

This print-out should have 25 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

Remember to bubble your version number and uteid.

001 4.0 points

When a gas phase reaction takes place...

1. some state functions may increase, others may decrease and some may stay constant.

correct

2. all state functions must increase or stay constant.

3. all state functions must stay constant.

4. all state functions must change.

5. all state functions must decrease or stay constant.

Explanation:

State functions are the properties of a system (like P , V , T , ...). During a process some state functions may increase, others may decrease and some may stay constant.

002 4.0 points

Which of the following statements about gas laws is/are true?

I) Boyle's law says that above the boiling point, the pressure and volume of a gas are directly proportional.

II) Jacques Charles measured an inverse relationship between volume and temperature.

III) The ideal gas law is only accurate at very high concentrations.

1. II, III

2. I, II, III

3. II only

4. I, II

5. None are true **correct**

6. I only

7. III only

8. I, III

Explanation:

All three statements are false. Boyle's law describes an inverse proportionality between P and V , and says nothing about the boiling point. Charles' law describes a direct proportionality between V and T . Only gases that closely approximate the assumptions of kinetic molecular theory are well described by the ideal gas law - at high concentrations, intermolecular forces become significant.

003 4.0 points

A 22.4 L vessel contains 0.02 mol H_2 gas, 0.02 mol N_2 gas, and 0.1 mol NH_3 gas. The total pressure is 700 torr. What is the partial pressure of the H_2 gas?

1. 28 torr

2. 100 torr **correct**

3. None of these

4. 14 torr

5. 7 torr

Explanation:

$$n_{\text{total}} = 0.14 \text{ mol}$$

$$n_{H_2} = 0.02 \text{ mol}$$

$$P_{\text{total}} = 700 \text{ torr}$$

$$X_{H_2} = \frac{n_{H_2}}{n_{\text{total}}} = \frac{0.02 \text{ mol}}{0.14 \text{ mol}} = 0.142857$$

$$\begin{aligned} P_{H_2} &= X_{H_2} P_{\text{total}} \\ &= (0.142857) (700 \text{ torr}) \\ &= 100 \text{ torr} \end{aligned}$$

004 4.0 points

What volume will 40.0 L of He at 50.00°C and 1201 torr occupy at STP?

- 26.7 L
- 53.4 L **correct**
- 12.8 L
- 18.6 L
- 31.1 L

Explanation:

$$\begin{array}{ll}
 P_1 = 1201 \text{ torr} & P_2 = 760 \text{ torr} \\
 V_1 = 40 \text{ L} & T_2 = 273.15 \text{ K} \\
 T_1 = 50^\circ + 273.15 = 323.15 \text{ K} &
 \end{array}$$

Using the Combined Gas Law,

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

and recalling that STP implies standard temperature (273.15 K) and pressure (1 atm or 760 torr), we have

$$\begin{aligned}
 V_2 &= \frac{P_1 V_1 T_2}{T_1 P_2} \\
 &= \frac{(1201 \text{ torr})(40.0 \text{ L})(273.15 \text{ K})}{(323.15 \text{ K})(760 \text{ torr})} \\
 &= 53.4302 \text{ L}
 \end{aligned}$$

005 4.0 points

If 250 mL of a gas at STP weighs 2 g, what is the molar mass of the gas?

- 179 g · mol⁻¹ **correct**
- 44.8 g · mol⁻¹
- 56.0 g · mol⁻¹
- 28.0 g · mol⁻¹
- 8.00 g · mol⁻¹

Explanation:

$$\begin{array}{ll}
 V = 250 \text{ mL} & P = 1 \text{ atm} \\
 T = 0^\circ\text{C} = 273.15 \text{ K} & m = 2 \text{ g}
 \end{array}$$

The density of the sample is

$$\rho = \frac{m}{V} = \frac{2 \text{ g}}{0.25 \text{ L}} = 8 \text{ g/L}$$

The ideal gas law is

$$\begin{aligned}
 PV &= nRT \\
 \frac{n}{V} &= \frac{P}{RT}
 \end{aligned}$$

with unit of measure mol/L on each side. Multiplying each by molar mass (MM) gives

$$\frac{n}{V} \cdot \text{MM} = \frac{P}{RT} \cdot \text{MM} = \rho,$$

with units of g/L.

$$\begin{aligned}
 \text{MM} &= \frac{\rho RT}{P} \\
 &= \frac{(8 \text{ g/L})(0.08206 \text{ L} \cdot \text{atm/mol/K})}{1 \text{ atm}} \\
 &\quad \times (273.15 \text{ K}) \\
 &= 179.318 \text{ g/mol}
 \end{aligned}$$

006 4.0 points

A sample of nitrous oxide gas (NO) has a density of 12 g L⁻¹. What pressure does the sample exert at 27 °C?

