1. An electronic balance was used to determine that a sample has a mass of 9.00060 g. If the balance's precision is ± 1 mg, what is the correct number of significant figures for this measurement?

   \[ \pm 1 \text{ mg} = \pm 0.001 \text{ g} \]

   \[ 9.00060 \text{ g} \Rightarrow 9.001 \Rightarrow 4 \text{ sig figs} \]

   A) 4
   B) 5
   C) 6
   D) 2
   E) 3

2. A 26 meter tall building is covered with 279 kg of gold. If the gold was applied to a thickness of 0.0015 mm, what surface area is covered in m² (meter square)? (Gold density = 19.3 g/cm³)

\[
\rho = \frac{m}{V} = \frac{m}{SA \cdot \text{thickness}} \Rightarrow SA = \frac{m}{\rho \cdot \text{thickness}}
\]

\[
\frac{1}{\text{m}^2} = \frac{2.79 \times 1.68}{1.13 \times 10^{-11}} = \frac{2.79 \times 10^{-14} \times 10^{-11}}{1.13 \times 10^{-1}} = 9.64 \times 10^3 \text{ m}^2
\]

A) \(9.64 \times 10^3\)
B) \(1.45 \times 10^3\)
C) \(1.45 \times 10^2\)
D) 14.5
E) \(8.64 \times 10^2\)

3. A mixture of sand, sugar, and water was filtered by a filter paper. We can classify the matter before and after filtration as:

**Before filtration:**

A) Heterogeneous mixture ✓
B) Heterogeneous mixture ✓
C) Homogeneous mixture ×
D) Homogeneous mixture ×
E) Heterogeneous mixture ×

**After filtration:**

A) Homogeneous mixture ✓
B) Compound ×
C) Pure substance ×
D) Pure mixture ×
E) Element ×
4. A flask has a mass of 78.23 g when empty and 593.63 g when filled with water. When the same flask is filled with concentrated sulfuric acid, H₂SO₄, its mass is 1026.57 g. What is the density of concentrated sulfuric acid? (Assume water has a density of 1.00 g/cm³ at the temperature of the measurement.)

\[ \frac{\text{g H}_2\text{O}}{\text{cm}^3} = \frac{78.23 - 593.63}{1.00} = 515.4 \text{ g/cm}^3 \]

A) 1.840 g/cm³
B) 1.992 g/cm³
C) 1.729 g/cm³
D) 1.598 g/cm³
E) 0.543 g/cm³

5. Identify the ions in the formation of CaHPO₄.

A) Ca²⁺ and HPO₄²⁻
B) Ca⁺ and HPO₄⁻
C) Ca²⁺ and HPO₄⁻⁻
D) Ca²⁺, H⁺, P⁵⁺, and O²⁻
E) Ca²⁺, 2H⁺ and PO₄⁻⁻

![Diagram of CaHPO₄ formation]

6. Compounds A and B were decomposed into their constituent elements. Compound A produced 0.2912 g P for every gram of Cl. Compound B produced 0.1747 g P for every gram of Cl.

A) The results are consistent with the law of multiple proportions with ratio of 5:3
B) The results are consistent with the law of definite proportions with ratio of 5:3
C) The results are consistent with the law of definite proportions with ratio of 1.667:1
D) The results are consistent with the law of multiple proportions with ratio of 3:1
E) The results are consistent with the law of definite proportions with ratio of 3:1

\[ \frac{0.2912 \text{ g P}}{0.1747 \text{ g P}} = \frac{8 \text{ g Cl}}{5 \text{ g Cl}} = 1.667 \]

\[ \text{Ratio of ratios} = \frac{5}{3} = \frac{\text{law of multiple proportions}}{\text{law of definite proportions}} \]
7. The following table gives numbers of electrons, protons, and neutrons in atoms or ions of a number of elements.

