(3 pts) 1. Which contains more atoms?
(A) 3 mol CO  (B) 2 mol CO$_2$  (C) Neither

(3 pts) 2. Which contains more molecules?
(A) 1 mol O$_2$  (B) 1 mol O$_3$  (C) Neither

(3 pts) 3. There are two stable isotopes of indium: $^{113}\text{In}$ and $^{115}\text{In}$. Given that the molar mass of indium is 114.82, which isotope is more abundant?
(A) $^{113}\text{In}$  (B) $^{115}\text{In}$  (C) Neither

(3 pts) 4. If we mix 2 L of 0.5 M NaOH and 5 L of 0.1 M HCl, the resulting solution will be ...
(A) Acidic  (B) Basic  (C) Both  (D) Neither

(3 pts) 5. A compound containing the –COOH group should be expected to react as a...
(A) Weak acid  (B) Weak base  (C) Strong Acid  (D) Strong base

(3 pts) 6. How many hydrogen atoms are present in 0.5 mol C$_2$H$_4$?
(A) $6 \times 10^{23}$  (B) $3 \times 10^{23}$  (C) 2  (D) $1.2 \times 10^{24}$  (E) $1.8 \times 10^{24}$

(3 pts) 7. Ammonium carbonate is a strong electrolyte. How many moles of NH$_4^+$ ions would be present in 2.0 L of 0.25 M (NH$_4$)$_2$CO$_3$?
(A) 0.50  (B) 0.75  (C) 1.50  (D) 1.25  (E) 1.00

(3 pts) 8. Given that the formula for sodium oxalate is Na$_2$C$_2$O$_4$, what must be the charge on an oxalate ion?
(A) 2+  (B) 1+  (C) 1–  (D) 2–  (E) 3–

(3 pts) 9. Which of the following properties does not need to be the same on both sides of a balanced chemical equation?
(A) Total number of atoms  (B) Electric charge
(C) Number of molecules  (D) Mass
(E) Number of atoms of each element
10. The structure shown below is a compound known as homosalate, which is used in some sunscreens. What is the correct molecular formula for homosalate?

(A) C_{14}H_{16}O_{3}      (B) C_{13}H_{10}O_{3}     (C) C_{14}H_{12}O_{3}     (D) C_{16}H_{16}O_{3}     (E) C_{16}H_{22}O_{3}

11. Ammonia (NH_{3}) can react with O_{2} gas to form nitric oxide (NO) and water. Write a properly balanced chemical equation for this process. What is the sum of all of the stoichiometric coefficients in the balanced equation? (If your equation includes any coefficients of one, be sure to count those.)

(A) 19     (B) 29     (C) 27     (D) 21     (E) 13

\[ 4 \text{NH}_3 + 5 \text{O}_2 \rightarrow 4 \text{NO} + 6 \text{H}_2\text{O} \]

12. A certain metal forms an ionic compound with the formula MCl_{2}, where M represents the metal. If MCl_{2} is 44.73% chlorine by mass, what is the correct identity of the metal M?

(A) Pb     (B) Ba     (C) Cs     (D) Pt     (E) Sr

2 Cl atoms contribute 70.90 g/mol, and that’s 44.73% of the molar mass. So molar mass is just:

\[
\frac{70.90}{0.4473} = 158.51 \quad 158.51 - 70.90 = 87.61
\]

That has to be the molar mass of M, and it tells us that M is strontium (Sr). Note that strontium is in Group 2, so it should form Sr^{2+}, consistent with SrCl_{2}.
The pictures below show a molecular scale view of a chemical reaction between the compounds $A_2$ and $B_2$. (Shaded circles represent $B$ atoms and open circles are $A$ atoms). The box on the left represents the reactants at the instant of mixing, and the box on the right shows what is left once the reaction has gone to completion. Use these pictures to answer Questions 13 & 14.

(4 pts) **13.** Was there a limiting reagent in this reaction? If so, what was it?

(A) Yes, $A$

(B) Yes, $AB_3$

(C) Yes, $B_2$

(D) Yes, $AB_2$

(E) No

(5 pts) **14.** Write a properly balanced chemical equation for this reaction, using the smallest possible whole number coefficients. What is the sum of all of the coefficients in the equation?

(A) 19  

(B) 12  

(C) 18  

(D) 5  

(E) 6

$A_2 + 3B_2 \rightarrow 2AB_3$
(6 pts) 15. Consider the reaction:

\[ 3 \text{NaBH}_4 + 4 \text{BF}_3 \rightarrow 2 \text{B}_2\text{H}_6 + 3 \text{NaBF}_4 \]

Suppose that 12 moles of NaBH\(_4\) and 20 moles of BF\(_3\) are combined and allowed to react. Which choice indicates the expected contents of the reaction vessel after the reaction has gone to completion?

