1. Which of the following compounds does not have the correct chemical formula or does not have the correct name?
   a) Li₂O lithium oxide
   b) FePO₄ iron(III) phosphate
   c) HF hydrogen fluoride
   d) N₂O nitrogen dioxide
   e) Mg₃N₂ magnesium nitride

2. A metal oxide contains 83.0% metal by mass. Determine the identity of the metal.
   a) Na
   b) Ca
   c) K
   d) Rb
   e) Sr

3. How many atoms of nitrogen are present in 3.52 g of calcium nitrate?
   a) 1.29 × 10²²
   b) 2.58 × 10²²
   c) 1.02 × 10²⁴
   d) 6.02 × 10²³
   e) 2.08 × 10²²

4. Consider the reaction: 3 MnO₂(s) + 4 Al(s) → 3 Mn(s) + 2 Al₂O₃(s)
How many moles of which reagent are left over when 3.5 moles of MnO₂ reacts with 4.5 moles of Al. Assume that the reaction goes to completion.
   a. 0.16 mol Al
   b. 1.5 mol Al
   c. 0.13 mol MnO₂
   d. 0.5 mol Al
   e. 0.5 mol MnO₂

5. A 0.4647-g sample of a compound known to contain only carbon, hydrogen, and oxygen was burned in oxygen to yield 0.8635 g of CO₂ and 0.1767 g of H₂O. What is the empirical formula of the compound?
   a) CHO
   b) C₂H₂O
   c) C₃H₃O₂
   d) C₆H₆O₂
   e) C₃H₆O₂

6. Which of the following is true?
   a) ¹⁸⁸O and ¹⁹⁹F have the same number of neutrons.
   b) ¹⁴⁶⁷C and ¹⁴⁷N are isotopes of each other
   c) ¹⁸⁸O²⁻ has the same number of electrons as ²⁰₁⁰Ne.
   d) ³²₁⁶S and ³²₁⁶S²⁻ are isotopes of each other
   e) (a) and (c) are both true
7. A solution is prepared by dissolving 0.115 moles of ammonium sulfate, \(\text{(NH}_4\text{)}_2\text{SO}_4\), in enough water to make 100.0 mL of stock solution. A 11.00 mL sample of this stock solution is added to 50.00 mL of water. Calculate the concentration of ammonium ions in the final solution.
   a) 1.15 M
   b) 0.51 M
   c) 0.41 M
   d) 0.21 M
   e) 1.53 M

8. Silver chloride can be prepared by the reaction of 100.0 mL of 0.20 M silver nitrate with 100.0 mL of 0.15 M calcium chloride. After the reaction goes to completion, what concentration of which ion remains in solution?
   a) 0.05 M \(\text{Cl}^-\)
   b) 0.025 M \(\text{Ca}^{2+}\)
   c) 0.05 M \(\text{Ag}^+\)
   d) 0.025 M \(\text{Cl}^-\)
   e) 0.025 M \(\text{Ag}^+\)

9. The empirical formula of a certain hydrocarbon is \(\text{CH}_2\). When 0.131 mole of the hydrocarbon is completely combusted with excess oxygen, 16.1 L \(\text{CO}_2\) gas is produced at 27 °C and 1.00 atm. What is the molecular formula of the hydrocarbon?
   a. \(\text{C}_5\text{H}_{10}\)
   b. \(\text{C}_2\text{H}_2\)
   c. \(\text{C}_3\text{H}_6\)
   d. \(\text{C}_2\text{H}_4\)
   e. \(\text{C}_6\text{H}_{12}\)

10. Consider the following reaction: \(2\text{NOBr}(g) \rightarrow 2\text{NO}(g) + \text{Br}_2(g)\)
    A 1.0-liter vessel was initially filled with pure \(\text{NOBr}\), at a pressure of 4.0 atm, at 300 K. After equilibrium was established, the partial pressure of \(\text{NOBr}\) was 2.5 atm. What is \(K_p\) for the reaction?
    a) 0.45
    b) 0.27
    c) 0.18
    d) 0.75
    e) 0.14

