King Saud University

Petroleum and Natural Gas Engineering Department

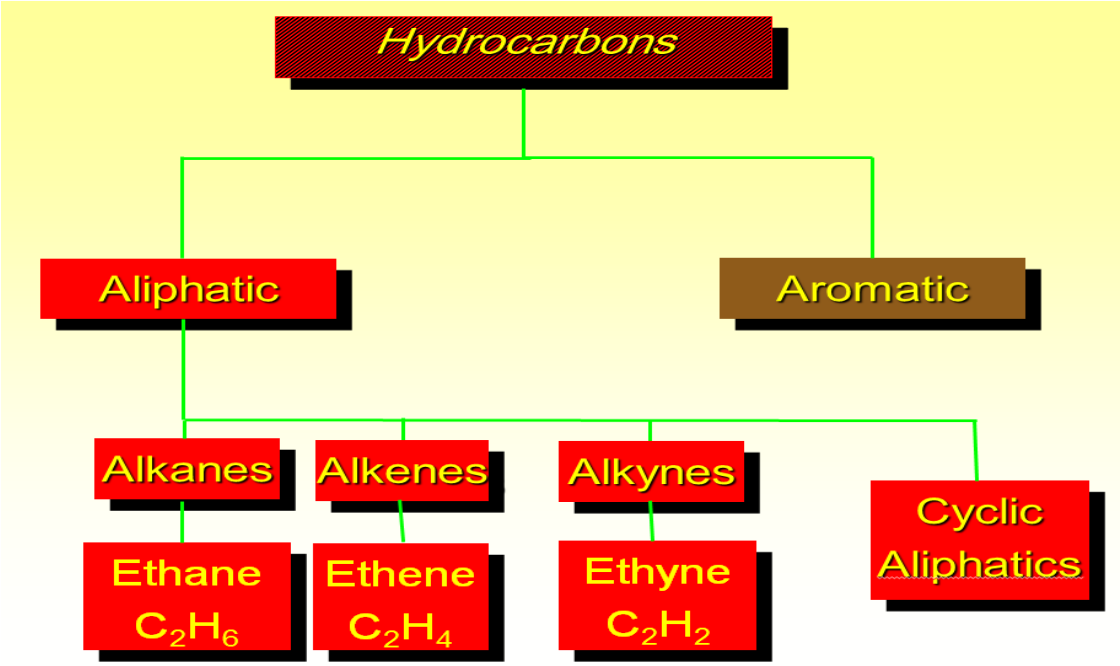
PGE 362: **Properties of Reservoir Fluids**

Mid Term Exam 1_Solution

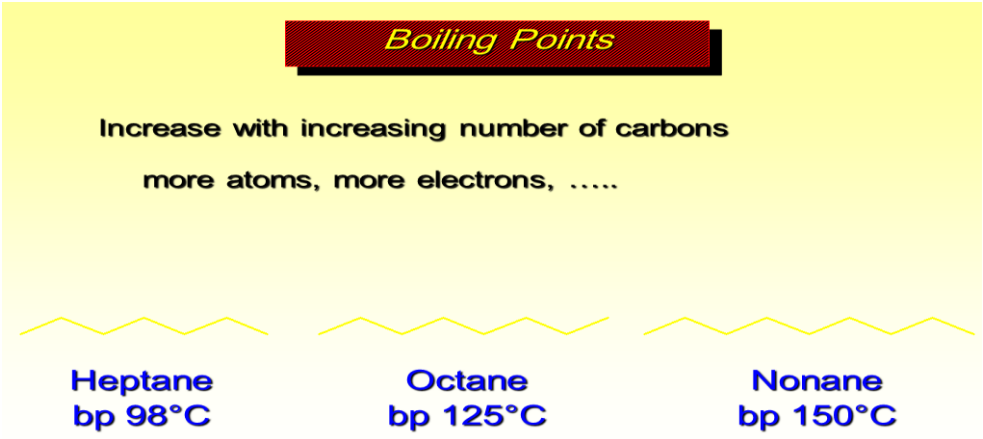
Question 1 (35 marks)

1. Define the **hydrocarbons** and indicate their **classifications** with **examples**.

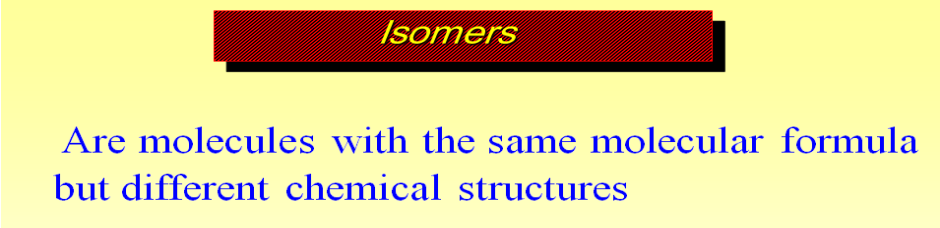
Hydrocarbons: Are chemical compounds composed exclusively of hydrogen and carbon atoms. Hydrocarbons can be solids, liquids or gasses and are what petroleum and natural gas are primarily made of.

