For the next two questions, consider the following reaction for the production of methanol (CH₃OH):

\[ \text{CO}(g) + 2 \text{H}_2(g) \rightarrow \text{CH}_3\text{OH}(g) \]

1. How many moles of CH₃OH(g) can be produced when 16.0 L of H₂(g) are reacted with 25.0 L of CO(g), with all gases measured at STP? Assume 100% yield.
   a) 0.357 mol          b) 1.16 mol          c) 0.558 mol         d) 0.714 mol         e) 0.279 mol

2. If 5.30 g of CH₃OH(g) are actually produced at STP in the above reaction, what is the percent yield of the reaction?
   a) 53.7%           b) 23.9%           c) 76.1%           d) 3.13%           e) 46.3%

3. What volume of 0.0521 \(M\) \(\text{Ba(OH)}_2\) is required to react completely with 14.20 mL of 0.141 \(M\) \(\text{H}_3\text{PO}_4\)?
   a) 115 mL  b) 57.6 mL  c) 38.4 mL  d) 28.8 mL  e) 19.2 mL

For the next two questions, consider the following reaction involving two hypothetical elements A and B:

\[ 2 \text{A}(g) + 3 \text{B}_3(g) \rightarrow \text{A}_2\text{B}_9(g) \]

(Molar masses: A: 40.0 g/mol; \(\text{A}_2\text{B}_9\): 125 g/mol)

Initially a reaction vessel contains 11.0 moles of A and 12.0 moles of \(\text{B}_3\). Assuming the above reaction goes to completion, answer the following two questions.

4. If 4.0 moles of \(\text{A}_2\text{B}_9\) are formed in the reaction, how many moles of A remain unreacted?
   a) 0 mol          b) 1.0 mol          c) 2.0 mol          d) 3.0 mol          e) 8.0 mol

5. What is the total mass of \(\text{B}_3\) consumed in the reaction?
   a) 60.0 g          b) 180. g          c) 45.0 g          d) 15.0 g          e) 120. g
6. Which of the following is the net ionic equation when 0.10 M solutions of HgCl$_2$ and K$_2$S are mixed together?

a) HgCl$_2$(aq) + K$_2$S(aq) $\rightarrow$ HgS(s) + 2 KCl(aq)
b) HgCl$_2$(aq) + K$_2$S(aq) $\rightarrow$ 2 KCl(s) + HgS(aq)
c) K$^+$ (aq) + Cl$^-$ (aq) $\rightarrow$ KCl(s)
d) Hg$^{2+}$(aq) + S$^{2-}$(aq) $\rightarrow$ HgS(s)
e) No reaction will occur.

7. A solution is made by mixing 50.0 mL of 3.00 M CaBr$_2$ with 400.0 mL of 0.250 M KBr. This mixture is diluted by adding water until the final solution volume is 800.0 mL. What is the molarity of the Br$^-$ ions in the final solution?

a) 0.125 M b) 0.250 M c) 0.500 M d) 0.750 M e) 1.00 M

8. A bag of potato chips is packed and sealed in Los Angeles, California, and later shipped to Deming, New Mexico. In Deming it is noticed that the volume of the bag of potato chips has increased. Which of the following external conditions (a-c) could cause the volume of the bag of potato chips to increase in Deming as compared to Los Angeles? (Assume no gas molecules can enter or leave the sealed bag of potato chips and assume no chemical reaction occurs inside the bag.)

a) The temperature outside the bag decreased.
b) The pressure outside the bag decreased.
c) The moles of air molecules outside the bag increased.
d) None of the above (a-c) could cause the volume of the bag of potato chips to increase.

9. Consider a 2.0 L sample of SO$_2$ gas and a 2.0 L sample of F$_2$ gas, both of which are at STP. Which of the following statements (a-d) about the two gas samples is true?

a) The F$_2$ molecules and SO$_2$ molecules collide with the container walls of their respective containers, on average, with identical frequency.
b) The moles of F$_2$ molecules is greater than the moles of SO$_2$ molecules.
c) The average kinetic energy of the SO$_2$ molecules is greater than the average kinetic energy of the F$_2$ molecules.
d) The SO$_2$ molecules collide with the container walls of their respective containers, on average, more forcefully than the F$_2$ molecules.
e) None of the statements (a-d) are true.
10. Propane gas (C₃H₈) burns in oxygen gas to give CO₂(g) and H₂O(g). What mass of O₂ is required to react completely with 0.125 mol of propane?
   a) 0.800 g b) 20.0 g c) 6.00 g d) 10.0 g e) 4.00 g