- 9.9 atm **correct**
- 1.0 atm
- 997.9 atm
- not enough information
- 61.6 atm

Explanation:

By thoughtful substitutions and rearrangement, the ideal gas law can be used to relate the mass density of a gas to its pressure.

$$PV = nRT$$

Recalling that a number of moles (n) is equal to a mass (m) divided by a molecular weight (M.W.), we can substitute into the ideal gas law.

$$n = \frac{m}{\text{M.W.}}$$

$$PV = \frac{m}{\text{M.W.}}RT$$

This can be rearranged to solve for P.

$$P = \frac{m}{V} \frac{RT}{M.W}$$

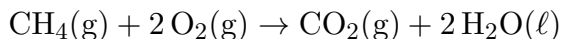
By substituting the definition of density (ρ), we can arrive at a readily usable equation.

$$\rho = \frac{m}{V}$$

$$P = \rho \frac{RT}{M.W} = 12 \frac{0.0821 \times 300}{30} = 9.852 \text{ atm}$$

007 4.0 points

What is the final volume if 20 L methane reacts completely with 20 L oxygen



at 100°C and 2 atmospheres?

1. 10 L
2. 30 L
3. 20 L **correct**
4. Cannot be determined from the information given.
5. 15 L

Explanation:

$$V_1 = 20 \text{ L CH}_4 \qquad V_2 = 20 \text{ L O}_2$$

Avogadro's Principle tells us that because P and T are the same, $V \propto n$, so we can work with the volume instead of the number of moles. From the equation above, we need 2 times more L of O_2 than that of CH_4 , but we only have 20 L, not 40 L of O_2 ! This means O_2 is the limiting reactant.

Find out how much CO_2 is made based on the L of O_2 :

$$L_{\text{CO}_2} = 20 \text{ L O}_2 \times \left(\frac{1 \text{ L CO}_2}{2 \text{ L O}_2} \right) = 10 \text{ L CO}_2$$

We now find out how much CH_4 was used reacting with all the L of O_2 :

$$L_{\text{CH}_4} = 20 \text{ L O}_2 \times \left(\frac{1 \text{ L CH}_4}{2 \text{ L O}_2} \right) = 10 \text{ L CH}_4$$

This means 20 L – 10 L = 10 L CH_4 are unused and still present.

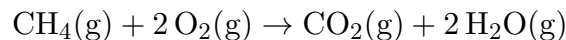
The final mixture is

10 L unreacted CH_4 + 10 L CO_2 = 20 L of gas.

We assume the volume of the water is insignificant.

008 4.0 points

Consider the balanced reaction for the combustion of methane below.



If 100 g of methane react completely with 100 g of molecular oxygen in a sturdy, closed 100 L vessel at 227 °C, what is the approximate final pressure in the vessel?

1. 1.92 atm
2. 3.85 atm **correct**
3. 0.87 atm
4. 1.75 atm

Explanation:

Although we have equal masses of methane and oxygen, their different molar masses and different stoichiometric coefficients result in oxygen being the limiting reagent.

$$100 \text{ g CH}_4 \times \frac{1 \text{ mol}}{16 \text{ g}} = 6.25 \text{ mol}$$

$$100 \text{ g O}_2 \times \frac{1 \text{ mol}}{32 \text{ g}} = 3.125 \text{ mol}$$

In addition to having fewer moles of oxygen, 2 moles of oxygen are required to react with 1 mole of methane; oxygen is definitely the limiting reagent. From this, we can be certain that 0 moles of oxygen will remain once the reaction has gone to completion. In order to answer the question, we will need to determine the total moles of methane remaining and add to that the number of moles of products.

$$3.125 \text{ mol O}_2 \times \frac{1 \text{ CH}_4}{2 \text{ O}_2} = 1.5625 \text{ mol CH}_4$$

$$6.25 - 1.5625 \text{ mol CH}_4 = 4.6875 \text{ mol CH}_4$$

$$3.125 \text{ mol O}_2 \times \frac{3}{2 \text{ O}_2} = 4.6875 \text{ mol products}$$

