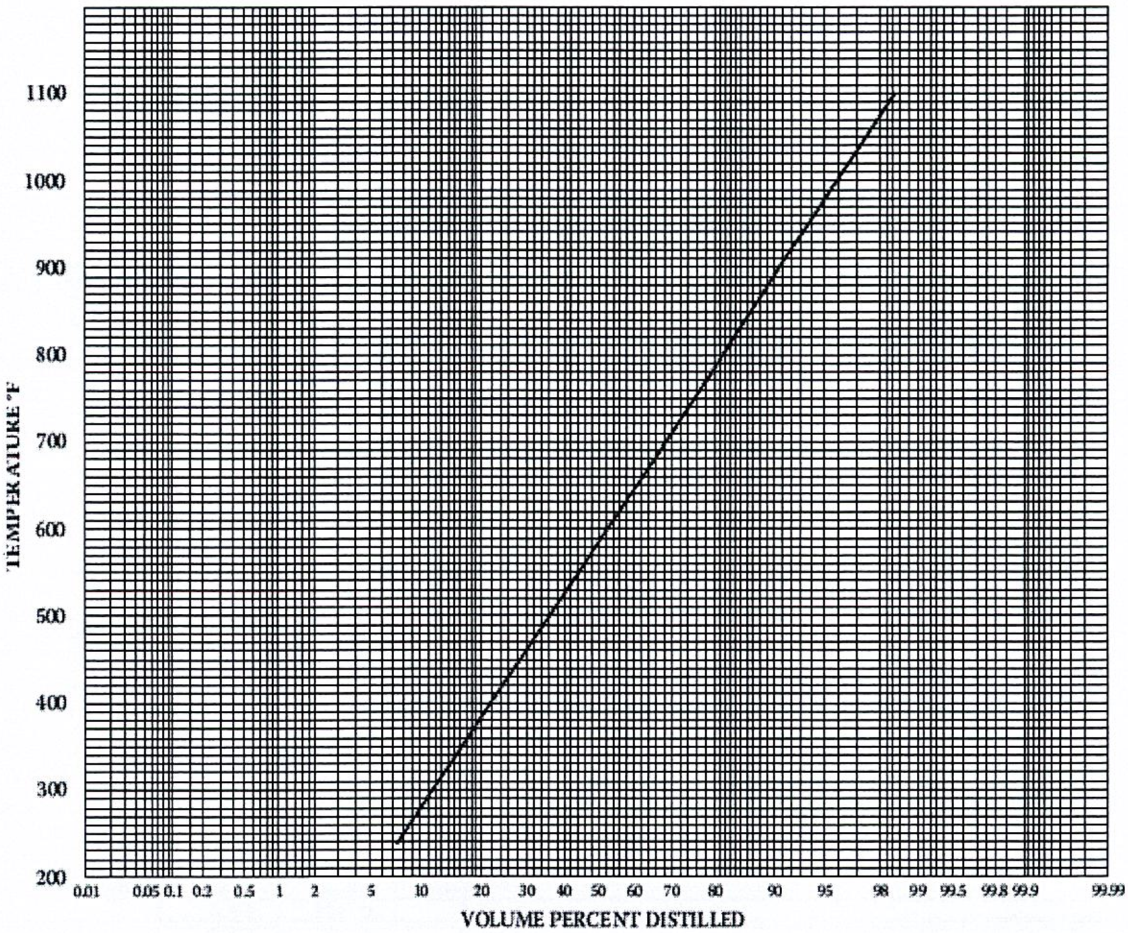


Figure 1b: Plot of distillation temperature versus volume percent distilled

QUESTION 2

Figure 2 shows a simplified flow diagram of sulfur recovery process. The Claus burner is located in the main combustion chamber, which also can be a part of the waste heat boiler.