11. In a 50.0 L container, 4.00 moles of chlorine and 2.00 moles of bromine are placed and kept at 293.0 K until equilibrium is reached. At equilibrium there are 82.63 g of \(\text{Br}_2\) (l). Determine the total pressure in the 50.0 L container at equilibrium. The reaction is:
    \[\text{Br}_2\ (l) + \text{Cl}_2\ (g) \rightarrow 2 \text{BrCl} (g)\]
    a) 0.110 atm
    b) 2.64 atm
    c) 0.180 atm
    d) 1.43 atm
    e) 1.21 atm
12. When the equation below is balanced using integer coefficients, what is the coefficient in front of $K_2CrO_4$?

$$\text{FeCr}_2\text{O}_4 + K_2\text{CO}_3 + O_2 \rightarrow K_2\text{CrO}_4 + Fe_2\text{O}_3 + CO_2$$

a) 8  

b) 4  

c) 1  

d) 2  

e) 6

13. When aqueous solutions of $Na_3\text{PO}_4$ and $Pb(\text{NO}_3)_2$ are mixed, $Pb_3(\text{PO}_4)_2$ precipitates. What volume of 0.10 M $Na_3\text{PO}_4$ is required to precipitate all of the lead(II) ions from 200 mL of 0.30 M $Pb(\text{NO}_3)_2$?

a) 66.7 mL  

b) 400 mL  

c) 250 mL  

d) 900 mL  

e) 600 mL

14. Consider the reaction: $2 \text{NH}_3 + 3 \text{O}_2 + 2 \text{CH}_4 \rightarrow 2 \text{HCN} + 6\text{H}_2\text{O}$

How many grams of HCN will be formed when 400 g of $\text{NH}_3$, 600 g of $\text{O}_2$, and 300 g of $\text{CH}_4$ are mixed? The reaction goes to completion.

a) 635 g  

b) 759 g  

c) 506 g  

d) 338 g  

e) 400 g

15. A mass of 3.051 g of a metal carbonate, $MCO_3$, is heated to drive off carbon dioxide. The remaining metal oxide has a mass of 1.458 g.

$$MCO_3(s) \rightarrow MO(s) + CO_2(g)$$

What is the identity of the metal?

a. Ni  

b. Ba  

c. Ca  

d. Co  

e. Mg

16. A 4.40-g piece of solid $CO_2$ (dry ice) is allowed to sublime in a balloon. The final volume of the balloon is 1.00 L at 300 K. What is the pressure of the gas?

a) 2.46 atm  

b) 246 atm  

c) 0.122 atm  

d) 122 atm  

e) none of these

17. Which of the following relationships is not true?

a) $PV = \text{constant}$ when temperature and moles of gas are held constant.  

b) $V/T = \text{constant}$ when pressure and moles of gas are held constant.  

c) $nT = \text{constant}$ when pressure and volume are held constant.  

d) $P/n = \text{constant}$ when volume and temperature are held constant.  

e) All of the above are true.
18. Consider a sample of neon gas in a container fitted with a moveable piston (assume the piston is massless and frictionless). The temperature of the gas is increased from 20.0 °C to 40.0 °C. The density of neon __________ .
   a) increases less than 10%.
   b) decreases less than 10%.
   c) increases more than 10%.
   d) decreases more than 10%.
   e) does not change.

19. A sample of nitrogen gas has a volume of 160.0 mL at STP. What volume does the gas occupy if the absolute temperature and pressure are each doubled?
   a) 40.00 mL
   b) 80.00 mL
   c) 160.0 mL
   d) 320.0 mL
   e) 640.0 mL

20. Body temperature is about 308 K. On a cold day, what volume of air at 273 K must a person with a lung capacity of 2.00 L breathe in to fill the lungs?
   a) 2.26 L
   b) 1.77 L
   c) 1.13 L
   d) 3.54 L
   e) none of these

21. Given a cylinder of fixed volume filled with 1 mol of argon gas, which of the following is correct? (Assume all gases obey the ideal gas law.)
   a) If the temperature of the cylinder is changed from 25 °C to 50 °C, the pressure inside the cylinder will double.
   b) If a second mole of argon is added to the cylinder, the ratio $T/P$ would remain constant.
   c) A cylinder of identical volume filled with the same pressure of helium must contain more atoms of He gas because He has a smaller atomic radius than argon.
   d) (a) and (b) are both correct.
   e) None of the above statements are correct.

