Section I: Multiple Choice. You may choose **only 1 answer** to the following questions. All responses must be filled in on the scantron sheet. The point value of each question is written next to the question.

1. (3 pts) What is the charge of a fluoride ion?
   
   (A) –2  (B) –1  (C) +1  (D) +2

Consider the following equation for the **next two questions**:

NaN₃ (s) → Na (s) + N₂ (g)

2. (3 pts) When the equation is balanced, the coefficients are __________.

   (A) 1, 1, 1  (B) 2, 2, 6  (C) 3, 3, 1  (D) 2, 2, 3

3. (3 pts) What kind of reaction is demonstrated by the equation shown above?

   A) Disproportionation
   B) Combination
   C) Decomposition
   D) Combustion

4. (3 pts) In the following list, only ________ is **not** an example of a chemical reaction.

   A) increased acidity of water (H₂O) after addition of solid carbon dioxide (CO₂)
   B) **sublimation of carbon dioxide** (CO₂)
   C) explosion of a hydrogen (H₂) and oxygen (O₂) balloon
   D) transfer of an electron from sodium (Na) to water (H₂O)

5. (3 pts) The atomic weight of thallium is 204.3833 amu. The masses for the two stable isotopes are 202.9723 amu for thallium-203 and 204.9744 amu for thallium-205. What is the percent abundance of thallium-203?

   (A) **29.523%**  (B) 70.476%
   
   (C) 99.310%  (D) 0.0069037%
6. (3 pts) Assuming atmospheric pressure, which one of the following is a temperature at which nitrogen, N₂, would not exist as a gas?

(A) 10 °C    (B) 10 °F    (C) 10 K   (D) 100 °C

7. (3 pts) The law of the conservation of mass _______.

A) confirmed the plum-pudding model of the atom  
B) led to the discovery of the atomic nucleus  
C) determined the magnitude of the elementary charge  
D) supports Dalton’s atomic theory of matter

8. (3 pts) The molecular formula of caffeine is C₈H₁₀N₄O₂. The molar mass of caffeine, rounded to the nearest integer, is _______ g.

(A) 194    (B) 97
(C) 52     (D) 102

9. (3 pts) 10.0 g of Al₂(SO₄)₃ contains ________ Al³⁺ ions?

(A) 8.03 x 10²²    (B) 5.28 x 10²²
(C) 1.76 x 10²²    (D) 3.52 x 10²²

10. (3 pts) A nitrogen oxide is 30.43% by mass nitrogen. The molecular formula could be ________.

(A) NO    (B) NO₂
(C) N₂O    (D) N₂O₅

11. (3 pts) Which of the following ions result when ammonium phosphate (NH₄)₃PO₄ is dissolved in water?

(A) N³⁻, H⁺, P⁵⁺, O²⁻    (B) NH₄⁺, P⁵⁺, O²⁻
(C) N³⁻, H⁺, PO₄³⁻    (D) NH₄⁺, PO₄³⁻

12. (3 pts) An atom of ruthenium,¹⁰¹Ru, has ________ protons, ________ neutrons, and ________ electrons.

(A) 101, 44, 101    (B) 44, 57, 57
(C) 44, 101, 44    (D) 44, 57, 44
Section II: Calculation and long answer. Complete the following questions by showing your work and providing the answer in the box or line provided. **Failure to show your work will result in no partial credit!**

13. (4 pts) The recommended adult dose of Elixophyllin®, a drug used to treat asthma, is 6.00 mg/kg of body mass.

Calculate the dose in milligrams for a 185-lb person. (1 lb = 453.59 g) Show your work for full credit.

\[
185 \text{ lb} \times (453.59 \text{ g/lb}) \times (1 \text{ kg/g}) = 83.914 \text{ kg}
\]
\[
83.914 \text{ kg} \times 6.00 \text{ mg/kg} = 503 \text{ mg}
\]

(3 sig figs)

Answer: ___________________________
Elemental analysis of an unknown material yielded the following percent compositions:

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<th>molar mass</th>
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Determine the empirical formula for this material. Show all your work for full credit.