Thus, once the reaction has gone to completion, there are a total of 9.375 moles of gas on

the container. Under the specified conditions, that produces a pressure of:

$$P = \frac{nRT}{V} = \frac{9.375 \times 0.0821 \times 500}{100} = 3.85 \text{ atm}$$

All of these calculations can also be approximated while still allowing you to reach the correct answer.

$$100 \text{ g CH}_4 \times \frac{1 \text{ mol}}{16 \text{ g}} \approx 6 \text{ mol}$$

$$100 \text{ g O}_2 \times \frac{1 \text{ mol}}{32 \text{ g}} \approx 3 \text{ mol}$$

$$3 \text{ mol O}_2 \times \frac{1 \text{ CH}_4}{2 \text{ O}_2} = 1.5 \text{ mol CH}_4$$

$$6 - 1.5 \text{ mol CH}_4 = 4.5 \text{ mol CH}_4$$

$$3 \text{ mol O}_2 \times \frac{3}{2 \text{ O}_2} = 4.5 \text{ mol products}$$

$$P = \frac{nRT}{V} = \frac{9 \times 0.0821 \times 500}{100}$$

$$P \approx 10 \times 0.08 \times 5 \approx 4 \text{ atm}$$

Even when approximating, it is possible to eliminate all but one answer choice.

009 4.0 points

When two samples of ideal gases have the same ?, their molecules must have the same ?.

1. pressure; average kinetic energy
2. mass; average kinetic energy
3. density; mass
4. density; average kinetic energy
5. volume; average kinetic energy
6. volume; mass
7. pressure; mass
8. mass; density
9. temperature; speed
10. temperature; average kinetic energy **correct**

Explanation:

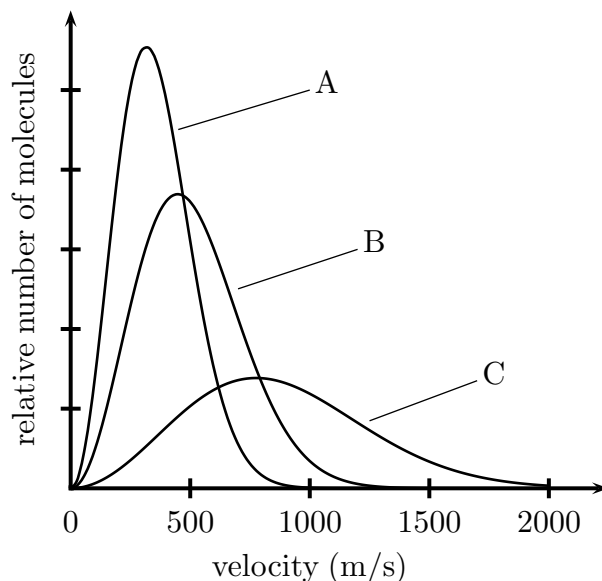
From kinetic molecular theory:

$$\bar{U} \propto \sqrt{\frac{T}{MW}}$$

For samples of an ideal gas temperature and average kinetic energy are directly proportional.

010 4.0 points

The graph shows the Maxwell distribution plots for a given gas at three different temperatures.



Which plot corresponds to the highest temperature?

1. C **correct**
2. Can not be determined from this type of plot.
3. B
4. A

Explanation:

The higher the temperature, the broader the range of velocity distributions and the higher the average velocity. So curve C matches that criteria.

011 4.0 points

Calculate the ratio of the rate of effusion of He to that of CO₂ (at the same temperatures).

1. 1 : 11
2. 1 : 11²
3. $\sqrt{11}$: 1 **correct**
4. 11 : 1
5. 1 : 1
6. 11² : 1
7. 1 : $\sqrt{11}$

Explanation:

$$\frac{\text{Eff}_{\text{HC}}}{\text{Eff}_{\text{CO}_2}} = \frac{\sqrt{\text{MW}_{\text{CO}_2}}}{\sqrt{\text{MW}_{\text{HC}}}} = \sqrt{\frac{44}{4}} = \sqrt{11}$$

012 4.0 points

Under which of the following conditions is a real gas most likely to deviate from ideal behavior?

1. high volume
2. low density
3. if it is a noble gas
4. Tuesdays and Thursdays
5. zero pressure
6. low pressure
7. new moon
8. low temperature **correct**

Explanation:

Deviations from ideality occur due to molecular attractions or repulsions. More attractions or repulsions can occur when the molecules are closer together. Low pressure, high volume, and low density all correspond to molecules being far apart. Low temperature often corresponds to molecules being

close together. It also corresponds to low kinetic energy which allows molecules to 'stick together' easier.