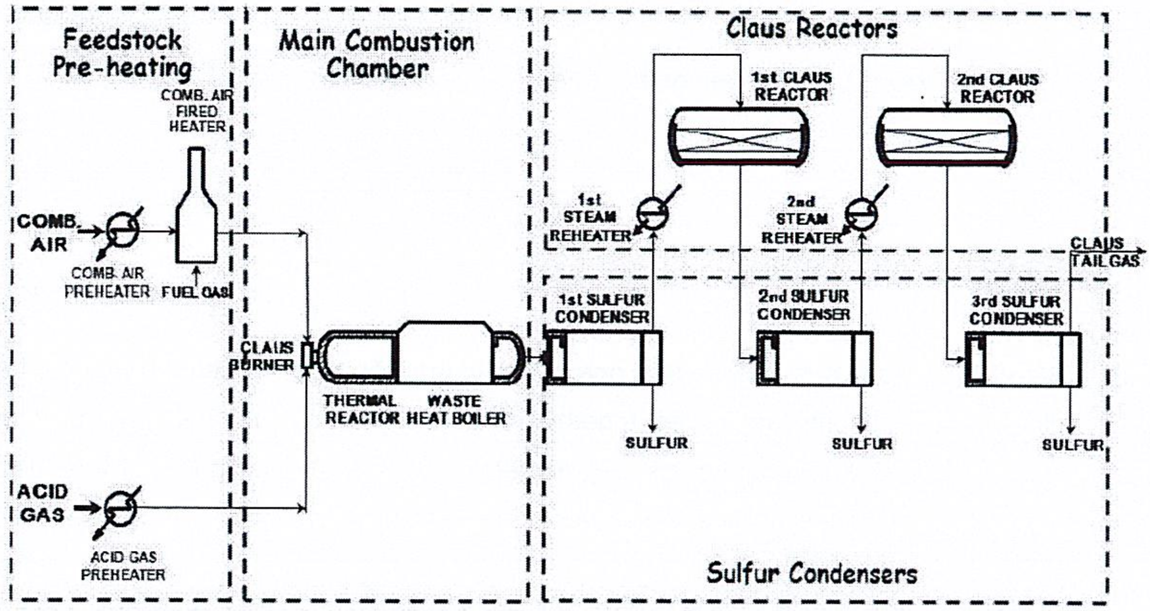


Figure 2: The modified Claus process

(a) Identify **TWO (2)** reactions occur in burner and reaction chamber with the presence of catalyst, if any.

(4 marks)

(b) Explain the main function of reaction chamber in Figure 2.

(2 marks)

(c) If ammonia presents in the feed stream in Figure 2, presume the impact to modified Claus unit.

(1 mark)

(d) Determine **TWO (2)** important factors that will affect the above process.

(2 marks)

(e) Suggest other **TWO (2)** processes for acid gas removal purposes.

(2 marks)

(f) Provide **TWO (2)** explanations why acid gas must be removed from the process.

(4 marks)

(g) After the process in Figure 2, suggest **ONE (1)** process that can be added to ensure the compliance to air emission regulation. Explain the process.

(2 marks)

(h) Suggest **ONE (1)** treatment process using physical absorption that does not involve chemical reaction.

(1 mark)

(i) Discuss **TWO (2)** advantages of the process suggested in (h).

(2 marks

QUESTION 3

(a) Blending process is one of the final operations in the refining of crude oil. Two or more different components are mixed together in order to obtain the desired range of properties in the finished products. Define Cetane Number and compare between high and low concentration of Cetane Number in diesel engine condition.

(4 marks)

(b) Primary petrochemicals also referred as the first generation of petrochemicals can be converted to secondary or intermediate petrochemicals by a series of chemical reactions.

i. Identify an olefinic hydrocarbon which known as "king of petrochemicals".

(1 mark)

ii. Determine **THREE (3)** derivatives or intermediate petrochemicals that can be produced from (i).

(3 marks)

(c) The removal of salt from crude oil for refinery feed stocks has been and still is a mandatory step. This is particularly true if the salt content exceeds 20 PTB (pounds of salt per thousand barrels of oil).

i. Determine **TWO (2)** importance of desalting process.

(2 marks)

ii. Electrostatic desalting is a common process used in the petroleum industry to remove salt and water impurities from crude oil before refining. Describe the principle of electrostatic desalting and explain how this process enhances salt removal from crude oil.

