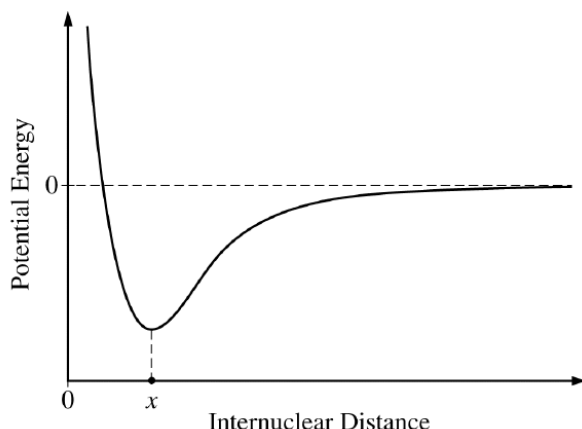


MULTIPLE CHOICE – NO CALCULATOR ALLOWED



- The potential energy of a system of two atoms as a function of their internuclear distance is shown in the diagram above. Which of the following is true regarding the forces between the atoms when their internuclear distance is x ?

 - (A) The attractive and repulsive forces are balanced, so the two atoms will maintain an average internuclear distance x .
 - (B) There is a net repulsive force pushing the atoms farther apart, so the atoms will continue to move farther apart from each other.
 - (C) There is a net attractive force pulling the atoms closer together, so the atoms will continue to move closer together.
 - (D) The diagram only shows potential energy, so it cannot be determined if the forces between the two atoms are attractive or repulsive.

- Which of the following choices most accurately describes both the molecular geometry and the polarity for both CO_2 and SO_2 ?

(A)	Substance	Molecular Geometry	Polarity
	CO_2	linear	polar
	SO_2	bent	nonpolar

(C)	Substance	Molecular Geometry	Polarity
	CO_2	linear	nonpolar
	SO_2	linear	nonpolar

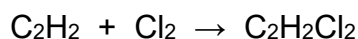
(B)	Substance	Molecular Geometry	Polarity
	CO_2	linear	nonpolar
	SO_2	linear	polar

(D)	Substance	Molecular Geometry	Polarity
	CO_2	linear	nonpolar
	SO_2	bent	polar

3. Which of the following statements most accurately describes boron trifluoride?
- (A) It is a nonpolar substance that contains nonpolar bonds.
 (B) It is a nonpolar substance that contains polar bonds.
 (C) It is a polar substance that contains nonpolar bonds.
 (D) It is a polar substance that contains polar bonds.
4. Which of the following choices represents the correct estimates of the bond angles in methane and water?

	H–C–H bond angle in CH ₄	H–O–H bond angle in H ₂ O
(A)	90°	180°
(B)	109.5°	105°
(C)	109.5°	109.5°
(D)	109.5°	115°

5. Which of the following lists is arranged in order of increasing bond angle (i.e., from smallest bond angle to largest bond angle) ?
- (A) NF₃, CF₄, BF₃
 (B) NF₃, BF₃, CF₄
 (C) CF₄, NF₃, BF₃
 (D) CF₄, BF₃, NF₃



6. When the reaction shown above occurs, does the hybridization of the carbon atoms change?
- (A) No; the hybridization of the carbon atoms does not change.
 (B) Yes; the hybridization of the carbon atoms changes from sp to sp².
 (C) Yes; the hybridization of the carbon atoms changes from sp to sp³.
 (D) Yes; the hybridization of the carbon atoms changes from sp² to sp³.