**CoN₄H₁₂Cl₃**

Answer: ___________________________
15. When ethane (C\(_2\)H\(_6\), MW = 30.1 g/mol) reacts with chlorine (Cl\(_2\), MW = 70.9 g/mol), the main product is C\(_2\)H\(_5\)Cl (MW = 64.5 g/mol), but other products containing Cl, such as C\(_2\)H\(_4\)Cl\(_2\), are also obtained. The formation of these other products reduces the yield of C\(_2\)H\(_5\)Cl.

a. (4 pts) Calculate the theoretical yield (in grams) of C\(_2\)H\(_5\)Cl when 125 g of C\(_2\)H\(_6\) reacts with 255 g of Cl\(_2\), assuming that C\(_2\)H\(_6\) and Cl\(_2\) react only to form C\(_2\)H\(_5\)Cl and HCl.

*Balance, find limiting reagent, find yield*

\[
\text{C}_2\text{H}_6 + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{HCl} \quad \text{(Balanced!)}
\]

\[
125 \text{ g C}_2\text{H}_6 / 30.1 \text{ g/mol} = 4.15 \text{ mol C}_2\text{H}_6
\]

\[
255 \text{ g Cl}_2 / 70.9 \text{ g/mol} = 3.60 \text{ mol Cl}_2 \quad \text{Limting reactant! The ratio should be 1:1 (from balanced equation) but there is clearly fewer moles of Cl}_2 \text{ than C}_2\text{H}_6.
\]

\[
3.60 \text{ mol Cl}_2 \times (1 \text{ mol C}_2\text{H}_5\text{Cl} / 1 \text{ mol Cl}_2) \times (64.5 \text{ g/mol C}_2\text{H}_5\text{Cl}) = 232 \text{ g C}_2\text{H}_5\text{Cl}
\]

*Alternatively, you can determine the theoretical yield based on each reactant: the one giving the least grams of product is the limiting reagent AND you already have the yield!*

**Based on C\(_2\)H\(_6\):**

\[
(125 \text{ g C}_2\text{H}_6 / 30.1 \text{ g/mol}) \times (1 \text{ mol C}_2\text{H}_5\text{Cl} / 1 \text{ mol C}_2\text{H}_6) \times (64.5 \text{ g/mol C}_2\text{H}_5\text{Cl}) = 268 \text{ g C}_2\text{H}_5\text{Cl}
\]

**Based on Cl\(_2\):**

\[
(255 \text{ g Cl}_2 / 70.9 \text{ g/mol}) \times (1 \text{ mol C}_2\text{H}_5\text{Cl} / 1 \text{ mol Cl}_2) \times (64.5 \text{ g/mol C}_2\text{H}_5\text{Cl}) = 232 \text{ g C}_2\text{H}_5\text{Cl}
\]

*Answer: __________232 g of C\(_2\)H\(_5\)Cl ________________*

b. (4 pts) Calculate the percent yield if the reaction produces 206 g of C\(_2\)H\(_5\)Cl. (If you do not have an answer for part (a), use 250 g as the theoretical yield.)

\[
206 \text{ g} / 232 \text{ g} \times 100\% = 88.8\%
\]
Answer: ___________________________

**Formulas and Equations**

°F = $\frac{9}{5}(°C) + 32$  
°C = $\frac{5}{9}(°F - 32)$  
Kelvin = $0°C + 273.15$

Avogadro’s Number, $N_A = 6.022 \times 10^{23}$  
Density of water = 1.000 g/ml at 25 °C

1 in = 2.54 cm  
100 cm = 1 m  
1,000 mm = 1 m  
1 pm = $10^{-12}$ m

1 nm = $10^{-9}$ m  
1 cm³ = 1 mL  
1,000 mg = 1 g  
1 kg = 2.20 lb

Periodic Table of the Elements

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