Question: Arrange the gases according to increasing molecular speed.

Ar (25°C)   Ne (100 °C)   Ne (25°C)   Ar (0°C)

A. Ar (25) < Ne (100) < Ne (25) < Ar (0)
B. Ar (25) < Ne (100) < Ar (0) < Ne (25)
C. Ar (0) < Ne (25) < Ar (25) < Ne (100)
D. Ne (25) < Ar (0) < Ne (100) < Ar (25)
E. Ar (0) < Ar (25) < Ne (25) < Ne (100)

Note: there is no need for a calculation.

Concepts: To answer this question we need to know how temperature and atomic mass will affect the speeds of molecules.

Connections:

What is given? We are given four samples of gas: two each of argon and neon at different temperatures.

What do I want to know? We want to list the gases in order of increasing molecular speed. To do this we need to relate the identity of the gas and its temperature to the speed. We do not need to solve for actual speeds, only do a relative comparison.

There are two concepts that we discover in kinetic molecular theory (E12-1-4) that will help to solve this problem:

Molecules move faster at higher T than they do at lower T.

At the same T, heavier molecules move more slowly than lighter molecules.

We know from kinetic molecular theory that temperature is a measure of average kinetic energy. As temperature increases, the average kinetic energy must increase.

We also know that kinetic energy is related to mass and velocity of a particle. For a collection of particles, the average kinetic energy ε will related to the mass and the rms speed urms of the gas molecules such that: ε = 1/2mu2. In the case of a single gas (constant molecular weight) that means that the molecular speed must increase if the average kinetic energy increases.

For any two gases at the same temperature (same average kinetic energy) the heavier molecule (greater molecular weight) must move more slowly to compensate for the increased mass.

Be sure you understand everything above before moving on to the solution below.

Solution:

We start by organizing the information given. We have four samples of gas.

Ne (25°C)   Ne (100°C)   Ar (25°C)   Ar (0°C)

We can easily compare samples of the same gas that are at different temperature using $u = \sqrt{\frac{3RT}{M}}$. The sample that is at the higher temperature will have the greater average kinetic energy and greater speed.

Ne is at 100°C and 25°C. So the Ne at the higher T must be moving faster than the Ne at 25°C.

Ne (25°C) < Ne (100°C)

For the two Ar samples, one is at 25°C and the other at 0°C. Ar at 25°C must be moving faster than the Ar at 0°C.

Ar (0°C) < Ar (25°C)

Finally we have samples of Ar and Ne at 25°C: they have the same average kinetic energy, so the heavier one (Ar) must be moving more slowly.

Ar (25°C) < Ne (25°C)

Combining these we get:

Ar (0°C) < Ar (25°C) < Ne (25°C) < Ne (100°C)

Answer: E