

## In-Class Exercise: Application of the Ideal Gas Law to Natural Gas Extraction

Volumes of natural gas in formation are measured in cubic feet or millions of cubic feet (Mcf). The volume of gas extracted from the reservoir is dependent upon temperature and pressure at depth, according to the Ideal Gas Law:

$$PV = nRT$$

where  $P$  is the [pressure](#) of the gas,  $V$  is the [volume](#) of the gas,  $n$  is the [amount of substance](#) of gas (measured in [moles](#)),  $R$  is the ideal, or universal, [gas constant](#), and  $T$  is the [temperature](#) of the gas.

$P$  = pressure in atm

$V$  = Volume in liters

$n$  = mass in moles

$T$  = temperature in degree Kelvin

$R$  = 0.0821 liter-atm/ $^{\circ}$ K-mole

When natural gas is extracted from the reservoir at depths of thousands of feet, and delivered to the surface of the Earth, the temperature and pressure changes will result in volume change during the process. Volume-temperature-pressure are important as they will dictate how much the natural gas sells per cubic foot on the market. Let's explore the effects of these relationships in a hypothetical scenario described below:

Our goal is to extract 10 moles of methane ( $\text{CH}_4$ ) from a gas well located in a reservoir at a depth of 7000 ft below the surface. The following information is available related to the conditions:

Drill Hole Depth = 7000 ft

Surface Temperature = 25  $^{\circ}\text{C}$

Mass = 10 moles of methane

Bottom Hole Temperature = 125  $^{\circ}\text{C}$

Surface Pressure = 1 bar

Bottom Hole Pressure = 2700 psi

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Task 1. Using the periodic chart, determine the mass of 10 moles of  $\text{CH}_4$  in grams.

Task 2. Calculate the volume of methane occupied by 10 moles at the bottom of the hole, vs. the volume of methane occupied by the same 10 moles at the top of the hole (surface).

Task 3. Determine the percent change in volume from subsurface to surface. SHOW ALL OF YOUR MATH WORK AND UNIT ALGEBRA.

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*Conversion factors and constants that may be helpful:*

$R$  = 0.0821 liter-atm/ $^{\circ}$ K-mole

$^{\circ}\text{K} = 273 + ^{\circ}\text{C}$

1 atm = 1013 mb

1 bar = 1000 mb

1 bar = 100,000 Pa = 14.5 lb/in<sup>2</sup>