iClicker Question:

Which answer represents a list in order of increasing deviation from ideal gas behavior?

***Key points of Deviation from Ideal Gas Behavior***

- *The greater the deviation the less ideal the gas is.*
- *The deviation from ideal behavior is large at high pressure.*
- *Low pressure = more ideal (less deviation)*
- *As temperature increases the deviation from ideal behavior decreases.*
- *As temperature decreases the deviation increases. (Maximum deviation near the temperature at which the gas becomes a liquid (at point of phase change known as the "critical point").*
- *Ideal gas particles occupy very little space and have no attraction forces.*
- *Van der Waals equation used to predict gas behavior:*

$$P = (nRT/ V - nb) – (n^2a/ V^2)$$

A) a. $N^2$ at 25°C and 1 atm,
b. $N^2$ at 25°C and 1 atm,
c. $N^2$ at 25°C and 4 atm

*Note:* *a → b: higher temperature, molecules moving faster so volume increasing.*
*b → c: increase of pressure. (c is less ideal than a.)*
***Not in correct order!***

B) a. $CH_4$ at 273 K and 1 atm,
b. $CH_4$ at 273 K and 0.4 atm,
c. $CH_4$ at 373 K and 1 atm

*Note:* *a is Methane at STP (standard temp. pressure).*
*a → b: lower pressure thus more ideal (particles become farther apart)*
*b → c: higher temp so deviation decreases. (c. is more ideal than b.)*
***Not in correct order!***

C) a. $SO_2$ at 20°C and 1 atm,
b. $SO_2$ at 0°C and 1 atm,
c. $SO_2$ at 0°C and 3 atm

*Note:* *a → b: Lower temperature (cooling) so volume is also decreasing. Deviation is increasing.*
*b → c: More pressure so larger deviation! Also, volume is decreasing as pressure increases (deviation increases when this occurs).* ***Correct answer!***

D) $H_2O$ at 200°C and 1 atm,
$CO_2$ at 200°C and 1 atm,
Ar at 200°C and 1 atm

*Note:* *a is polar and most likely to deviate (less ideal)*
*b and c are non-polar. c. is most ideal.* ***Not in correct order!***

Particles in Phases:

- Gas particles are uniformly distributed and do not display any order to their arrangement. They “bounce” around. Least dense of the 3 common phases.
- Solid particles are most ordered in their arrangement and usually the most dense of the 3 common phases (but there are important exceptions, e.g., water).
- Liquid particles have organization of particles that is in between solid and gas - some order but not as much order as in solids. Potential energy is greater in liquids than in solids, but not as great as in gases.
- Temperature is a measure of average kinetic energy. This holds true for solids and liquids as well as for gases.
- Attraction between molecules decrease as temperature increases.
- Increased temperature in a liquid (or solid) = increased vapor pressure. Vapor pressure is the pressure due to the vapor (gas) that forms when some of the particles change phases (liquid to gas).
- Critical point is the condition of pressure and temperature beyond which it is impossible to tell the difference between the liquid and the gas.