1. Which of the following is not a strong acid in aqueous solution?
   A) HBr
   B) HClO₄
   C) HF
   D) HI
   E) HCl

2. A particular sheet of paper measures 4.0 x 10.5 inches. What is the surface area of one side of the paper in cm²? (2.54 cm = 1 in exactly)
   A) 1.1 x 10² cm²
   B) 4.2 x 10¹ cm²
   C) 6.5 cm²
   D) 2.7 x 10² cm²
   E) 1.7 x 10¹ cm²

3. A 5.95-g sample of AgNO₃ is reacted with BaCl₂ according to the equation
   \[2\text{AgNO}_3(aq) + \text{BaCl}_2(aq) \rightarrow 2\text{AgCl(s)} + \text{Ba(NO}_3)_2(aq)\]
   to give 4.12 g of AgCl. What is the percent yield of AgCl?
   A) 69.2 %
   B) 54.7 %
   C) 100 %
   D) 41.0 %
   E) 82.1 %

4. In the reaction of acetic acid with aqueous sodium hydroxide, what is the spectator ion?
   A) OH⁻(aq)
   B) There is no spectator ion.
   C) C₂H₃O₂⁻(aq)
   D) Na⁺(aq)
   E) H⁺(aq)

5. How many valence electrons are present in the Lewis formula for the hypochlorite ion, ClO⁻?
   A) 14
   B) 16
   C) 12
   D) 18
   E) 20
6. The density of a particular solid is 7.90 g/cm³ at 25°C. What is its density in kilograms per cubic meter (kg/m³)?
   A) $7.90 \times 10^1$
   B) $7.90 \times 10^7$
   C) $7.90 \times 10^{-2}$
   D) $7.90 \times 10^{10}$
   E) $7.90 \times 10^3$

7. $2\text{KHCO}_3(\text{s}) \rightarrow \text{K}_2\text{CO}_3(\text{s}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$
   How many moles of potassium carbonate will be produced if 355 g of potassium hydrogen carbonate are heated?
   A) 1.77 mol
   B) 178 mol
   C) 13.3 mol
   D) 2.57 mol
   E) 3.55 mol

8. What is the net ionic equation for the acid–base reaction that occurs when acetic acid and sodium hydroxide solutions are mixed?
   A) $\text{HC}_2\text{H}_3\text{O}_2(aq) + \text{OH}^-(aq) \rightarrow \text{C}_2\text{H}_3\text{O}_2^-(aq) + \text{H}_2\text{O}(l)$
   B) $\text{H}^+(aq) + \text{OH}^-(aq) \rightarrow \text{H}_2\text{O}(l)$
   C) $\text{H}_3\text{O}^+(aq) + \text{OH}^-(aq) \rightarrow 2\text{H}_2\text{O}(l)$
   D) $\text{C}_2\text{H}_3\text{O}_2^-(aq) + \text{H}^+(aq) + \text{Na}^+(aq) + \text{OH}^-(aq) \rightarrow \text{Na}^+(aq) + \text{C}_2\text{H}_3\text{O}_2^-(aq) + \text{H}_2\text{O}(l)$
   E) $\text{HC}_2\text{H}_3\text{O}_2(aq) + \text{NaOH}^-(aq) \rightarrow \text{NaC}_2\text{H}_3\text{O}_2^-(aq) + \text{H}_2\text{O}(l)$

9. Which of the following atoms is the most electronegative?
   A) B
   B) N
   C) Al
   D) Cs
   E) Na
10. The mass spectrum of an element with two naturally occurring isotopes is shown below. What is the best estimate of the element’s atomic mass?

![Mass Spectrum Diagram]

A) 10 amu  
B) 11 amu  
C) 10.8 amu  
D) 10.2 amu  
E) 10.5 amu

11. Analysis of a compound showed that it contained 14.4% hydrogen atoms and 85.6% carbon atoms by mass. What is its empirical formula?

