1 Cognitive reasoning for the chemical sciences 2.4

1. **Set 1:** Please answer the questions.

   (a) For an ideal gas. If \( T \) is constant and one doubles mass, what happens to \( v_{rms} \)?

   (b) Which has greater kinetic energy, one mole of the ideal gas \( \text{N}_2 \) or one mole of the ideal gas \( \text{He} \)? (If they have equal kinetic energy please say so.)

   (c) For the van der Waals equation, if \( b > 0 \) and \( a = 0 \), what happens to \( pV/nRT \)?

   (d) For effusion. If one doubles the molar density, keeping \( T \) constant, what happens to the rate of effusion?

   (e) For effusion. If we double the radius of the molecules, what happens to the rate of effusion?

2. **Set 2:** State a procedure which allows the carrying out of the posed problem.

   (a) Given: the volume, the pressure, the temperature, and the number of grams of a flask of ideal gas. Find the molar mass.

   (b) Given: the volume, \( v_{rms} \), number of moles, and pressure of a flask of ideal gas. Find: the molar mass of the gas.

   (c) Given: the density of the ideal gas \( \text{O}_2 \), the volume, temperature and pressure of a flask. Find the number of \( \text{O}_2 \) molecules.

   (d) Given: the value of the van der Waals \( a \) and \( b \) constant for the molecules \( \text{C}_4\text{H}_8 \) decide approximately values for \( \text{C}_{12}\text{H}_{24} \).

3. **Set 3:** State answers to the following questions:

   (a) The volume of a gas increases by 1%, the number of moles increases by 2%, the pressure increases by 3% and the temperature remains unchanged. Is this gas an ideal gas?

   (b) Given: Two van der Waals gases. They have the same \( b \) value but different \( a \) values. At a given \( p \) and \( T \), does one mole of the one with a bigger \( a \) value occupy more or less volume than a mole of the other gas?

   (c) Gas effuses from a flask into a vacuum. Given: The initial rate of gas effusion. The molar density of gas molecules increases by \( x \)% find the decrease in temperature required so that no change in effusion rate occurs.

   (d) Given: Two van der Waals gases. They have different \( a \) values and \( b \) values from each other. In the limit of very high pressure and assuming constant temperature, how many of these four constants control which of these gases has a greater molar density? Please state reason.
(e) The volume of a gas increases by 1%, the number of moles increases by 2%, the pressure increases by 3% and the temperature remains unchange. Assuming the gas is a van der Waals can you deduce $a > 0$, $b > 0$ or that both $a$ and $b$ are $> 0$? State your reasoning.

4. Set 4: Please answer the following questions.

(a) In an ideal gas if one doubles $V$, keeping all other variables but $T$ constant what change is there in $T$?

(b) If one doubles the mass, keeping all other variables constant, what happens to the rate of effusion?

(c) If one increase the volume of a sphere by a factor of eight, what happens to the surface area of a sphere?

(d) If one increases the volume of a cube by a factor of eight (retaining the cubic shape in the process), what happens to the surface area of the cube?

(e) If one increases $KE$ of a baseball by a factor of 2 what happens to the momentum of the baseball?

(f) If we increase the velocity by a factor of 2, keeping $n$ constant, what happens to $pV$?

(g) Assume in a van der Waals gas the $a$ term dominates. Comparing the van der Waals gas to an ideal gas with the same number of moles, volume and at the same temperature, is $p$ greater or smaller?

(h) Assume in a van der Waals gas the $b$ term dominates. Comparing the van der Waals gas to an ideal gas with the same number of moles, volume and at the same temperature, is $p$ greater or smaller?

(i) In a van der Waals gas $\frac{pV}{nRT}$ is less than one. Does the attractive $a$ or the repulsive $b$ term dominate?