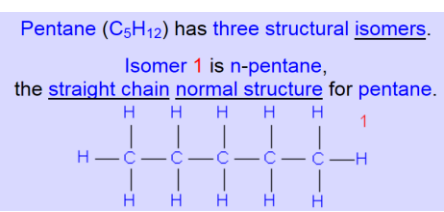


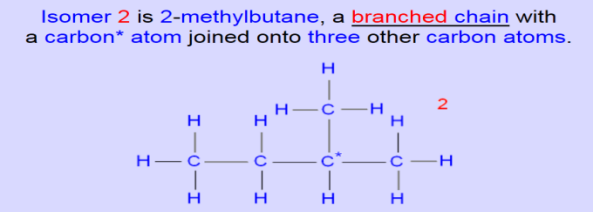
2. What is the effect of **chain length** for **Alkanes** on the **boiling point**? Explain why?

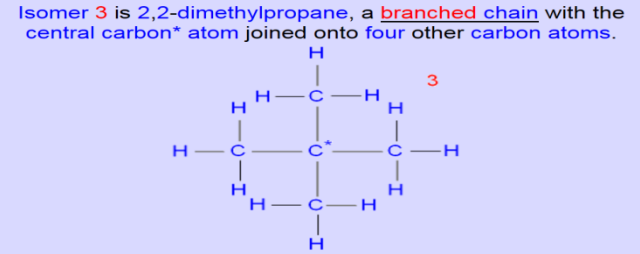


3. Define the **isomers** and draw the structural formulas for the **pentane** isomers and indicate their **names** according to **IUPAC** rules.









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4. What are the quantities commonly needed to describe a gas?

   Four quantities are commonly needed to describe a gas:
   1. Amount of gas
   2. Temperature
   3. Volume
   4. Pressure

5. Define the gas compressibility factor (**Z)**.

   The **compressibility factor** (Z), also known as the compression **factor**, is the ratio of the molar volume of a **gas** to the molar volume of an ideal **gas** at the same temperature and pressure. It is a useful thermodynamic property for modifying the ideal **gas** law to account for the real **gas** behavior.

$$Z = \frac{V_{actual}}{V_{ideal}}$$

Question 2 (20 marks)

a. What is the theory that describes the behavior of gases?

Kinetic Molecular Theory or

"**Theory of Moving Molecules**"

b. According to this theory, the particles in an ideal gas are:

   a. have no volume.
   b. have elastic collisions.
   c. are in constant, random, straight-line motion.
   d. don't attract or repel each other.
   e. have an avg. KE directly related to Kelvin temperature.

Question 3 (35 marks)

a. A gas mixture has the following composition;

Calculate the following:

1. Mole fraction. (table)
2. The gas **apparent molecular weight** (22.16) and the gas **specific gravity** (0.764)
3. The **partial pressure** for each component if the total pressure is **1500** psia. (table)
4. The **compressibility factor** if the temperature is **140** °F. (Z = 0.8)

Composition	Volume %	MW	Yi	Yi x MW	Pi
Methane	80	16	0.8	12.8	1200
Ethane	7	30	0.07	2.1	105
Propane	5	44	0.05	2.2	75
i-butane	3	58	0.03	1.74	45
n-butane	2	58	0.02	1.16	30
i-pentane	1	72	0.01	0.72	15
n-pentane	2	72	0.02	1.44	30

Ma =	22.16

$$\gamma_g = \frac{M_a}{29}$$ 0.764137931

Pt = 1500

T = 140 °F 600 °R

$$T_c = 168 + 325\,\gamma - 12.5\,\gamma^2$$ 409.0 °R Tr = 1.466828

$$P_c = 677 + 15\,\gamma - 37.5\,\gamma^2$$ 666.6 psia Pr = 2.250341

Z =	0.8

b. Prove that the value of the gas constant (**R**) is equal to **10.73** if the gas properties are measured with the following units;

i. Volume (**ft^3**)
ii. Pressure (**psia**)
iii. Temperature (**°R**)
iv. Number of moles (**lb-mole**)

Hint: Gas Molar Volume = **0.791049 ft^3** at standard condition (**1** atm, **1** gm-mole, and **32 °F**)

$$R = \frac{P\,V}{n\,T} = \frac{(14.7)(\,0.791049)}{\frac{1}{454}\,(32+460)} = 10.73$$

Question 4 (10 marks)

A piece of sandstone core sample with a bulk volume of **2.5 cc** is contained in a **10-cc** cell filled with helium at **760 mmHg**. Temperature is maintained constant and the cell is opened to another evacuated cell with the same volume. The final pressure in the two vessels is **340.7 mm Hg**. What is the porosity of the sandstone?