<table>
<thead>
<tr>
<th>Number of</th>
<th>Atom of ion of element</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>electrons</td>
<td>5</td>
</tr>
<tr>
<td>protons</td>
<td>5</td>
</tr>
<tr>
<td>neutrons</td>
<td>5</td>
</tr>
</tbody>
</table>

Charge: neutral  -  +  +  +  -

A) A is neutral, charges ✓  B and E have negative charges ✓  C and D have positive charges ✓
B) A is neutral, charges ✓  C and D have negative charges, B and E have positive charges ×
C) B and E are neutral, charges ✓  A has negative charges, C and D have positive charges ✓
D) B and E are neutral, charges ×  C and D have negative charges, A has positive charges ×
E) C and D are neutral, charges ×  B and E have negative charges, A has positive charges ✓

8. Which subatomic particle(s) was/were discovered by researchers working with cathode ray tubes?

- A) the electron ✓
- B) the proton
- C) the neutron
- D) the electron and neutron
- E) the electron, proton and neutron

9. If the total number of atoms in a sample of potassium dichromate is $2.13 \times 10^{24}$, then the amount of chromium in this sample is

- A) 33.4 g
- B) 52.0 g
- C) 85.7 g
- D) 6.80 g
- E) 24.2 g

$$\text{Cr}_{2}O_{7}^{2-}$$

\[ \frac{7 g \text{Cr}}{2.13 \times 10^{24} \text{atoms}} \times \frac{6.022 \times 10^{23} \text{atoms}}{1 \text{mol} \text{atoms}} \times \frac{1 \text{mol} \text{Cr}_{2}O_{7}^{2-}}{1 \text{mol} \text{Cr}} \]

\[ \frac{2 \text{mol} \text{Cr}}{1 \text{mol} K_{2} \text{Cr}_{2}O_{7}} \times \frac{52.00 g \text{Cr}}{1 \text{mol} \text{Cr}} = 33.4 g \text{Cr} \]
10. When the following equation is balanced using the smallest possible integers, what is the coefficient of IF₅(l)?

\[ 2 \text{MnI}_2(s) + \frac{7}{4} \text{F}_2(g) \rightarrow 2 \text{MnF}_3(s) + \frac{4}{2} \text{IF}_5(l) \]

(A) 4
(B) 5
(C) 3
(D) 6
(E) 7

11. Nicotine, contains carbon, hydrogen and nitrogen. When a 5.00-g sample of nicotine was combusted in excess of oxygen, 13.56 g of CO₂, 3.886 g of H₂O and some nitrogen oxides were produced. The empirical formula for this compound is

\[ \text{C}_\text{n}\text{H}_\text{m}\text{N}_\text{p} \]

\[ ? \text{n} \text{C} = \frac{13.56 \text{g CO}_2}{44.01 \text{g CO}_2} \]
\[ ? \text{m} \text{H} = \frac{3.886 \text{g H}_2\text{O}}{18.01 \text{g H}_2\text{O}} \]
\[ ? \text{p} \text{N} = \frac{5.00 \text{g N}}{14.01 \text{g N}} \]

A) C₃H₄N
B) C₄H₅N
C) C₃H₄N
D) C₃H₅N₂
E) C₂H₇N

12. Calcium carbonate decomposes on heating to produce calcium oxide and carbon dioxide gas as follows:

\[ \text{CaCO}_3(s) \rightarrow \text{CaO}(s) + \text{CO}_2(g) \]

If the yield of the reaction is only 73.0%, what is the minimum amount of calcium carbonate needed to produce 12.7 g of calcium oxide?

\[ \text{CaO} \text{yield} = \frac{73.0 \% \text{ actual}}{100 \%} \rightarrow \text{theoretical} = \frac{12.7 \text{g CaO}}{0.73} \]

A) 31.1 g
B) 17.4 g
C) 76.8 g
D) 29.3 g
E) 73.1 g

13. Which are the spectator ions in the following reaction? (Assume both H₂SO₄ and KOH dissociates completely in aqueous solution)

\[ \text{H}_2\text{SO}_4(aq) + 2\text{KOH(aq)} \rightarrow \text{K}_2\text{SO}_4(aq) + 2\text{H}_2\text{O(l)} \]

A) K⁺, SO₄²⁻
B) H⁺, SO₄²⁻
C) K⁺, OH⁻
D) H⁺, OH⁻
E) H⁺, OH⁻, SO₄²⁻
14. The equation, \(2H^+ (aq) + CO_3^{2-} (aq) \rightarrow H_2O(l) + CO_2(g)\), is the net ionic equation for the reaction of an aqueous mixture of

A) \(Na_2CO_3\) and \(HCl\).
B) \(CaCO_3\) and \(HCl\).
C) \(BaCO_3\) and \(H_2SO_4\).
D) \((COOH)_2\) and \(KOH\).
E) \(H_2CO_3\) and \(NaOH\).

