PART I: MULTIPLE CHOICE (Each multiple choice question has a 2-point value!!)

1. Water is an unusual substance in that the density of the solid state (ice) is normally lower than the density of the liquid state. Suppose a friend brings you a glass of ice water. If you leave the glass untouched, what will happen over time?
   a. The ice will melt and the resulting water level will be lower than before.
   b. The ice will melt and the resulting water level will be unchanged.
   c. The ice will melt and the resulting water level will be higher than before.
   d. The ice will only melt if the mixture is stirred.
   e. None of the above.

2. Three length scales ordered from smallest to largest are:
   a. microscale, nanoscale, macroscale.
   b. microscale, macroscale, nanoscale.
   c. macroscale, nanoscale, microscale.
   d. nanoscale, microscale, macroscale.
   e. none of the above.

3. Which characteristic below best fits the description of a liquid?
   a. rapid molecular motion
   b. highly disordered molecules
   c. large distances between the molecules
   d. molecules that are close together but are moving past one another
   e. highly ordered molecules

4. Carbon dioxide is always composed of three parts by weight of carbon and eight parts by weight of oxygen. This is an example of:
   a. Dalton’s Atomic Theory.
   b. The Law of Constant Composition.
   e. The Law of Multiple Proportion.

5. Which of the following represents a pair of allotropes?
   a. oxygen and ozone
   b. hydrogen and water
   c. methane and ethane
   d. diamond and glass
   e. carbon and carbon dioxide

6. Which of the following is not a metal?
   a. nickel (Ni, atomic number 28)
   b. sulfur (S, atomic number 16)
   c. lithium (Li, atomic number 3)
   d. uranium (U, atomic number 92)
   e. calcium (Ca, atomic number 20)

7. Which of the following is a metalloid?
   a. silicon (Si, atomic number 14)
   b. hydrogen (H, atomic number 1)
   c. tungsten (W, atomic number 74)
   d. chlorine (Cl, atomic number 17)
   e. uranium (U, atomic number 92)

8. In Rutherford’s gold foil experiment:
   a. the alpha particles used were attracted to the positive particles in the gold foil.
   b. neutrons were discovered.
   c. the alpha particles mostly bounced off the foil, with most particles undergoing sharp deflections.
   d. Rutherford concluded that there must be a compact, massive, positively charged particle inside the gold atoms.

9. An element containing 26 protons, 26 electrons and 30 neutrons will have the symbol:
   a. $^{52}_{26}$Te
   b. $^{52}_{26}$Te
   c. $^{56}_{26}$Fe
   d. $^{52}_{26}$Zn
   e. $^{52}_{26}$Te
10. Which of the following statements is not true?
   a. $^{95}_{42}$Mo contains 53 neutrons.
   b. $^{51}_{23}$V has an atomic number of 23.
   c. $^{12}_{6}$C has the same number of protons, neutrons and electrons.
   d. $^{66}_{30}$Zn has the same number of electrons and protons.
   e. $^{56}_{26}$Fe has the same number of neutrons and protons.

11. Assume that only two isotopes of argon $^{38}_{18}$Ar and $^{40}_{18}$Ar exist in nature. If this were true, the atomic weight of argon would fall most closely within which range?
   a. 38-40 amu  
   b. 56-58 amu  
   c. 18-38.5 amu
   d. 18-40 amu  
   e. 18-58 amu

12. An element that has 36 protons and 48 neutrons has an approximate atomic weight of:
   a. 60 amu.
   b. 84 amu.
   c. 12 amu.
   d. 36 amu.
   e. 48 amu.

13. Which element can be classified as a lanthanide?
   a. Th  
   b. Ti  
   c. Tl
   d. Tc  
   e. Tb

14. Which formula – name combination is incorrect?
   a. SeCl$_4$ and selenium tetrachloride
   b. N$_2$O$_3$ and nitrogen trioxide
   c. P$_2$O$_{10}$ and tetraphosphorus decaoxide
   d. AsF$_5$ and arsenic pentafluoride
   e. SF$_6$ and sulfur hexafluoride

15. Which combination below corresponds to a cation with a +1 charge?
   a. 7 protons and 8 electrons  
   b. 11 protons and 10 electrons  
   c. 18 protons and 18 electrons  
   d. 17 protons and 18 electrons  
   e. 20 protons and 18 electrons

16. Which of the following is not an ionic compound?
   a. TeBr$_4$  
   b. CaCl$_2$  
   c. NiCl$_2$  
   d. CuO  
   e. NaBr

17. Give the formula for the ionic compound that forms between sodium and oxygen.
   a. NaO  
   b. Na$_2$O  
   c. NaO$_2$
   d. Na$_2$O$_3$

18. Which compound is incorrectly named?
   a. Cr(NO$_3$)$_3$ chromium nitrate
   b. CaHPO$_4$ calcium hydrogen phosphate
   c. CuOH copper(I) hydroxide
   d. MgCO$_3$ magnesia carbonate
   e. NaH sodium hydride