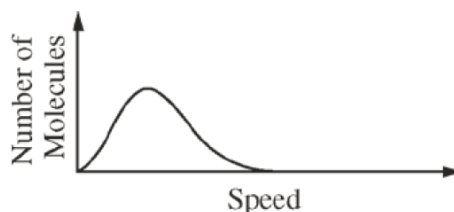
7. The hybridization of the carbon atoms in acetone, $(\text{CH}_3)_2\text{CO}$, is best described as
- (A) sp^2 for all three carbon atoms
 - (B) sp^3 for all three carbon atoms
 - (C) either sp or sp^2
 - (D) either sp^2 or sp^3
8. Which of the following molecules contains exactly three sigma (σ) bonds and two pi (π) bonds?
- (A) HCN
 - (B) HCO_2H
 - (C) C_2H_2
 - (D) C_2H_4
9. Equal masses of $\text{Ne}(g)$ and $\text{He}(g)$ are placed in a sealed rigid container at 500 K. Which of the following statements is true about this system?
- (A) The partial pressure of $\text{Ne}(g)$ is less than the partial pressure of $\text{He}(g)$.
 - (B) The partial pressure of $\text{Ne}(g)$ is equal to the partial pressure of $\text{He}(g)$.
 - (C) The average speed of $\text{Ne}(g)$ particles is equal to the average speed of $\text{He}(g)$ particles.
 - (D) The average speed of $\text{Ne}(g)$ particles is greater than the average speed of $\text{He}(g)$ particles.
10. Which of the following, upon reaction with excess hydrochloric acid, would produce the largest quantity of hydrogen gas?
- (A) 1.0 mol Na
 - (B) 1.0 mol Mg
 - (C) 1.0 mol Al
 - (D) 1.0 mol Ca

11. A gas mixture contains 14.0 g of carbon monoxide gas and 7.0 g of hydrogen gas. The total pressure of the gas mixture is 2.40 atm. What is the partial pressure of each gas in this mixture?

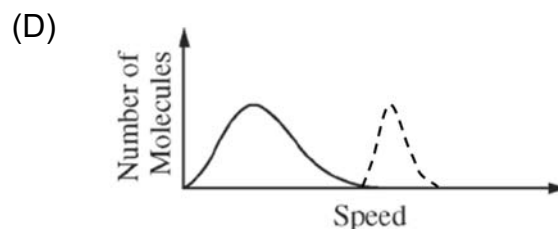
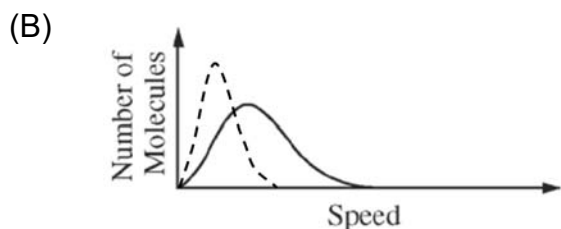
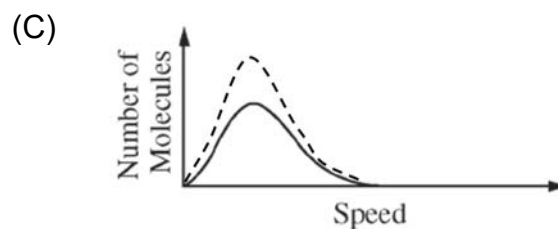
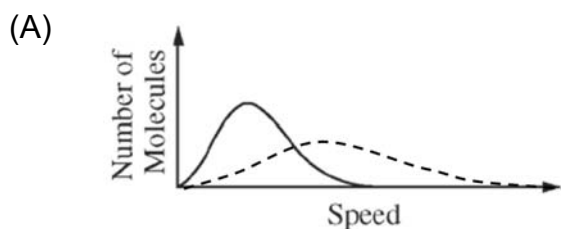
	Partial pressure of carbon monoxide gas	Partial pressure of hydrogen gas
(A)	0.15 atm	2.25 atm
(B)	0.30 atm	2.10 atm
(C)	0.60 atm	1.80 atm
(D)	1.60 atm	0.80 atm

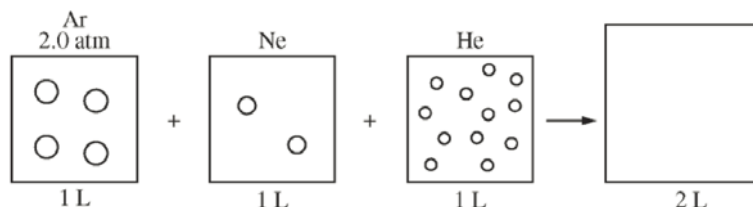
12. At which of the following temperatures and pressures would a real gas be most likely to deviate from ideal behavior?