\(Na_2CO_3\) and \(HCl\) → \(2NaCl\) (aq) + \(CO_2\) (g) + \(H_2O\) (l)
\(CaCO_3\) is a solid
\(BaCO_3\) is a solid
\((COOH)_2\) + \(2KOH\) → \(K_2CO_3\) (aq) + \(2H_2O\) (l)
\(H_2CO_3\) + \(2NaOH\) → \(Na_2CO_3\) (aq) + \(2NaOH\) → \(\text{does not produce CO}_2\)

15. A potassium hydrogen phthalate (KHC_8H_4O_4), a monoprotic acid has a molar mass of 204.2 g/mol. In a titration experiment, you find that a sample of 0.100 g of potassium hydrogen phthalate requires 8.85 ml of a sodium hydroxide to neutralize it. What is the molarity of the sodium hydroxide solution?

\[\text{?} \text{ M}_\text{KOH} = \frac{0.100 \text{g}}{204.2 \text{g/mol}} \times \frac{1 \text{mol KHP}}{\text{mol KOH}} \times \frac{\text{mol KOH}}{\text{mol OH}^-} \times \frac{1 \text{L}}{0.00885 \text{L}} = 0.0553 \text{mol/L}\]

A) 0.0553 mol/L
B) 0.0885 mol/L
C) 0.0276 mol/L
D) 20.4 mol/L
E) 0.0443 mol/L

16. Which of the statements below is false concerning the following reaction?

\[\text{NH}_3(g) + \text{H}_2\text{O}(l) \rightleftharpoons \text{NH}_4^+(aq) + \text{OH}^-(aq)\]

A) The double arrows indicate that ammonia, \(\text{NH}_3\), is completely ionized in water. - 
B) The reaction is reversible. - 
C) When \(\text{NH}_3\) is added to \(\text{H}_2\text{O}\), \(\text{NH}_4^+\) and \(\text{OH}^-\) ions are produced in a 1:1 ratio. - 
D) When solutions of \(\text{NH}_4^+\) and \(\text{OH}^-\) are mixed, some ammonia is produced. - 
E) Ammonia partially reacts with water. - 

17. An intensive property of a substance is

A) independent of the amount present. - 
B) dependent on its volume, but not its mass. - 
C) not affected by its temperature. - 
D) dependent only on its temperature and volume. - 
E) dependent only on its mass and volume. -
18. Which one of the following is correct name with its formula?

A) barium acetate : $\text{Ba(C}_2\text{H}_3\text{O}_2\text{)}_2$  **true**
B) sodium sulfide $\text{Na}_2\text{SO}_3$  **false**; sodium sulfate
C) iron(II) sulfate : $\text{Fe}_2\text{(SO}_4\text{)}_3$  **false**; iron(III) sulfate
D) cesium carbonate : $\text{Cs}_2\text{CO}_3$  **false**
E) barium hydroxide decahydrate : $\text{Ba(OH)}_2\cdot8\text{H}_2\text{O}$  **false**, barium hydroxide octahydrate

19. Calculate the number of moles of $\text{O}_2$ required to react with phosphorus to produce 4.76 g of $\text{P}_4\text{O}_6$. (Assuming 100% conversion)

$$4\text{P} + 3\text{O}_2 \rightarrow \text{P}_4\text{O}_6$$

\[ \text{mol O}_2 = \frac{4.76 \text{ g O}_2}{219.88 \text{ g/mol}} = 0.0649 \text{ mol} \]

\[ \text{mol P}_4\text{O}_6 = \frac{3 \text{ mol O}_2}{1 \text{ mol P}_4\text{O}_6} = 0.1947 \text{ mol} \]

\[ \text{FW} = 4(30.97) + 6(16.00) = 219.88 \text{ g/mol} \]

20. The oxidation number of nitrogen is highest in which of the following?

A) $\text{NaNO}_3$
B) $\text{NH}_3$
C) $\text{N}_2 \rightarrow 0$
D) $\text{HNO}_2$
E) $\text{NO}_2^-$

\[ \text{HNO}_2 \]

\[ +1 +3 -2 \]

\[ \text{NO}_2^- \]

\[ +3 -2 \]

\[ +1 +3 -4 \]

\[ +1 -4 = -1 \]