A) CH₃  
B) CH  
C) CH₂  
D) C₂H₅  
E) C₂H₃

12. Which of the following chemical reactions is an oxidation-reduction reaction?

A) Mg(s) + CO₂(g) → MgO(s) + CO(g)  
B) H₂SO₄(aq) + Ba(OH)₂(aq) → BaSO₄(s) + 2H₂O(l)  
C) Pb(NO₃)₂(aq) + 2HCl(aq) → PbCl₂(s) + 2HNO₃(aq)  
D) CO₂(aq) + H₂O(l) → H₂CO₃(aq)  
E) NH₃(g) + HCl(g) → NH₄Cl(s)
13. Which of the following Lewis formulas is incorrect?
   A) :Cl : Cl:
   B) :N : N:
   C) H : N : H
   D) H : C : H
   E) H : O : H

14. How many moles of pentane, C₅H₁₂, are contained in a 35-g sample?
   A) 0.49 mol
   B) 0.83 mol
   C) 0.58 mol
   D) 3.5 mol
   E) 4.4 mol

15. What is the ground-state electron configuration of phosphorus (P)?
   A) [Ne]3s³3p³
   B) [Ne]3s³3p²
   C) [Ar]3p⁵
   D) [Ne]3p⁵
   E) [Ar]3s²3p³

16. Which of the following orbital diagrams violates the Pauli exclusion principle?
   A) ↑↓  ↑↓  ↑↓  ↑↓  ↑↓
   B) ↑↓  ↑↓  □□□□□
   C) ↑↓  ↑↓  □□ □□ □□
   D) ↑↓  ↑↓  □□ □□□□□
   E) ↑↓  ↑  □□□□
17. In phosgene, COCl₂, the electron groups are located about the central carbon atom in a ___ arrangement.
A) square planar
B) trigonal bipyramidal
C) pyramidal
D) trigonal planar
E) tetrahedral

18. The nucleus of a ¹⁹⁶Pt nuclide contains
A) 196 protons, 78 neutrons, and 196 electrons.
B) 196 protons and 118 electrons.
C) 78 protons and 118 neutrons.
D) 196 neutrons and 274 electrons.
E) 78 protons and 196 neutrons.

19. Which of the following gases will have the slowest rate of effusion at constant temperature?
A) H₂
B) F₂
C) Ne
D) SO₃
E) CF₄

20. The complete combustion of butane, C₄H₁₀, yields carbon dioxide and water:

\[ \text{C}_4\text{H}_{10} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} \]

The smallest whole-number coefficient of oxygen in the balanced equation is
A) 12.
B) 14.
C) 10.
D) 11.
E) 13.

21. What is the ground-state electron configuration of the Mg²⁺ ion?
A) 1s²2s²2p⁶
B) 1s²2s²2p³
C) 1s²2s²2p¹
D) 1s²2s²2p⁶3s²
E) 1s²2s²2p⁶3s²3p²
22. What is the ground-state electron configuration of Fe\(^{3+}\)?
   A) [Ar]3d\(^6\)
   B) [Ar]3d\(^5\)
   C) [Ar]3d\(^3\)4s\(^2\)
   D) [Ar]3d\(^6\)4s\(^2\)
   E) [Ar]3d\(^4\)4s\(^1\)

23. Which of the following ground-state electron configurations corresponds to an atom having the largest ionization energy?
   A) [Ar]3d\(^{10}\)4s\(^2\)4p\(^3\)
   B) [Ne]3s\(^2\)3p\(^3\)
   C) [Ne]3s\(^2\)3p\(^2\)
   D) [Kr]4d\(^{10}\)5s\(^2\)5p\(^3\)
   E) [Xe]4f\(^{14}\)5d\(^{10}\)6s\(^2\)6p\(^3\)

24. The molecular geometry of the CH\(_3^+\) ion is best described as
   A) trigonal planar.
   B) pyramidal.
   C) linear.
   D) bent.
   E) tetrahedral.