013 4.0 points

Gas X has a larger value than Gas Y for the van der Waals constant "a". This indicates that

1. the molecules of X have stronger intermolecular attractions for each other than the molecules of Y have for each other. **correct**
2. the molecules of gas X have a higher velocity than do the molecules of gas Y.
3. the molecules of X are larger than the molecules of Y.
4. the molecules of gas X repel other X molecules.

Explanation:

014 4.0 points

Some of the following terms characterize both the bonding within a molecule (*intramolecular*) and that between atoms and molecules (*intermolecular*). Which of the following is normally considered only when characterizing *intermolecular* forces?

1. ionic forces
2. covalent bonding
3. van der Waals forces **correct**
4. polar covalent bonding
5. electrostatic forces

Explanation:

Only van der Waals forces occur between separate molecules; *i.e.*, are *intermolecular* forces.

015 4.0 points

Dispersion (London) forces result from

1. the balance of attractive and repulsive forces between two polar molecules.

2. attraction between molecules in a liquid and molecules or atoms in a solid surface with which the liquid is in contact.

3. the formation of a loose covalent linkage between a hydrogen atom connected to a very electronegative atom in one molecule and another very electronegative atom in a neighboring molecule.

4. distortion of the electron cloud of an atom or molecule by the presence of nearby atoms or molecules. **correct**

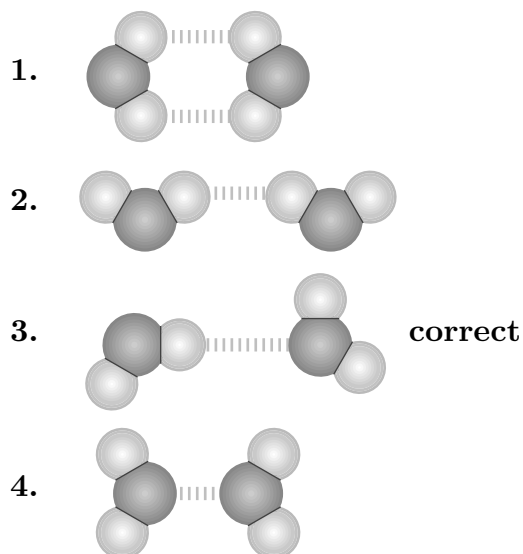
5. attractive forces between a molecule at the surface of a liquid and those beneath it which are not balanced by corresponding forces from above.

Explanation:

016 4.0 points



Which figure best describes the hydrogen bonding between two water molecules?



Explanation:

Note the water molecules line up so the δ^- on the oxygen of one water molecule is aligned with a δ^+ on the hydrogen of the other water

molecule.

017 4.0 points

Identify the dominant intermolecular force in the following species, respectively: RbCl, C₆H₆ (benzene), HI, Fe₂O₃, CH₂NH.

- ionic forces
- hydrogen bonding
- dipole-dipole
- instantaneous dipoles

1. a, c, c, d, b

2. a, d, c, a, b **correct**

3. a, b, c, b, a

4. a, b, d, a, c

5. c, b, d, c, c

6. b, d, c, d, d

7. c, d, a, a, b

Explanation:

Rubidium Chloride and Iron(III) oxide are both ion-ion. Benzene is non-polar and thus has only van der Waal's forces. Hydroiodic acid is polar and has dipole-dipole interactions. Methylamine has H-bonding.

018 4.0 points

Acetic acid (CH₃COOH) forms a molecular solid. What type of forces hold it in a solid configuration?

- London forces
- dipole-dipole forces
- hydrogen bonding

1. I only

2. I, II, and III **correct**

3. III only

4. II only

5. II and III only

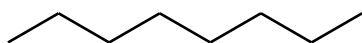
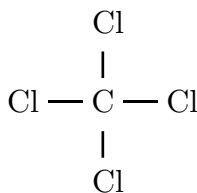
6. I and II only

Explanation:

Acetic acid will exhibit both London forces and dipole-dipole interactions, in addition to hydrogen bonding.

019 4.0 points

Carbon tetrachloride (CCl_4) and *n*-octane (C_8H_{18}) are both non-polar molecules. At standard pressure, they boil at 345 K and 399 K, respectively. Which answer choice below correctly explains their boiling points?



1. C_8H_{18} has a higher boiling point because its electron cloud is larger and allows it to form more instantaneous dipoles. **correct**

2. C_8H_{18} has a higher boiling point because its smaller surface area allows it to form stronger instantaneous dipoles.