11. A mixture contains only NaCl and Al₂(SO₄)₃. A 1.45 g sample of the mixture is dissolved in water and an excess of NaOH is added, producing a precipitate of Al(OH)₃ (molar mass = 78.00 g/mol). The precipitate is filtered, dried and weighed. The mass of the precipitate is 0.107 g. What is the mass percent of Al₂(SO₄)₃ (molar mass = 342.17 g/mol) in the sample?
   a) 64.7% b) 7.38% c) 16.2% d) 22.1% e) 32.4%

12. Which of the answers (a-d) **always** correctly completes the following sentence.

   The limiting reactant in a reaction:
   a) is the reactant for which there is the smallest amount in grams present.
   b) is the reactant which has the smallest coefficient in the balanced equation.
   c) is the reactant with the smallest molar mass.
   d) is the reactant for which there is the smallest number of moles present.
   e) None of the above (a-d) always correctly completes the sentence.

13. How many of the following four statements (I-IV) about gases is/are **true**?

   I. A non-ideal gas will more nearly behave like an ideal gas at low pressures.
   II. Non-ideal gas behavior is the result of the real volume of gas particles and the intermolecular attractions between gas particles.
   III. The effect of attractive forces between gas particles can be reduced by heating the gas.
   IV. 1.00 × 10²³ gas molecules placed in a closed 5.0 liter container at 150. K would behave more ideally than the same number of molecules placed in a closed 50.0 liter container at the same temperature.
   a) 0 (none) b) 1 c) 2 d) 3 e) 4 (All of the statements are true.)
14. Difluoromethane, $\text{CF}_2\text{H}_2$, has been considered as a replacement for the chlorofluorocarbon freon, $\text{CF}_2\text{Cl}_2$. The boiling point of $\text{CF}_2\text{H}_2$ is $-56^\circ\text{C}$ and the boiling point of $\text{CF}_2\text{Cl}_2$ is $-29^\circ\text{C}$. Which of the following statements concerning these two compounds is **false**? (Carbon is the central atom in both molecules.)

a) $\text{CF}_2\text{H}_2$ exhibits hydrogen bonding intermolecular forces.

b) Both compounds are gases at room temperature.

c) $\text{CF}_2\text{Cl}_2$ exhibits stronger London dispersion forces as compared to $\text{CF}_2\text{H}_2$.

d) Overall, $\text{CF}_2\text{Cl}_2$ exhibits stronger intermolecular forces as compared to $\text{CF}_2\text{H}_2$.

Consider the following information for the next two questions. 50.00 mL of 1.00 $M$ $\text{AgNO}_3$ is mixed with 75.00 mL of 1.00 $M$ $\text{K}_2\text{CrO}_4$ and a precipitate forms.

15. How many moles of precipitate can form assuming the reaction has 100% yield?

a) 0.0750 mol  
   b) 0.0500 mol  
   c) 0.0375 mol  
   d) 0.0250 mol  
   e) 0.0100 mol

16. Calculate the concentration of chromate anions in the mixture after the reaction has gone to completion.

   a) 0 $M$  
   b) 0.200 $M$  
   c) 0.400 $M$  
   d) 0.600 $M$  
   e) 1.00 $M$

17. An ideal gas in a container occupies a volume of 10.0 L at 38°C and 0.20 atm. If the gas sample is cooled to 7°C and the volume is decreased to 3.60 L, what is the new pressure of the gas sample?

   a) 0.50 atm  
   b) 0.20 atm  
   c) 0.92 atm  
   d) 0.11 atm  
   e) 1.7 atm

18. A compound containing carbon, hydrogen and oxygen that is responsible for the odor of pineapples is found to have 62.04% C and 10.41% H by mass. The empirical formula of this compound is:

   a) $\text{CH}_2\text{O}$  
   b) $\text{C}_6\text{H}_{12}\text{O}_2$  
   c) $\text{C}_3\text{H}_6\text{O}$  
   d) $\text{C}_6\text{H}_{10}\text{O}_2$  
   e) $\text{C}_3\text{H}_5\text{O}$
19. Which of the following statements (a-d) about hydrogen bonding intermolecular forces is true?

a) Compounds that can H-bond have higher boiling points than ionic compounds.
c) Given two covalent compounds having about the same molar mass, the compound that can H–bond will have the higher vapor pressure as compared to a compound that cannot H–bond.
d) H–bonding is a form of London dispersion forces.
e) None of the above statements (a-d) are true.