22. At 0.967 atm, the height of mercury in a barometer is 0.735 m. If the mercury were replaced with water, what height of water (in meters) would be supported at this pressure? The densities of Hg and H₂O are 13.5 g/cm³ and 0.997 g/cm³, respectively.
   a. 0.760 m
   b. 13.1 m
   c. 0.735 m
   d. 0.0546 m
   e. 9.95 m
23. The two main components in air are nitrogen and oxygen gas. Air is 79% N\textsubscript{2} and 21% O\textsubscript{2} by volume. Considering only N\textsubscript{2} and O\textsubscript{2} in air, calculate the density of air at 1.0 atm, 25 °C.
   a) 0.590 g/L  
   b) 1.18 g/L  
   c) 2.46 g/L  
   d) 14.1 g/L  
   e) None of the above.

24. What kind of gases have low values of \( a \) in the van der Waals equation?
   a. Gases which have no affinity of each other  
   b. Gases with a large volume  
   c. Gases with a small volume  
   d. \( a \) depends on the pressure and temperature of the gas not the identity of the gas.  
   e. Gases which have high affinity of each other

25. Given the following equilibrium constants

\[ K_a (\text{HSO}_4^-) = 1.2 \times 10^{-2} \]  
\[ K_b (\text{CH}_3\text{CO}_2^-) = 5.6 \times 10^{-10} \]  
\[ K_w = 1.00 \times 10^{-14} \]

Determine the equilibrium constant for the reaction below at 25 °C.

\[ \text{HSO}_4^- (aq) + \text{CH}_3\text{CO}_2^- (aq) \rightarrow \text{SO}_4^{2-} (aq) + \text{CH}_3\text{CO}_2\text{H}(aq) \]

a. 2.1 \times 10^{-7}  
   b. 1.5 \times 10^{-3}  
   c. 6.7 \times 10^{-12}  
   d. 6.7 \times 10^{2}  
   e. 2.1 \times 10^{7}

26. Consider a solution of 2.0 M HCN and 1.0 M NaCN. Which of the following statements is true?
   a) The solution is not a buffer because [HCN] is not equal to [CN\textsuperscript{−}].  
   b) The pH will be below 7.00 because the concentration of the acid is greater than that of the base.  
   c) [OH\textsuperscript{−}] > [H\textsuperscript{+}]  
   d) The buffer will be more resistant to pH changes from addition of strong acid than of strong base.  
   e) All of the above are false.

27. If 25 mL of 0.75 M HCl are added to 100 mL of 0.25 M NaOH, what is the final pH?
   a) 12.7  
   b) 12.8  
   c) 1.30  
   d) 1.20  
   e) 7.00

28. A 50.0-mL sample of 0.10 M HNO\textsubscript{2} is titrated with 0.10 M NaOH. What is the pH after 25.0 mL of NaOH have been added?
   a) 7.00  
   b) 1.00  
   c) 12.50  
   d) 3.34  
   e) 2.48
29. Which of the following solutions has the lowest pH?
   a) 1.0 M NaNO₂
   b) 1.0 M KOH
   c) 1.0 M KCl
   d) 1.0 M NH₃

30. Which of the following is the net ionic equation for the reaction that occurs during the titration of nitrous acid, HNO₂, with potassium hydroxide, KOH?
   a) HNO₂ + K⁺ + OH⁻ → KNO₂ + H₂O
   b) HNO₂ + H₂O → NO₂⁻ + H₃O⁺
   c) HNO₂ + KOH → K⁺ + NO₂⁻ + H₂O
   d) HNO₂ + OH⁻ → NO₂⁻ + H₂O
   e) H⁺ + OH⁻ → H₂O

31. Is a 1.0 M NH₄I(aq) solution acidic, basic or neutral?
   a) acidic
   b) basic
   c) neutral
   d) can not be determined from the information given