	Temperature (K)	Pressure (atm)
(A)	100	0.01
(B)	100	50
(C)	1000	0.01
(D)	1000	50



13. The graph above shows the speed distribution of molecules in a sample of oxygen gas at 25°C. Which of the following graphs is most likely to represent the speed distribution of the same number of molecules of hydrogen gas at 25°C (as a dashed curve)?





14. The figure above represents three sealed 1.0 L vessels, each containing a different inert gas at 298 K. The pressure of Ar in the first vessel is 2.0 atm. The ratio of the numbers of Ar, Ne, and He atoms in the vessels is 2:1:6, respectively. After all the gases are combined in a previously evacuated 2.0 L vessel, what is the total pressure of the gases at 298 K?

- (A) 4.5 atm
- (B) 6.0 atm
- (C) 9.0 atm
- (D) 18 atm

Container	A	B
Gas	Ar	He
Temperature	30°C	30°C
Pressure	2.0 atm	4.0 atm

15. The information in the table above refers to two different gases in identical rigid containers A and B. Which of the following statements is true?

- (A) The average kinetic energy of the gas particles in Container B is greater than the average kinetic energy of the gas particles in Container A.
- (B) The density of the gas in Container B is greater than the density of the gas in Container A.
- (C) The number of gas particles in Container B is greater than the number of gas particles in Container A.
- (D) The average speed of the gas particles in Container B is less than the average speed of the gas particles in Container A.

16. Samples of F_2 gas and Xe gas are mixed in a container of fixed volume. Initially, the partial pressure of the F_2 gas is 8.0 atm and the partial pressure of the Xe gas is 1.7 atm. When all of the Xe gas reacted, forming a solid compound, the pressure of the unreacted F_2 gas was 4.6 atm. The temperature remained constant. What is the formula of the solid compound?

- (A) XeF
- (B) XeF_2
- (C) XeF_3
- (D) XeF_4

FREE RESPONSE – CALCULATOR IS ALLOWED

1. (a) Fill in the missing information in the table below.

Molecule	Molecular Geometry	Is this Molecule Polar or Nonpolar?
BeF ₂		
OF ₂		
XeF ₂		
CF ₄		
SF ₄		
XeF ₄		

(b) Identify the bond angles for each of the following.

The F–Be–F angle in BeF₂ _____ The F–C–F angle in CF₄ _____

(c) Identify the hybridization of the central atom (sp, sp², or sp³) for each of the following.

BeF₂ _____ OF₂ _____ CF₄ _____

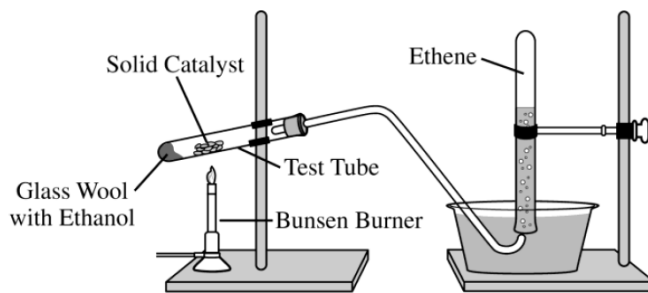
(d) (i) Make a prediction regarding the F–O–F bond angle in OF₂.

_____ The F–O–F bond angle in OF₂ is less than 109.5°.

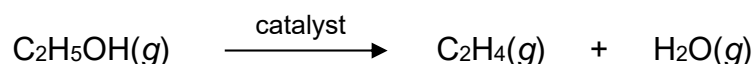
_____ The F–O–F bond angle in OF₂ is equal to 109.5°.

_____ The F–O–F bond angle in OF₂ is greater than 109.5°.

(ii) Justify your choice in part (d)(i) with a complete and thorough explanation.