Note: No need to change the units

$$\emptyset = \frac{V_P}{V_B}$$

V_B = 2.5 CC

P_1 = 760 mmHg

P_2 = 340.7 mmHg

$V1 = 10 - V_B + V_P = 10 - 2.5 + V_P = 7.5 + V_P$

$V2 = 10 + 10 - 2.5 + V_P = 17.5 + V_P$

$P_1V_1 = P_2V_2$

$(760)(7.5 + V_P) = (340.7)(17.5 + V_P)$

$V_P = 0.625$

$$\emptyset = \frac{0.625}{2.5} = 0.25$$

Formula sheet

$$T_c = 168 + 325\,\gamma - 12.5\,\gamma^2$$

$$P_c = 677 + 15\,\gamma - 37.5\,\gamma^2$$

$$\gamma_g = \frac{M_a}{29}$$

Conversion Factors:

1 °F = 1.8 °C + 32

1 lb = 454 gm

1 ft = 30.48 cm

1 litter = 1000 cm^3

1 atm = 14.7 psia

1 bar = 14.5 psia

1 atm = 760 mm-Hg

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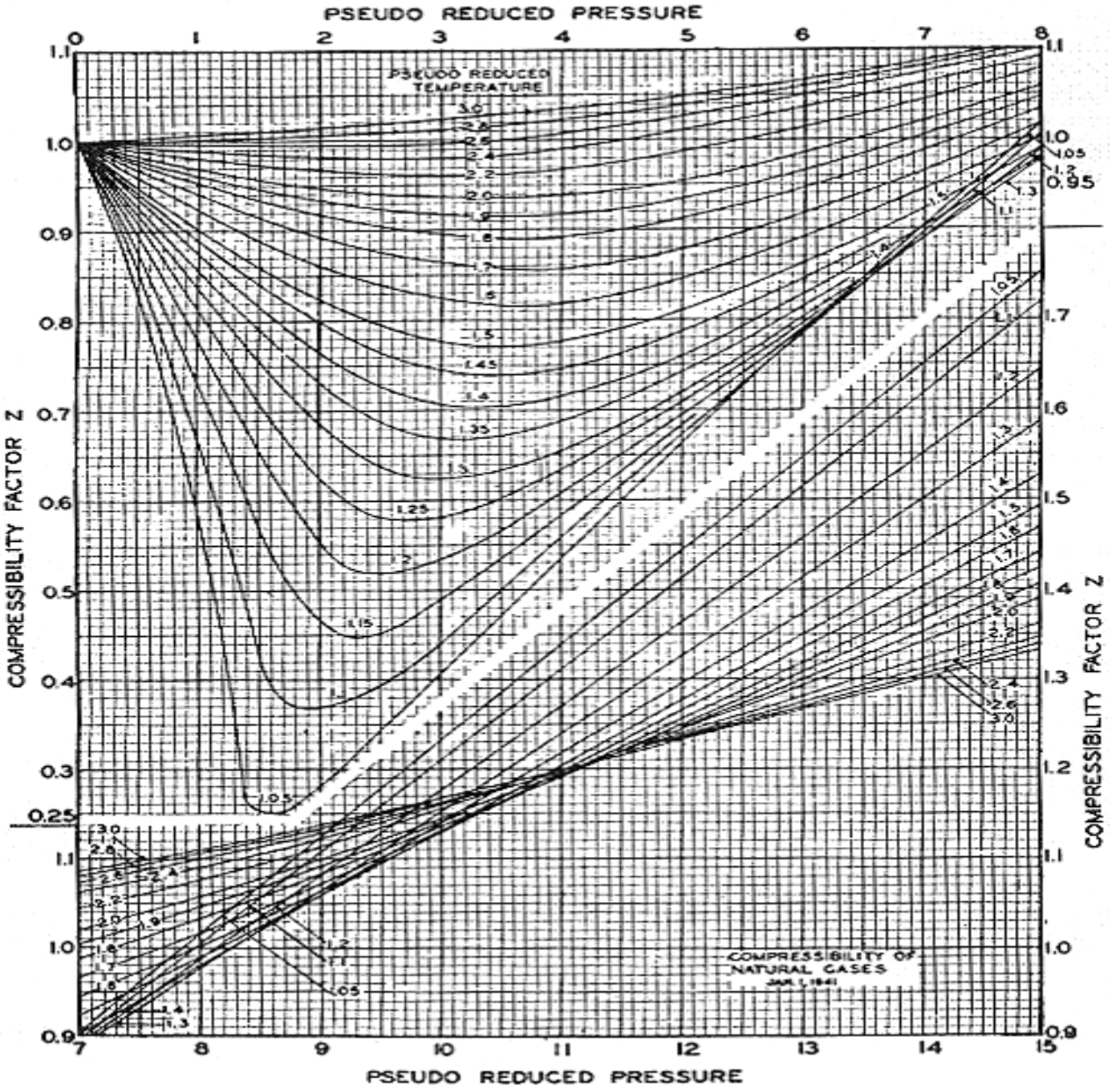
PSEUDO REDUCED PRESSURE
PSEUDO REDUCED TEMPERATURE
COMPRESSIBILITY FACTOR Z
COMPRESSIBILITY FACTOR Z
PSEUDO REDUCED PRESSURE
COMPRESSIBILITY OF NATURAL GASES