(A) 3 mol NaBH\(_4\), 0 mol BF\(_3\), 12 mol B\(_2\)H\(_6\), 18 mol NaBF\(_4\)
(B) 0 mol NaBH\(_4\), 4 mol BF\(_3\), 8 mol B\(_2\)H\(_6\), 12 mol NaBF\(_4\)
(C) 0 mol NaBH\(_4\), 0 mol BF\(_3\), 10 mol B\(_2\)H\(_6\), 15 mol NaBF\(_4\)
(D) 0 mol NaBH\(_4\), 0 mol BF\(_3\), 18 mol B\(_2\)H\(_6\), 27 mol NaBF\(_4\)
(E) 3 mol NaBH\(_4\), 3 mol BF\(_3\), 12 mol B\(_2\)H\(_6\), 18 mol NaBF\(_4\)

(6 pts) 16. KF and MgF\(_2\) are both soluble ionic compounds. Suppose that we mix 200.0 mL of 1.50 M KF and 100.0 mL of 0.500 M MgF\(_2\). What would the concentration of fluoride ions be in the resulting solution. (Assume a final volume of 300.0 mL.)

Find total moles of F\(^{-}\).

\[
(0.200 \text{ L} \times 1.500 \text{ M}) + 2(0.100 \text{ L} \times 0.500 \text{ M}) = 0.400 \text{ mol F}^{-}
\]

Volume is 0.300 L, so

\[
\frac{0.400 \text{ mol F}^{-}}{0.300 \text{ L}} = 1.33 \text{ M}
\]
(6 pts) **17.** In an acid–base titration, 24.10 mL of KOH solution was required to react completely with 25.00 mL of 0.400 M phosphoric acid \( \text{H}_3\text{PO}_4 \), producing water and \( \text{K}_3\text{PO}_4 \) as products. What was the concentration of the KOH solution used?

(A) 0.415 M  
(B) 1.24 M  
(C) 0.138 M  
(D) 0.843 M  
(E) 0.713 M

\[
\text{H}_3\text{PO}_4 + 3 \text{KOH} \rightarrow 3 \text{H}_2\text{O} + \text{K}_3\text{PO}_4
\]

\[
0.025 \text{ L} \times 0.400 \text{ M} = 0.01 \text{ mol} \text{H}_3\text{PO}_4
\]

\[
0.01 \text{ mol} \text{H}_3\text{PO}_4 \times \frac{3 \text{ mol} \text{KOH}}{1 \text{ mol} \text{H}_3\text{PO}_4} = 0.03 \text{ mol} \text{KOH}
\]

\[
\frac{0.03 \text{ mol} \text{KOH}}{0.02410 \text{ L}} = 1.24 \text{ M}
\]

(8 pts) **18.** Home carbon monoxide (CO) detectors sound an alarm if the measured level of CO reaches 100 parts per million, which corresponds to 0.40 µg of CO per cubic centimeter of air \( \text{i.e.}, \) 0.40 µg/cm³. How many CO molecules would need to be present in a room with dimensions of 15 ft \( \times \) 12 ft \( \times \) 8 ft in order to reach that level?

\[
15 \text{ ft} \times 12 \text{ ft} \times 8 \text{ ft} = 1440 \text{ ft}^3
\]

\[
1440 \text{ ft}^3 \times \left(\frac{0.3048 \text{ m}}{1 \text{ ft}}\right)^3 = 40.78 \text{ m}^3 \times \frac{10^6 \text{ cm}^3}{1 \text{ m}^3} = 4.08 \times 10^7 \text{ cm}^3
\]

\[
4.08 \times 10^7 \text{ cm}^3 \times \frac{0.40 \text{ µg}}{1 \text{ cm}^3} \times \frac{10^{-6} \text{ g}}{1 \text{ µg}} = 16.3 \text{ g CO}
\]

\[
16.3 \text{ g CO} \times \frac{1 \text{ mol CO}}{28.01 \text{ g CO}} \times \frac{6.022 \times 10^{23} \text{ molecules}}{1 \text{ mol CO}} = 3.51 \times 10^{23} \text{ molecules}
\]
19. Antimony sulfide (Sb₂S₃) reacts with iron (Fe) according to the following equation.

\[ \text{Sb}_2\text{S}_3 + 3 \text{Fe} \rightarrow 2 \text{Sb} + 3 \text{FeS} \]

A reaction mixture consisting of 49.5 g of Sb₂S₃ and 19.77 g Fe is prepared and allowed to react, and 24.71 g of Sb are produced. What was the percentage yield for this reaction? (Antimony is in Group 15 in the periodic table, and iron is in Group 8.)