25. How many moles of gas are in a gas sample occupying 0.870 L at 167 mmHg and 30°C?
   A) 0.00768 mol
   B) 0.000631 mol
   C) 59.0 mol
   D) 130 mol
   E) 5.84 mol

26. According to the following thermochemical equation, if 680.7 g of NO\(_2\) is produced, how much heat is released at constant pressure?
   \[2\text{NO}(g) + \text{O}_2(g) \rightarrow 2\text{NO}_2(g); \Delta H^\circ = -114.4 \text{ kJ}\]
   A) 1.693 \times 10^3 \text{ kJ}
   B) 8.463 \times 10^2 \text{ kJ}
   C) 114.4 \text{ kJ}
   D) 7.732 \text{ kJ}
   E) 7.787 \times 10^4 \text{ kJ}
27. The density of ethane, C₂H₆ (30.1 g/mol), at 25°C and 1.17 atm pressure is
   A) 0.695 g/L.
   B) 1.44 g/L.
   C) 0.141 g/L.
   D) 1.34 g/L.
   E) 17.2 g/L.

28. Calculate the lattice energy for LiF(s) given the following:
   sublimation energy for Li(s) +166 kJ/mol
   DH_f for F(g) +77 kJ/mol
   first ionization energy of Li(g) +520. kJ/mol
   electron affinity of F(g) −328 kJ/mol
   enthalpy of formation of LiF(s) −617 kJ/mol
   A) 1052 kJ/mol
   B) 285 kJ/mol
   C) −650. kJ/mol
   D) 800. kJ/mol
   E) none of these

29. How many 100-mg aspirin tablets can be made from 10.0 kg of aspirin?
   A) 100,000
   B) 10,000
   C) 1,000,000
   D) 1000
   E) 10,000,000

30. What is the percent by mass hydrogen in (NH₄)₂SO₄?
   A) 40.0 %
   B) 6.10 %
   C) 3.05 %
   D) 1.00 %
   E) 67.0 %

31. How many joules are there in 5.11 kcal? (1 calorie = 4.184 J)
   A) 1.22 × 10³ J
   B) 2.14 × 10^4 J
   C) 21.4 J
   D) 1.22 J
   E) 2.14 × 10⁻² J
32. Which of the following represents a pair of isotopes?

<table>
<thead>
<tr>
<th>Atomic Number</th>
<th>Mass Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>A) I 17</td>
<td>37</td>
</tr>
<tr>
<td>II 18</td>
<td>38</td>
</tr>
<tr>
<td>B) I 17</td>
<td>35</td>
</tr>
<tr>
<td>II 17</td>
<td>37</td>
</tr>
<tr>
<td>C) I 7</td>
<td>15</td>
</tr>
<tr>
<td>II 8</td>
<td>16</td>
</tr>
<tr>
<td>D) I 17</td>
<td>37</td>
</tr>
<tr>
<td>II 18</td>
<td>37</td>
</tr>
<tr>
<td>E) I 7</td>
<td>14</td>
</tr>
<tr>
<td>II 8</td>
<td>14</td>
</tr>
</tbody>
</table>

33. A sample of methane, CH₄, occupies a volume of 316.0 mL at 25°C and exerts a pressure of 975.0 mmHg. If the volume of the gas is allowed to expand to 630.0 mL at 298 K, what will be the pressure of the gas?

A) 314.0 mmHg
B) 489.0 mmHg
C) 1940 mmHg
D) 0.01657 mmHg
E) 5830 mmHg

34. The Lewis formula for phosphine, PH₃, has

A) four lone pairs.
B) four bonding pairs.
C) two bonding pairs and two lone pairs.
D) three bonding pairs and one lone pair.
E) one bonding pair and three lone pairs.

35. Which net ionic equation best represents the reaction that occurs when an aqueous solution of barium chloride is mixed with an aqueous solution of lithium sulfate?