(3 marks)

(d) Figure 3 shows a reaction occurred in a crude oil refining process.

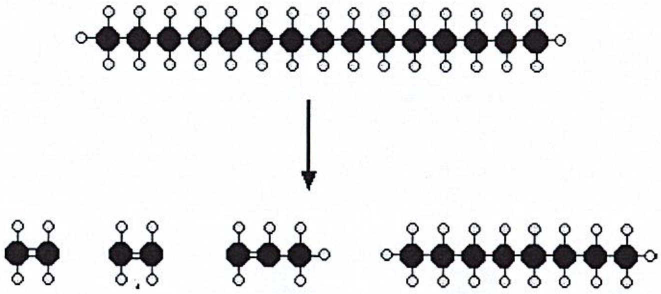


Figure 3: Reaction in crude oil refining process

i. Suggest **THREE (3)** refining processes that occur based on Figure 3.

(3 marks)

ii. Vis-breaking is a non-catalytic process under mild condition. Describe the process of vis-breaking and the type of vis-breakers that commonly used.

(4 marks)

QUESTION 4

(a) Identify Process *X* shown in Figure 4 and describe the process.

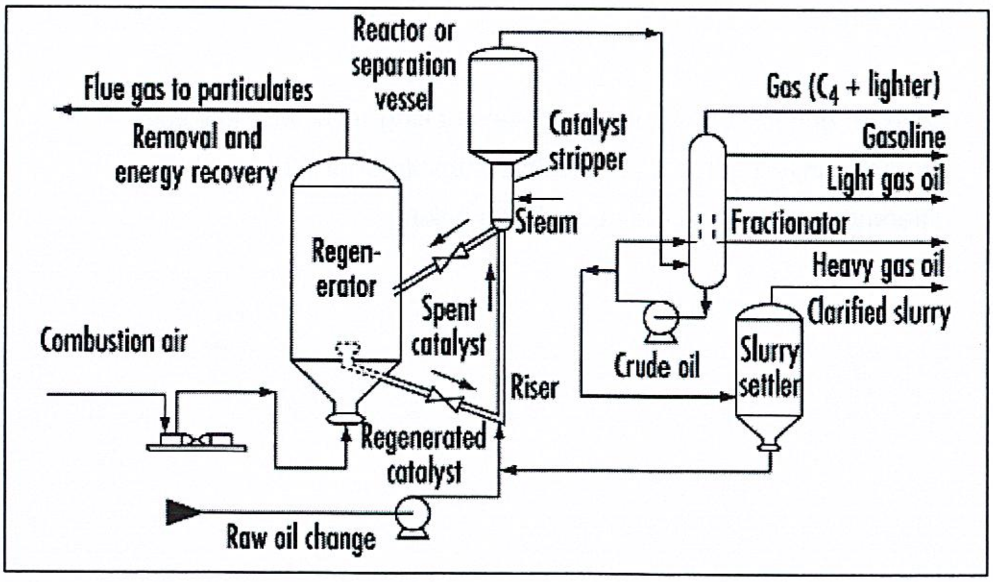


Figure 4: Process *X* used in refinery crude oil

(5 marks)

(b) Identify Process *Y* shown in Figure 5 and describe the process.