**Start by finding limiting reactant and then the theoretical yield. Use that together with given actual yield to get percentage.**

Convert the given reactant amounts to moles:

\[
\begin{align*}
49.5 \text{ g Sb}_2\text{S}_3 & \times \frac{1 \text{ mol Sb}_2\text{S}_3}{339.70 \text{ g Sb}_2\text{S}_3} = 0.1457 \text{ mol Sb}_2\text{S}_3 \\
19.77 \text{ g Fe} & \times \frac{1 \text{ mol Fe}}{55.85 \text{ g Fe}} = 0.3540 \text{ mol Fe}
\end{align*}
\]

So the Fe is the limiting reactant.

\[
\begin{align*}
0.3540 \text{ mol Fe} & \times \frac{2 \text{ mol Sb}}{3 \text{ mol Fe}} \times \frac{121.76 \text{ g Sb}}{1 \text{ mol Sb}} = 28.73 \text{ g Sb} \\
\frac{24.71 \text{ g Sb}}{28.73 \text{ g Sb}} & \times 100\% = 86.0\% \text{ yield}
\end{align*}
\]

If you chose the Sb₂S₃ as the LR, you would get 35.48 g for theoretical yield and then 69.64%.
Both KCl and NaCl are soluble ionic compounds and fully dissociate in aqueous solution. A 6.972-g mixture of KCl and NaCl is dissolved in water, then a solution of AgNO₃ is added so that all of the chlorine present is converted to solid AgCl. The AgCl product is dried and found to have a mass of 15.620 g. What mass of KCl was present in the original mixture?

Molar masses involved along the way:

KCl = 74.55 g/mol 
NaCl = 58.44 g/mol 
AgCl = 143.32 g/mol

I am guessing most who get this will do the $x$ & $1-x$ thing, so I will do it that way. Find mass of AgCl expected if initial 6.972 g is all KCl or all NaCl:

$$6.972 \, \text{g KCl} \times \frac{1 \, \text{mol KCl}}{74.55 \, \text{g}} \times \frac{1 \, \text{mol AgCl}}{1 \, \text{mol KCl}} \times \frac{143.32 \, \text{g}}{1 \, \text{mol AgCl}} = 13.403 \, \text{g AgCl}$$

$$6.972 \, \text{g NaCl} \times \frac{1 \, \text{mol NaCl}}{58.44 \, \text{g}} \times \frac{1 \, \text{mol AgCl}}{1 \, \text{mol NaCl}} \times \frac{143.32 \, \text{g}}{1 \, \text{mol AgCl}} = 17.098 \, \text{g AgCl}$$

Let $x =$ fraction of KCl. Then $1-x =$ fraction of NaCl, and:

$$15.620 = 13.403x + 17.098(1-x)$$

$$-1.478 = -3.695x$$

And $x = 0.40$. Multiply that by the original 6.972 g to get 2.79 g KCl.
An alternate solution:
Start by finding how much Cl is in the AgCl.

\[
\frac{15.620 \text{ g AgCl}}{143.32 \text{ g/mol}} = 0.10899 \text{ mol AgCl} \rightarrow 0.010899 \text{ mol Cl}
\]

Because NaCl and KCl each contain 1 Cl, this is also the total moles of KCl & NaCl.

\[n_{\text{Cl}} = 0.10899 = n_{\text{NaCl}} + n_{\text{KCl}}\]

We will need a second equation for those 2 n's. Get it from the original mass by writing mass of each compound in terms of the number of moles and the molar mass:

\[m_{\text{NaCl}} + m_{\text{KCl}} = 6.972 = 58.44 \cdot n_{\text{NaCl}} + 74.55 \cdot n_{\text{KCl}}\]

Now solve that pair of equations for the \(n_{\text{KCl}}\):

\[n_{\text{NaCl}} = 0.10899 - n_{\text{KCl}}\]
\[6.972 = 58.44 \cdot (0.10899 - n_{\text{KCl}}) + 74.55 \cdot n_{\text{KCl}}\]
\[6.972 = 6.3692 + 16.11 \cdot n_{\text{KCl}}\]
\[16.11 \cdot n_{\text{KCl}} = 0.60281\]
\[n_{\text{KCl}} = 0.03742\]

Finally convert to mass and get 2.79 g KCl.