20. The diffusion rate of N₂ gas is 1.73 times greater than the diffusion rate of a certain noble gas (both gases are at the same temperature). What is the noble gas?

a) He  b) Ne  c) Ar  d) Kr  e) Xe

21. Which of the following three statements (I-III) about gases is/are true?

I. Equal masses of ideal gases at the same temperature and pressure contain equal numbers of molecules.

II. On average, a N₂ molecule will possess the same kinetic energy as a CO₂ molecule at the same temperature.

III. On average, an H₂ molecule has a faster average velocity than a N₂ molecule at the same temperature.

a) I and II  b) II and III  c) I and III  d) I, II, and III  e) Only statement I is true.

22. Nitrogen dioxide, NO₂, decomposes by the following unbalanced reaction:

\[ \text{NO}_2(g) \rightarrow \text{N}_2(g) + \text{O}_2(g) \]

If 3.0 atm of pure NO₂(g) are decomposed initially, what is the final total pressure in the reaction container? Assume the above reaction goes to completion and assume a constant temperature and container volume.

a) 4.5 atm  b) 6.0 atm  c) 9.0 atm  d) 3.0 atm  e) 1.5 atm
23. The compounds below are classified as either a strong electrolyte, a weak electrolyte, or a nonelectrolyte. Which compound is **incorrectly** classified?

a) Ethanol, \( \text{C}_2\text{H}_6\text{O} \), is a strong electrolyte.
b) Fingernail polish remover, \( \text{C}_3\text{H}_6\text{O} \), is a nonelectrolyte.
c) Vinegar, \( \text{HC}_2\text{H}_3\text{O}_2 \), is a weak electrolyte.
d) Slaked lime, \( \text{Ca(OH)}_2 \), is a strong electrolyte.
e) Washing soda, \( \text{Na}_2\text{CO}_3 \), is a strong electrolyte.

24. Separate samples of a solution of an unknown soluble ionic compound are treated with KCl, \( \text{Na}_2\text{SO}_4 \) and NaOH. A precipitate forms only when \( \text{Na}_2\text{SO}_4 \) is added. Which one of the following cations could the solution contain?

a) \( \text{K}^+ \)   b) \( \text{Ag}^+ \)   c) \( \text{Pb}^{2+} \)   d) \( \text{Hg}_2^{2+} \)   e) \( \text{Ba}^{2+} \)

25. Determine the density of uranium hexafluoride gas at 60.°C and 745 torr. Uranium is element #92.

a) 12.6 g/L   b) 2.54 g/mL   c) 8.97 g/L   
d) 6.74 g/mL   e) 0.0269 g/L

26. Which of the following four organic compounds has the **lowest** vapor pressure at -50°C?

a) \( \text{CH}_4 \)

b)

```
H\_\_\_\_
C\_O\_C\_H
H\_\_\_\_\_
```

c)

```
H\_\_\_\_
C\_F\_F
H\_\_\_\_
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d)

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H\_\_\_\_
C\_C\_C\_H
H\_\_\_\_
```
27. An unknown organic compound contains only C, H, and Cl. When a 1.500 g-sample of the compound was combusted, 0.3678 g of H₂O was formed. In a separate experiment, all of the chlorine in a 1.000 g-sample of the unknown compound was reacted by suitable methods to form 1.950 g of AgCl. Determine the mass percent of chlorine in the unknown compound. The molar of mass of AgCl = 143.35 g/mol.

   a) 16.25% Cl  
   b) 23.45% Cl  
   c) 38.92% Cl  
   d) 48.22% Cl  
   e) 57.84% Cl

28. An unknown organic compound contains only C, H, and Cl. When a 1.500 g-sample of the compound was combusted, 0.3678 g of H₂O was formed. In a separate experiment, all of the chlorine in a 1.000 g-sample of the unknown compound was reacted by suitable methods to form 1.950 g of AgCl. Determine the empirical formula of the unknown compound.

   a) C₂H₃Cl₂  
   b) C₄H₆Cl₃  
   c) C₃H₂Cl  
   d) CH₃Cl₂  
   e) C₂H₅Cl

29. F₂ boils at a temperature very close to the boiling point of one of the following substances. Which substance below has a boiling point similar to that of F₂?

   a) HF  
   b) Cl₂  
   c) Ne  
   d) HCl  
   e) Ar

30. An oxybromate compound, KBrOₓ, where x is a whole number, is analyzed and found to contain 52.91% Br by mass. What is x?

   a) 0  
   b) 1  
   c) 2  
   d) 3  
   e) 4

31. My answers for this Chemistry 102 exam should be graded with the answer sheet associated with:

   a) Form A  
   b) Form B  
   c) Form C  
   d) Form D  
   e) Form E