

MODULE -1

Composition of petroleum, laboratory test, refinery feedstock and product

Q1: Define specific gravity and write the relationship between specific gravity and API gravity?

A1: The specific gravity is defined as the weight of unit volume of oil to the weight of same volume of water at a standard temperature. The relationship between the specific gravity and API is

$$\text{Deg. API} = \frac{141.5}{\text{sp gr}} - 131.5$$

Q2: What are the terms Characterization factor and correlation index. How are they important?

A2: Characterization factor is developed by UOP (Universal Oil Products Co.). It correlates the boiling point with specific gravity, given by:

$$K = \frac{\sqrt[3]{T_B}}{S}$$

to the following expression.

$CI = (48640/T_B)^{0.75} + 473.7$ $S = 456.8 - T_B$ T_B is the average molal boiling point ($^{\circ}F$) and S is the specific gravity at $60^{\circ}F$. This gives a relative idea about the Parafinic, Naphthenic and Aromatic nature of the crude oil. Correlation index (CI) developed by US Bureau of mines. It correlates the boiling point with specific gravity, according

Q3: Define BPCD?

A3: BPCD stands for Barrels per Calendar Day. It is the measurement of the rated capacity of a process unit of a process unit or operation. Basically it is $1/365^{\text{th}}$ of the annual throughput. This measure accounts for down time for maintenance, etc. An alternate measure is barrels per steam day, the measure of the maximum daily capacity. On-stream factor is the ratio of BPCB to BPSD.

Q4: What is BTX?

A4: BTX stands for Benzene, Toluene, and Xylene. These aromatic molecules are very important components of gasoline and petrochemicals. Benzene, the simplest aromatic is carcinogenic and its level in gasoline is severely restricted. Toluene and xylene have benzene rings to which are attached one or two methyl (CH₃) groups, respectively. Xylene has three isomers, with the methyls adjacent on the ring (ortho), separated by one carbon (meta), or separated by two carbons (para).

Q5: What is performance number?

A5: Performance number = ((Octane number – 100) *3) + 100

It is used to estimate knocking characteristics of aviation gasolines of octane number higher than 100.

Q6: What is cetane number?

A6: Cetane number = % n-cetane + 0.15 (% heptamethyl nonane)

The shorter the ignition delay period, higher is the cetane number of the fuel.

Q7: What is diesel index?

A7: Diesel index is an indication of the ignition quality of a diesel fuel. It can be determined by calculation from the specific gravity and the aniline point of the sample

Diesel index = (Aniline point * °API) / 100.

Q8: What is the calorific value of the fuel?

A8: It is the quantity of heat released per unit quantity of fuel, when it is burned completely with oxygen and the products of combustion returned to ambient temperature. Calorific value = 12400 – 2100 ρ².

Q9: What is cloud point and pour point?

A9: Cloud point of petroleum products is the temperature at which a cloud or haze of wax crystals appears at the bottom of the test jar when the oil is cooled under prescribed conditions. It is generally determined for products that are transparent in a 40-mm thick layer and have cloud points below 49 °C. Pour point is the lowest temperature expressed in multiple of 3°C at which the oil is observed to flow when cooled and examined under prescribed conditions.

Q10: What is SVI?

A10: SVI stands for Smoke Volatility Index. It is defined as:

SVI = smoke point + 0.42 (percent of fuel boiling below 204.4°C).

Q11: What is the world energy demand and availability of crude oil.?

A11: During the year 2008, total worldwide energy consumption was 474 exajoules (474×10^{18} J = 132,000 TWh). This is equivalent to an average energy consumption rate of 15 terawatts (1.504×10^{13} W). The potential for renewable energy is: solar energy 1600 EJ (444,000 TWh), wind power 600 EJ (167,000 TWh), geothermal energy 500 EJ (139,000 TWh), biomass 250 EJ (70,000 TWh), hydropower 50 EJ (14,000 TWh) and ocean energy 1 EJ (280 TWh).

The estimates of remaining non-renewable worldwide energy resources vary, with the remaining fossil fuels totaling an estimated 4×10^5 EJ and the available nuclear fuel such as uranium exceeding 2.5×10^5 EJ.

Q12: What is the crude composition of Indian crude?

A12: Crude compositions of Indian crude are as below
C: 84-87%, H: 11-14%, S: 0-5%, N: 0-1%, O: 0-2%.

Q13: What is API gravity?

A13: The density of petroleum oils is expressed in the United States in terms of API gravity rather than specific gravity; it is related to specific gravity in such a fashion that an increase in API gravity corresponds to a decrease in specific gravity
 $API = 141.5 / Sp.Gr - 131.5$.

Q14: What does pour point of an oil signify?

A14: The pour point of the crude oil, in °F or °C, is a rough indicator of the relative paraffinicity and aromaticity of the crude. The lower the pour point, the lower the paraffin content and the greater the content of aromatics.

Q15: What is a Characterization factor?

A15: Characterization factors: $K = (T_B)^{1/3} / d$. It correlates boiling point with sp.gravity
Here T_B is the average boiling point in degrees Rankine and d is the specific gravity
 $60^\circ F / 60^\circ F$.

Q16: How does a Characterization factor vary for different crude?

A16: Highly paraffin oils: K: 12.5 to 13.0
Cyclic (naphthenes) oils have K: 10.5 to 12.5.
Aromatics: 9.0- 10.5

Q17: What is correlation index?

A17: The correlation index is useful in evaluating individual fractions from crude oils. The CI scale is based upon straight-chain paraffins having a CI value of 0 and benzene having a CI value of 100 and is defined as follows:

$$C.I = 87552/TB + 473.7 G - 456.8$$

Q18: What is gasoline?