3. CCl_4 has a lower boiling point because its smaller surface area allows it to form stronger instantaneous dipoles.

4. CCl_4 has a lower boiling point because its greater molecular weight enables it to form stronger instantaneous dipoles.

5. C_8H_{18} has a higher boiling point because its greater molecular weight enables it to form stronger instantaneous dipoles.

Explanation:

Carbon tetrachloride (CCl_4) and *n*-octane (C_8H_{18}) both have only instantaneous dipoles. Despite the fact that (CCl_4) has a greater molecular weight ($153.81 \text{ g mol}^{-1}$) compared to C_8H_{18} ($114.23 \text{ g mol}^{-1}$), the latter boils at a substantially higher tempera-

ture. In general, dispersion forces are greater in molecules with greater molecular weight, more total electrons and a larger surface area (i.e. the shape of the molecule). Since *n*-octane is a long skinny molecule, more of its electrons are accessible and ready to form instantaneous dipoles.

020 4.0 points

H_2S has a lower boiling point than H_2O or H_2Se . Which of the following is NOT part of the explanation for this observation?

1. ΔEN for the O—H bond is larger than ΔEN for the S—H bond.

2. The strength of London forces is greater for H_2Se than for H_2S .

3. Hydrogen bonding is most significant for compounds containing electronegative atoms in the second row.

4. ΔEN for the Se—H bond is larger than ΔEN for the S—H bond. **correct**

Explanation:

All three compounds are polar molecules which possess polar bonds but the ΔEN (electronegativity difference) for O-H is much greater than for S-H or Se-H. H_2O exhibits H-bonding, so it has the highest boiling point of the three compounds. The relative polarities (ΔEN) of the H_2Se and H_2S bonds are similar and one would predict slightly smaller for H-Se based on general trends, so dipole-dipole interactions do not explain the trend. However, London interactions become longer as the size of the molecule's electron cloud increases; since Se is bigger than S, H_2Se has stronger London forces and thus a higher boiling point than H_2S .

021 4.0 points

Surface tension describes

1. the resistance to flow of a liquid.

2. the forces of attraction between the surface of a liquid and the air above it.

3. adhesive forces between molecules.
4. the inward forces that must be overcome in order to expand the surface area of a liquid. **correct**
5. capillary action.
6. the forces of attraction between surface molecules of a solvent and the solute molecules.

Explanation:

Molecules in the interior of a liquid interact with molecules all around them, whereas molecules at the *surface* of a liquid can only be affected by those beneath the surface layer. This phenomenon leads to a net inward force of attraction on the surface molecules, contracting the surface and making the liquid behave as though it had a skin. Surface tension is a measure of the inward forces that must be overcome to expand the surface area of a liquid.

022 4.0 points

Which of the following substances would you predict might evaporate the fastest?

1. C_6H_{14} **correct**
2. C_8H_{18}
3. $C_{12}H_{24}$
4. $C_{10}H_{22}$

Explanation:

All the listed molecules are nonpolar hydrocarbons; therefore the dominant intermolecular force that exists in the condensed phase of all listed molecules is dispersion forces. Therefore, the molecule with the least number of atoms and the lowest molecular weight would have the lowest dispersion forces, and therefore would evaporate the easiest.

023 4.0 points

Which of the following would you expect to

have the highest heat of vaporization?

1. C_8H_{18}
2. CH_4
3. C_3H_6
4. C_5H_{12}
5. $C_{12}H_{26}$ **correct**

Explanation:

024 4.0 points

Arrange

Al_2O_3 Nb I_2 $C(s)$ (diamond)
in the order metallic solid, covalent network, covalent solid, ionic solid.

1. $C(s)$ (diamond); Nb , Al_2O_3 ; I_2
2. Nb , I_2 ; $C(s)$ (diamond); Al_2O_3
3. Al_2O_3 ; $C(s)$ (diamond); I_2 ; Nb
4. Nb ; $C(s)$ (diamond); I_2 ; Al_2O_3 **correct**

Explanation:

025 4.0 points

Put the following compounds

LiF , HF , F_2 , NF_3

in order of increasing melting points.

1. NF_3 , HF , F_2 , LiF
2. NF_3 , F_2 , HF , LiF
3. LiF , NF_3 , HF , F_2
4. F_2 , HF , NF_3 , LiF
5. F_2 , NF_3 , HF , LiF **correct**
6. LiF , HF , NF_3 , F_2
7. LiF , F_2 , HF , NF_3
8. LiF , HF , F_2 , NF_3