A) \(2H^+(aq) + 2Cl^-(aq) \rightarrow 2HCl(g)\)
B) \(Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)\)
C) \(Ba^{2+}(aq) + 2Cl^-(aq) + 2Li^+(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s) + 2LiCl(aq)\)
D) \(BaCl_2(aq) + Li_2SO_4(aq) \rightarrow BaSO_4(s) + 2LiCl(aq)\)
E) No net reaction occurs.
36. Use the bond energies provided to complete the following statement.

when all of the bonds in acetic acid (CH$_3$COOH) are broken.

<table>
<thead>
<tr>
<th>Bond</th>
<th>Bond Energy (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-H</td>
<td>413</td>
</tr>
<tr>
<td>C-O</td>
<td>358</td>
</tr>
<tr>
<td>O-H</td>
<td>463</td>
</tr>
<tr>
<td>C=O</td>
<td>745</td>
</tr>
<tr>
<td>C=C</td>
<td>348</td>
</tr>
<tr>
<td>C=C</td>
<td>614</td>
</tr>
</tbody>
</table>

A) $3153 \text{ kJ/mol of energy is consumed}$
B) $3153 \text{ kJ/mol of energy is released}$
C) $2805 \text{ kJ/mol of energy is released}$
D) $2805 \text{ kJ/mol of energy is consumed}$
E) $2766 \text{ kJ/mol of energy is consumed}$

37. What is $\Delta H^\circ$ for the following reaction?

$$2\text{C}_2\text{H}_2(g) + 5\text{O}_2(g) \rightarrow 4\text{CO}_2(g) + 2\text{H}_2\text{O}(l)$$

<table>
<thead>
<tr>
<th>Substance</th>
<th>$\Delta H^\circ$ (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{C}_2\text{H}_2(g)$</td>
<td>+226.7</td>
</tr>
<tr>
<td>$\text{CO}_2(g)$</td>
<td>$-393.5$</td>
</tr>
<tr>
<td>$\text{H}_2\text{O}(l)$</td>
<td>$-285.8$</td>
</tr>
</tbody>
</table>

A) $+1692.2 \text{ kJ}$
B) $-452.6 \text{ kJ}$
C) $-1692.2 \text{ kJ}$
D) $+2599.0 \text{ kJ}$
E) $-2599.0 \text{ kJ}$

38. Ammonia, NH$_3$, and oxygen can be reacted together in the presence of a catalyst to form only nitrogen monoxide and water. The number of moles of oxygen consumed for every 7.00 moles of NO produced is __________.

A) 8.75
B) 35.0
C) 17.5
D) 4.38
E) 26.3
39. Sulfuric acid reacts with aqueous sodium hydroxide to produce aqueous sodium sulfate and liquid water. Which is the correct balanced chemical equation for this reaction description?
A) \( \text{H}_2\text{SO}_4(\text{aq}) + 2\text{NaOH}(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\ell) + 2\text{O}_2(\text{g}) \)
B) \( \text{H}_2\text{S}(\text{aq}) + 2\text{NaOH}(\text{aq}) \rightarrow \text{Na}_2\text{S}(\text{aq}) + 2\text{H}_2\text{O}(\ell) \)
C) \( \text{H}_2\text{SO}_4(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + \text{H}_2\text{O}(\text{g}) \)
D) \( \text{H}_2\text{SO}_4(\text{aq}) + 2\text{NaOH}(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\ell) \)
E) \( \text{H}_2\text{SO}_4(\text{aq}) + (\text{NaOH})_2(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\ell) \)

40. What is the molecular geometry of the bromate ion, \( \text{BrO}_3^- \)?
A) square planar
B) trigonal planar
C) square pyramidal
D) tetrahedral
E) trigonal pyramidal