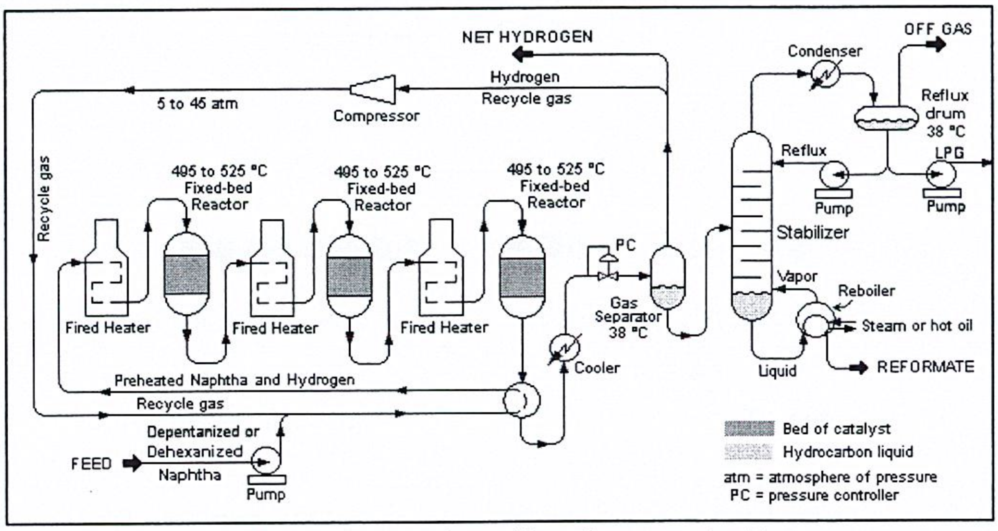


Figure 5: Process *Y* used in refinery crude oil

(5 marks)

(c) Explain **ONE (1)** advantage of Process *X* in Figure 4 compared to Process *Y* in Figure 5.

(2 marks)

(d) 'Reformates' are the products from the processes shown in Figure 4 and Figure 5. Explain the importance of the processes in Figure 4 and Figure 5 that are shown by the reformates.

(2 marks)

(e) Coke produced from delayed and flexi coking units with low sulfur and ash contents has been investigated as a possible substitute for carbon black. Explain **THREE (3)** differences of delayed coking and flexi coking.

(6 marks)

QUESTION 5

(a) Blending process is one of the final operations in the refining of crude oil. Two or more different components are mixed together in order to obtain the desired range of properties in the finished products. Calculate the American Petroleum Institute (API) gravity of a blend from two streams as shown below *(Hints: Use information in the appendix section, Table D.1, Table D.2 and Table D.3)*

Stream 1 : 2,000 bbls oil of 90 °API

Stream 2 : 7,000 bbls oil of 30 °API

(5 marks)

(b) SRC Refinery Sdn Bhd will blend the following stocks for producing the gasoline.

Stream A: 1,250 bbls HSR gasoline

Stream B: 750 bbls LSR gasoline

Stream C: 620 bbls C_5^+ FCC gasoline

(Hints: Use information in the appendix section, Table D.1, Table D.2 and Table D.3)

i. Calculate the amount of n-butane required to produce a gasoline with Reid Vapor Pressure (RVP) of 9 psi.

(5 marks)

ii. Calculate the Research Octane Number (RON) and Motor Octane Number (MON) for the blend.

(5 marks)

