

Free Response Questions

1) Answer the following questions related to hydrocarbons.

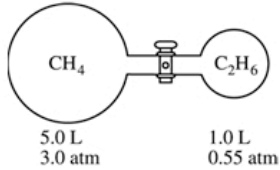
a) Determine the empirical formula of a hydrocarbon that contains 85.7% carbon by mass.

b) The density of the hydrocarbon in part (a) is 2.0 g L^{-1} at 50°C and 0.948atm .

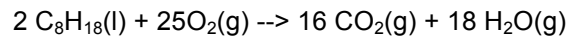
(i) Calculate the molar mass of the hydrocarbon.

(ii) Determine the molecular formula of the hydrocarbon.

c) Two flasks are connected by a stopcock below. The 5.0L flask contains CH_4 at a pressure of 3.0atm , and the 1.0L flask contains C_2H_6 at a pressure of 0.55atm . Calculate the total pressure of the system after the stopcock is opened. Assume that the temperature remains constant.



d) Octane, $\text{C}_8\text{H}_{18}(\text{l})$, has a density of 0.703 g mL^{-1} at 20°C . A 255 mL sample of $\text{C}_8\text{H}_{18}(\text{l})$ measured at 20°C reacts completely with excess oxygen as represented by the equation below.



Calculate the total number of moles of gaseous products formed.

2) The van der Waals equation of state for one mole of a real gas is as follows:

$$(P + a/V^2)(V - b) = RT$$

For any given gas, the values of the constants a and b can be determined experimentally.

a) Indicate which physical properties of a molecule determine the magnitudes of the constants a and b .

b) Which of the two molecules, H_2 (nonpolar) or H_2S (polar) has the higher value for a and which has the higher value for b ?

Explain.

c) One of the van der Waals constants can be correlated with the boiling point of a substance. Specify which constant and how it is related to the boiling point.

2004 #2
1984 #7

7) Average score 4.28

Points awarded for each statement follow that statement.

Constant a is related to the attractive forces that exist between real molecules. (1 point)

Constant b is related to the fact that real molecules do have volumes. (1 point)

H₂S has a larger value for a. (1 point)

H₂S is a polar molecule and, therefore, has stronger intermolecular forces. (2 points)

H₂S has a larger value for b because an H₂S molecule has a larger volume than H₂ has. (1 point)

The constant a correlates with the boiling point since a is related to the intermolecular forces, which must be overcome in the process of boiling a liquid. (2 points)