A18: Gasolines are complex mixtures of hydrocarbons having typical boiling ranges from 100 to 400 °F (38 to 200 °C). It consists of mainly C₅-C₁₀ HC (mainly n-paraffins, isoparaffins, naphthenes and aromatic hydrocarbons).

Q19: What is Light straight-run (LSR)?

A19: gasoline consists of the (C₅)-190 °F (C₅)-88 °C) fraction of the naphtha from the atmospheric crude still. (C₅)-190 °F fraction means that pentanes are included in the cut but that (C₄) and lower-boiling compounds are excluded and the TBP end point is approximately 190 °F.

Q20: What is kerosene oil?

A20: Kerosene is also called paraffin or paraffin oil, is a flammable pale-yellow or colorless oily liquid with a characteristic odor. It is intermediate in volatility between gasoline and gas diesel oil. It is a medium oil distilling between 150°C and 300 °C (300 °F to 570 °F). (HC: C₁₀-C₁₄).

Q21: What is automotive diesel fuel?

A21: It is super-diesel is generally made from virgin or hydrocracker stocks having cetane numbers above 45. It has a boiling range from 360 to 600 °F (182 to 320 °C) and is used in high-speed engines in automobiles, trucks, and buses.

Q22: What is CNG?

A22: It is mixture of hydrocarbons (80 to 90 % methane) compressed to a pressure 200 to 250 kg/cm².

Q23: What is 'leaded' Gasoline?

A23: It means, for labeling purposes, any gasoline or gasoline-oxygenate blend which contains more than 0.013 gram of lead per liter (0.05 g lead per U.S. gal). The term "leaded" shall only be used when the fuel meets specification requirements.

Q24: What is octane rating?

A24: The octane rating is a measure of the auto ignition resistance of gasoline and other fuels used in spark-ignition internal combustion engines

Q25: What is motor octane number?

A25: MON testing uses a similar test engine to that used in RON testing, but with a preheated fuel mixture, a higher engine speed, and variable ignition timing to further stress the fuel's knock resistance. Depending on the composition of the fuel, the MON of a modern gasoline will be about 8 to 10 points lower than the RON.

Q26: What is petroleum?

A26: Petroleum is a mixture of gaseous, liquid, and solid hydrocarbon compounds that occur in sedimentary rock deposits throughout the world and also contains small quantities of nitrogen, oxygen, and sulfur-containing compounds as well as trace amounts of metallic constituents.

Q27: What is 'fraction' or 'cut' in petroleum refinery?

A27: The separation of crude oil by atmospheric and vacuum distillation into groups of hydrocarbon compounds of different boiling point ranges called "fractions" or "cuts".

Q28: What are the CDU and VDU in distillation unit?

A28: The first step in crude oil processing, where the first separation takes place is called Crude Distillation Unit (CDU) Atmospheric & Vacuum Unit (AVU).

Q29: What are the product of CDU and VDU?

A29: Typical products from CDU are: Gas, LPG, naphtha, SKO/ATF, HSD and RCO. Vacuum Distillation of RCO produces VGO (or LOBS cuts) and VR.

Q30: What are the factors deciding the complexity of a refinery?

A30: (1) Nature/source of crude oils- flexibility to process variety of crudes. (2) Demand pattern in the markets. (3) Product quality - current/ future. (4) Production of feedstock for downstream units. (5) Inter-fuel substitution.

Q31: What are the type of hydrocarbon found in crude oil?

A31: The hydrocarbons found in petroleum are classified into the following types: Paraffins, cycloparaffins (naphthenes) and aromatic.

Q32: What is the type of crude based on based on residue after distillation?

A32: There are two type of crude

Paraffin base: The presence of paraffin wax in residue is reflected in the paraffin nature of the constituent.

Asphaltic base: High asphaltic content corresponds with the naphthene properties of the fractions. Asphalt-base crude oils our mainly of highly Aromatic (or Naphthenes) hydrocarbons.

Q33: What is pour point?

A33: Pour point is the lowest temperature at which oil will move, pour , or flow when it is chilled without disturbance under definite conditions (ASTM D97)

Q34: What is carbon residue?

A34: Carbon residue is determined by distillation to a coke residue in the absence of air. The carbon residue is roughly related to the asphalt content of the crude and to the quantity of the lubricating oil fraction that can be recovered.

Q35: What are the methods to determine carbon residue?

A35: In most cases the lower the carbon residue, the more valuable the crude. This is expressed in terms of the weight percent carbon residue by either the Ramsbottom (RCR) or Conradson (CCR).

Q36: What is LPG?

A36: It is a mixture of light HCs propane and butane, gases at ambient temperature but condensed to liquid state by applying moderate pressure. Mainly consists of propane, propylene, butane, butene, and iso – butane

Q37: What are the methods of Extraction of LPG from NG ?

A37: Compression and cooling.
Adsorption.Absorption.

Q38: Why most of the refinery technology favors alkylation processes rather than polymerization ?

A38: (1)Larger quantities of higher octane product can be made from the light olefins available. (2)The alkylation product is paraffinic rather than olefinic, and olefins are highly photo reactive and contribute to visual air pollution and ozone production.

Q39: What is alkylate gasoline?

A39: It is the product of the reaction of isobutane with propylene, butylene, or pentylene to produce branched-chain hydrocarbons in the gasoline boiling range.

Q40: What is ignition delay in engine?

A40: It is the time interval between injection and the onset of the pressure rise. Distillate fuels having high cetane number will show a short ignition delay period while those fuels with poor cetane number will give long ignition delay period.