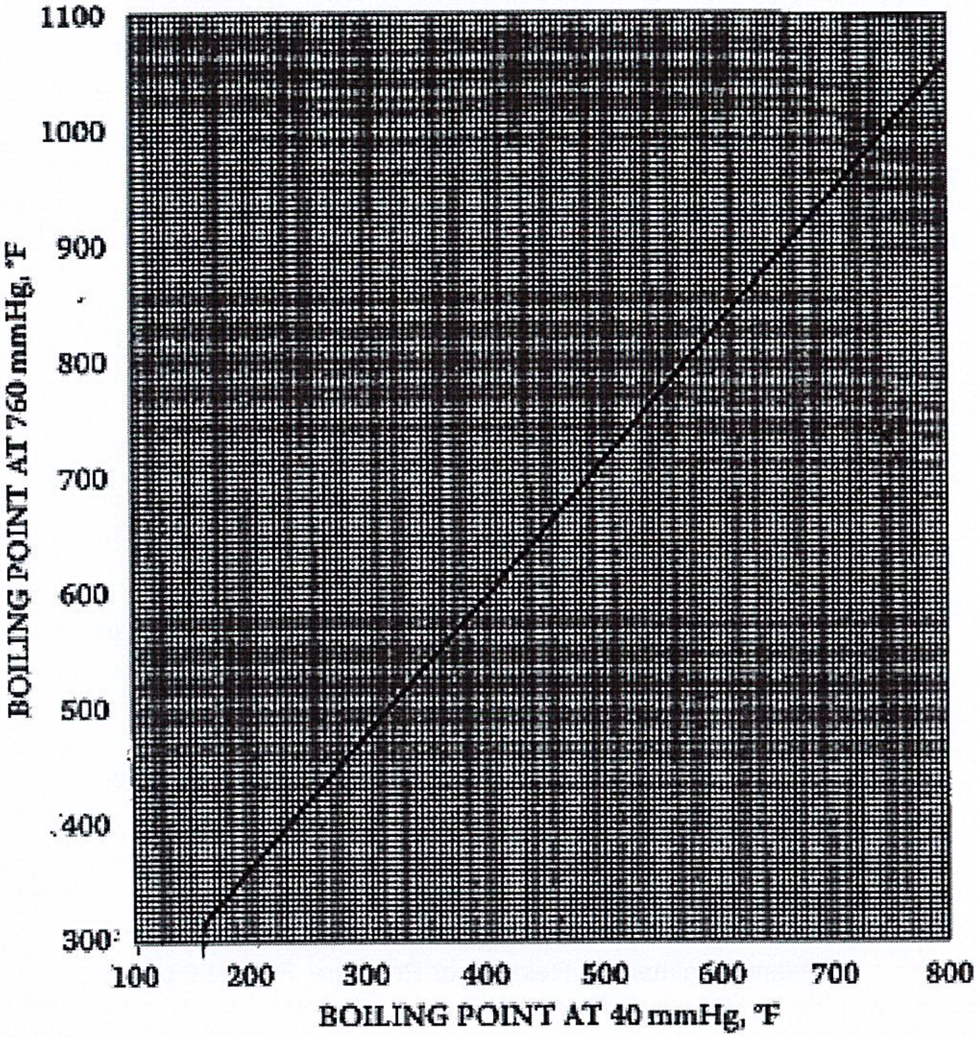
iii. Calculate the posted octane number (PON) if 10% volume MTBE is added to the blend (maintaining Reid Vapor Pressure, RVP at 9 psi).

(5 marks)

END OF EXAMINATION QUESTIONS

APPENDICES

APPENDIX A



APPENDIX B

$$API = \frac{141.5}{SG} - 131.5$$

$$SG_{oil} = \frac{\rho_{oil}}{\rho_{H_2O}}$$

$$K_W = \frac{(T_B)^{1/3}}{SG}$$

$$CI = \frac{87552}{T_B} + 473.7SG - 456.8$$

Tb (1atm) = 126.14 + 1.169 Tb (40 mmHg)

$^{0}F + 460 = {}^{0}R$

$(°C \times 9/5) + 32 = °F$

$$\text{Diesel Index} = \frac{\text{Aniline point x API gravity}}{100}$$

APPENDIX C

- **Volumetric average boiling point**

$$VABP = \sum_{i=1}^{n} x_{vi} T_{bi}$$

xvi = volume fraction of component i.
Tbi = normal boiling point of component i (°F or R).

- **Molal average boiling point**

$$MABP = \sum_{i=1}^{n} x_i T_{bi}$$

xi = mole fraction of component i.
Tbi = normal boiling point of component i (°F or R).

- **Weight average boiling point**

$$WABP = \sum_{i=1}^{n} x_{wi} T_{bi}$$

xwi = weight fraction of component i.
Tbi = normal boiling point of component i (°F or R).

- **Cubic average boiling point [R]**

$$CABP = \left(\sum_{i=1}^{n} x_{vi} T_{bi}^{1/3} \right)^3$$

Tbi = normal boiling point of component i (R only).