32. When 20 mL of 0.1 M Ba(OH)₂ is added to 40 mL of 0.1 M weak acid (HA) what is the pH of the solution?
   a) pH < 7
   b) pH = 7
   c) pH > 7
   d) pH = pKa
   e) None of these

33. Balance the following reaction in basic solution. NO₂⁻ (aq) + Al (s) → NH₃ (g) + AlO₂⁻ (aq)
   In the balanced equation what is the coefficient in front of Al?
   a) 4
   b) 2
   c) 3
   d) 1
   e) 6

34. Calculate the pH of a 2.0 M HClO solution.
   a) 3.6
   b) 3.8
   c) 2.0
   d) 4.5
   e) 7.5

35. Calculate the pH of a 0.240 M solution of the salt NaA. Kₐ for the acid HA is 3.8 x 10⁻⁴.
   a) 5.6
   b) 8.4
   c) 2.0
   d) 12.0
   e) none of these
36. Consider a 100.0 mL of buffer solution that is 0.50 M CH₃COOH and 0.50 M NaCH₃COO. What is the pH of the solution after 10.0 mL of 1.0 M NaOH is added.
   a) 4.75
   b) 4.93
   c) 4.57
   d) 4.67
   e) 7.0

37. An aqueous solution is made by adding 50.0 mL of 4.0 M sodium carbonate to 30.0 mL of 5.0 M sodium hydrogen carbonate. Calculate the sodium ion concentration.
   a) 6.9 M
   b) 4.4 M
   c) 3.8 M
   d) 9.0 M
   e) 5.6 M

38. How much solid NaCN must be added to 1.0 L of a 0.5 M HCN solution to produce a solution with pH = 7.0?
   A) 0.0034 g
   B) 11 g
   C) 160 g
   D) 24 g
   E) 0.15 g

39. The following plot show the pH curves for the titrations of various acids, HA, by 0.10 M NaOH. At the start of the titration, all of the acids were 50.0 mL of 0.10 M HA. Which pH curve corresponds to an acid with $K_a = 2 \times 10^{-6}$?
   a) a
   b) b
   c) c
   d) d
   e) e
40. Which of the following solutions can absorb the most acid or base without a change in pH? There is 50 mL of each solution.
   a) 0.61 M HF and 0.65 M NaF
   b) 0.84 M HF and 0.89 M NaF
   c) 0.21 M HF and 0.30 M NaF
   d) 0.17 M HF and 0.20 M NaF

41. A 40.0 mL solution of 0.10 M HNO₃ is titrated with 0.0500 M NaOH. What is the pH after the following volumes of base has been added?
   a. 25.0 mL   b. 80.0 mL   c. 120 mL

42. A 50.0-mL sample of 0.10 M HNO₃ is titrated with 0.10 M NaOH. What is the pH after the following volumes of base have been added?
   a. 25.0 mL   b. 50.0 mL   c. 100 mL

43. The concentration of OH⁻ in a saturated solution of Mg(OH)₂ is $3.6 \times 10^{-4}$ M. What is $K_{sp}$ for Mg(OH)₂?
   A) $1.3 \times 10^{-7}$
   B) $4.7 \times 10^{-11}$
   C) $1.2 \times 10^{-11}$
   D) $3.6 \times 10^{-4}$
   E) none of these

44. The solubility of Cd(OH)₂ in water is $1.7 \times 10^{-5}$ mol/L at 25°C. What is $K_{sp}$ for Cd(OH)₂?
   A) $2.0 \times 10^{-14}$
   B) $4.9 \times 10^{-15}$
   C) $5.8 \times 10^{-10}$
   D) $2.9 \times 10^{-10}$
   E) none of these

45. Calculate the solubility of Ca₃(PO₄)₂ ($K_{sp} = 1.3 \times 10^{-32}$) in a $1.0 \times 10^{-2}$ M Ca(NO₃)₂ solution.
   A) $5.7 \times 10^{-14}$ mol/L
   B) $6.2 \times 10^{-7}$ mol/L
   C) $1.6 \times 10^{-14}$ mol/L
   D) $3.16 \times 10^{-12}$ mol/L
   E) none of these