41. How many liters are in 14.7 fluid ounces of a soft drink? (1 fl oz = 28.35 mL)
A) \( 5.19 \times 10^{-4} \text{ L} \)
B) \( 5.19 \times 10^2 \text{ L} \)
C) \( 4.17 \times 10^3 \text{ L} \)
D) \( 4.17 \times 10^2 \text{ L} \)
E) \( 0.417 \text{ L} \)

42. A gas occupies a volume of 2.75 L at 350 mmHg and 200°C. Which mathematical expression gives the correct volume at 650 mmHg and 300°C?
A) \( \frac{2.75 \text{ L} \times 650 \text{ mmHg}}{350 \text{ mmHg}} \times \frac{573 \text{ K}}{473 \text{ K}} \)
B) \( \frac{2.75 \text{ L} \times 650 \text{ mmHg}}{350 \text{ mmHg}} \times \frac{573 \text{ K}}{473 \text{ K}} \)
C) \( \frac{2.75 \text{ L} \times 650 \text{ mmHg}}{350 \text{ mmHg}} \times \frac{573 \text{ K}}{473 \text{ K}} \)
D) \( \frac{2.75 \text{ L} \times 350 \text{ mmHg}}{650 \text{ mmHg}} \times \frac{300°C}{200°C} \)
E) \( \frac{2.75 \text{ L} \times 350 \text{ mmHg}}{650 \text{ mmHg}} \times \frac{573 \text{ K}}{473 \text{ K}} \)

43. The boiling point of chlorine is 172 K. This temperature corresponds to
A) -82°C.
B) 101°C.
C) 172°C.
D) -172°C.
E) -101°C.
44. A 1.00-L sample of a gas at STP has a mass of 1.43 g. The molar mass of the gas is
   A) 157 g/mol.
   B) 22.4 g/mol.
   C) 6.38 g/mol.
   D) 67.2 g/mol.
   E) 32.0 g/mol.

45. A sample of an oxide of antimony (Sb) contained 59.5 g of antimony combined with 19.5 g of oxygen. What is the simplest formula for the oxide?
   A) Sb₂O₅
   B) Sb₂O₃
   C) SbO₃
   D) SbO
   E) Sb₂O

46. The change in energy for which of the following processes corresponds to the first ionization energy of strontium?
   A) Sr(g) → Sr⁺(g) + e⁻
   B) Sr(g) → Sr²⁺(g) + 2e⁻
   C) Sr(s) → Sr⁺(g) + e⁻
   D) Sr(s) + e⁻ → Sr⁺(s)
   E) Sr(s) → Sr⁺(s) + e⁻

47. What is the change in enthalpy at 25°C and 1 atm for the production of 3.00 mol SnO(s)?
   Sn(s) + SnO₂(s) → 2SnO(s); ΔH° = 16.2 kJ
   A) -16.2 kJ
   B) 5.40 kJ
   C) 24.3 kJ
   D) 16.2 kJ
   E) -24.3 kJ

48. Calculate the number of moles of bromine present in 21.0 mL of Br₂(l), whose density is 3.12 g/mL.
   A) 0.820 mol
   B) 0.131 mol
   C) 0.410 mol
   D) 2.44 mol
   E) 0.263 mol
49. The following equation represents the partial combustion of methane, CH₄.

\[ 2\text{CH}_4(g) + 3\text{O}_2(g) \rightarrow 2\text{CO}(g) + 4\text{H}_2\text{O}(g) \]

At constant temperature and pressure, what is the maximum volume of carbon monoxide that can be obtained from 5.09 \times 10² L of methane and 2.54 \times 10² L of oxygen?

A) 5.09 \times 10² L  
B) 1.02 \times 10³ L  
C) 7.63 \times 10² L  
D) 1.78 \times 10³ L  
E) 1.70 \times 10² L

50. When 20.0 g C₂H₆ and 60.0 g O₂ react to form CO₂ and H₂O, how many grams of water are formed?

A) 14.5 g  
B) 58.0 g  
C) 18.0 g  
D) 20.0 g  
E) none of these