2. Ethene, $C_2H_4(g)$, may be prepared by the dehydration of ethanol, $C_2H_5OH(l)$, using a solid catalyst. A setup for the lab synthesis is shown in the diagram above. The equation for the dehydration reaction is given below.



A student added a 0.200 g sample of $C_2H_5OH(l)$ to a test tube using the setup shown above. The student heated the test tube gently with a Bunsen burner until all of the $C_2H_5OH(l)$ evaporated and gas generation stopped. When the reaction stopped, the volume of collected gas was 85.4 mL at 625.0 torr and 32.0°C . (The vapor pressure of water at 32.0°C is 35.7 torr.)

(a) Calculate the number of moles of $C_2H_4(g)$

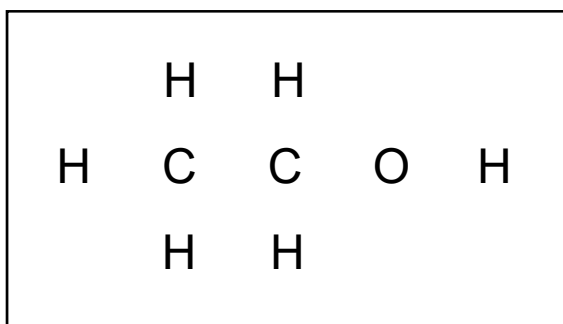
(i) that are actually produced in the experiment and measured in the gas collection tube,

(ii) and that would be produced if the dehydration reaction went to completion.

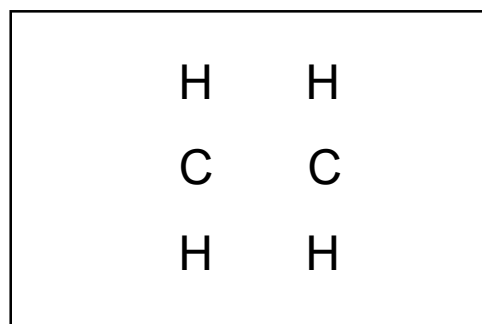
(b) Calculate the percent yield of ethene in the experiment.

2.(continued)

- (c) In the boxes below, complete the Lewis electron-dot diagrams for ethene and ethanol by drawing in all of the electron pairs. **Note that the diagrams below are not necessarily representative of the actual molecular geometry for either molecule.**



ethanol



ethene

- (d) Identify the hybridization (sp , sp^2 , or sp^3) of the carbon atoms

(i) in ethanol _____

(ii) in ethene _____

- (e) Identify the predicted value for the H–C–H bond angle

(i) in ethanol _____

(ii) in ethene _____

3. A sample of propane, $\text{C}_3\text{H}_8(g)$, is introduced into a previously evacuated rigid 5.00 L reaction vessel at 127°C . Then a sample of $\text{O}_2(g)$ is introduced into the same vessel at constant temperature. This mixture of $\text{C}_3\text{H}_8(g)$ and $\text{O}_2(g)$ is sparked so that a complete combustion reaction occurs, producing $\text{CO}_2(g)$ and $\text{H}_2\text{O}(g)$.

(a) Write a balanced chemical equation for the complete combustion of $\text{C}_3\text{H}_8(g)$.

(b) The table below represents the partial pressure of each substance, before and after the reaction occurs. Fill in the missing information in the table based on the stoichiometry of the reaction. Assume that temperature remains constant at 127°C .

Substance	$\text{C}_3\text{H}_8(g)$	$\text{O}_2(g)$	$\text{CO}_2(g)$	$\text{H}_2\text{O}(g)$
Partial pressure before the reaction at 127°C	0.200 atm	1.40 atm	0.00 atm	0.00 atm
Partial pressure after the reaction at 127°C	0.00 atm	0.400 atm		

(c) Calculate the mole fraction of $\text{O}_2(g)$ in the 5.00 L reaction vessel at 127°C

(i) before the reaction occurs,

(ii) and after the reaction occurs.

(d) Calculate the mass of $\text{C}_3\text{H}_8(g)$ that is consumed in the combustion reaction.