- **Mean average Boiling point**

$$MeABP = \frac{MABP + CABP}{2}$$

APPENDIX D

Table D.1: — Typical RVP Values for Gasoline Blending Components

Component	Typical RVP (psi)
n-Butane	52
Isobutane	52
LSR (Light Straight-Run Naphtha)	11.1
HSR (Heavy Straight-Run Naphtha)	1.0
C_5 FCC Gasoline	4.4
C_5–C_6 Alkylate	3.0
Reformate (light)	3.0
Reformate (heavy)	1.0
Isomerate	6.0
MTBE (Methyl Tertiary-Butyl Ether)	7.0
Ethanol (pure)	18
Toluene	<1
Xylene	<1
Heavy Cat Naphtha (HCN)	1.0
Light Cat Naphtha (LCN)	8.0

Table D.2: Reid Vapor Pressure Blending Index Numbers for Gasoline and Turbine Fuels.

Vapor Pressure, psi	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	0.00	0.05	0.13	0.22	0.31	0.42	0.52	0.64	0.75	0.87
1	1.00	1.12	1.25	1.38	1.52	1.66	1.79	1.94	2.08	2.23
2	2.37	2.52	2.67	2.83	2.98	3.14	3.30	3.46	3.62	3.78
3	3.94	4.11	4.28	44.4	4.61	4.78	4.95	5.13	5.30	5.48
4	5.65	5.83	6.01	6.19	6.37	6.55	6.73	6.92	7.10	7.29
5	7.47	7.66	7.85	8.04	8.23	8.42	8.61	8.80	9.00	9.19
6	9.39	9.58	9.78	9.98	10.2	10.4	10.6	10.8	11.0	11.2
7	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0	13.2
8	13.4	13.7	13.9	14.1	14.3	14.5	14.7	14.9	15.2	15.4
9	15.6	15.8	16.0	16.2	16.4	16.7	16.9	17.1	17.3	17.6
10	17.8	18.0	18.2	18.4	18.7	18.9	19.1	19.4	19.6	19.8
11	20.0	20.3	20.5	20.7	20.9	21.2	21.4	21.6	21.9	22.1
12	22.3	22.6	22.8	23.0	23.3	23.5	23.7	24.0	24.2	24.4
13	24.7	24.9	25.2	25.4	25.6	25.9	26.1	26.4	26.6	26.8
14	27.1	27.3	27.6	27.8	28.0	28.3	28.5	28.8	29.0	29.3
15	29.5	29.8	30.0	30.2	30.5	30.8	31.0	31.2	31.5	31.8
16	32.0	32.2	32.5	32.8	33.0	33.2	33.5	33.8	34.0	34.3
17	34.5	34.8	35.0	35.3	35.5	35.8	36.0	36.3	36.6	36.8
18	37.1	37.3	37.6	37.8	38.1	38.4	38.6	38.9	39.1	39.4
19	39.7	39.9	40.2	40.4	40.7	41.0	41.2	41.5	41.8	42.0
20	42.3	42.6	42.8	43.1	43.4	43.6	43.9	44.2	44.4	44.7
21	45.0	45.2	45.5	45.8	46.0	46.3	46.6	46.8	47.1	47.4
22	47.6	47.9	48.2	48.4	48.7	49.0	49.3	49.5	49.8	50.1
23	50.4	50.6	50.9	51.2	51.5	51.7	52.0	52.3	52.6	52.8

Equation:

$$VPBI = VP^{1.25}$$

Table D.3: — Typical BRON and BMON for Values of Gasoline Blending Components

Component	BRON (Research Octane Number)	BMON (Motor Octane Number)
n-Butane	93	92
Isobutane	100	98
LSR (Light Straight Run)	66.4	61.6
HSR (Heavy Straight Run)	62.3	58.7
C_5 FCC Gasoline	92.3	76.8
Light Cat Naphtha (LCN)	85 – 92	75 – 82
Heavy Cat Naphtha (HCN)	70 – 80	65 – 75
Alkylate (C_5–C_6)	92 – 96	90 – 94
Reformate (Light)	98 – 102	87 – 92
Reformate (Heavy)	100 – 102	85 – 88
Isomerate	88 – 92	80 – 85
MTBE (Methyl Tertiary-Butyl Ether)	109 – 111	100 – 101
Ethanol (pure)	110 – 115	90 – 95
Toluene	120	110
Xylene	120	110