19. A carbon compound has an empirical formula of CH$_2$O and had an approximate molecular weight of 119. What is its molecular formula?
   a. C$_3$H$_7$O$_3.9$  
   b. C$_3$H$_9$O$_3.9$  
   c. C$_6$H$_4$O$_4$  
   d. C$_6$H$_2$O$_8$  
   e. C$_6$H$_6$O$_4$
20. In the reaction given below, if 12 moles of aluminum oxide are consumed, how many moles of oxygen gas are produced?

\[ 2 \text{Al}_2\text{O}_3 \rightarrow 4 \text{Al} + 3 \text{O}_2 \]

a. 3  

b. 4  

c. 6  

d. 12  

e. 18

21. For the reaction given below, how many moles of aluminum will react if 24 moles of Br\(_2\) react and 16 moles of AlBr\(_3\) are produced?

\[ 2 \text{Al} + 3 \text{Br}_2 \rightarrow 2 \text{AlBr}_3 \]

a. 4  

b. 8  

c. 12  

d. 16  

e. 40

22. Classify the following reaction.

\[ \text{Pt(s)} + 2 \text{F}_2(g) \rightarrow \text{PtF}_4(l) \]

a. exchange  

b. combination  

c. decomposition  

d. displacement

23. Classify the following reaction.

\[ \text{MgSO}_3(s) \rightarrow \text{MgO(s)} + \text{SO}_2(g) \]

a. exchange  

b. combination  

c. decomposition  

d. displacement

24. Classify the following reaction.

\[ 2 \text{Al(s)} + 3 \text{Cl}_2(g) \rightarrow 2 \text{AlCl}_3(s) \]

a. exchange  

b. combination  

c. decomposition  

d. displacement

25. Classify the following reaction.

\[ \text{CuSO}_4(aq) + \text{Fe(s)} \rightarrow \text{FeSO}_4(aq) + \text{Cu(s)} \]

a. exchange  

b. combination  

c. decomposition  

d. displacement

26. Classify the following reaction.

\[ 3 \text{Fe(s)} + 4 \text{H}_2\text{O}(g) \rightarrow \text{Fe}_3\text{O}_4(s) + 4 \text{H}_2(g) \]

a. exchange  

b. combination  

c. decomposition  

d. displacement

27. Classify the following reaction.

\[ 2 \text{AgNO}_3(aq) + \text{BaCl}_2(aq) \rightarrow \text{Ba(NO}_3)_2(aq) + 2 \text{AgCl(s)} \]

a. exchange  

b. combination  

c. decomposition  

d. displacement
28. The Roman numerals in the reaction given represent the coefficients in the balanced chemical equation. What are the values of the coefficients?

\[ \text{I NH}_3 + \text{II O}_2 \rightarrow \text{III NO} + \text{IV H}_2\text{O} \]

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29. What is the maximum possible quantity of product obtained from a chemical reaction called?
   a. percent yield
   b. molecular weight of the product
   c. stoichiometric coefficients
   d. limiting reactant
   e. theoretical yield

30. The efficiency of a particular synthesis method is evaluated by determining the:
   a. molecular weight of the product.
   b. stoichiometric coefficients.
   c. limiting reactant.
   d. theoretical yield.
   e. percent yield.

PART II: SHORT ANSWER (Each short answer question has a 1-point value!!)

31. Oxygen (O\(_2\)) and ozone (O\(_3\)) are _________ of the same element.

32. Ions that contain atoms of more than two elements are called _________ ions.

33. _________ containing compounds are known as organic compounds.

34. A compound that forms between a non-metal and a non-metal is a _________.

35. Stoichiometric coefficients found in a balanced equation can be used to derive _________ ratios.

PART III: NOMENCLATURE

36. (8 pts) Name the following compounds:
   A. CuI
   B. TeBr\(_2\)
   C. SiF\(_4\)
   D. Mg\(_3\)N\(_2\)

37. (8 pts) Name the following compounds:
   A. (NH\(_4\))\(_2\)HPO\(_4\)
   B. Ba(MnO\(_4\))\(_2\)
   C. K\(_2\)CO\(_3\)
   D. LiCN

38. (8 pts) Provide formulas matching the following names:
   A. Silver(I) Perchlorate
   B. Iron(III) Sulfite
   C. Iodine Pentafluoride
   D. Dichlorine Heptaoxide
PART IV: CONCEPTS

39. (1 pts) A reaction occurs according to the equation:

\[ 2 \text{A} + \text{B} \rightarrow \text{C} \]

Given the diagram below, decide whether A or B is the limiting reactant.

![Diagram of reactants A and B]

PART V: CALCULATION PROBLEMS (Show your work in its entirety. Do not provide a single number! Pay attention to significant figures!).

40. (5 pts) The depletion of ozone in the stratosphere is a matter of great concern among scientists. It is believed that the cause for it is the reaction of ozone with nitrogen oxide, which is discharged by high-altitude jets. The process is described by the equation:

\[ \text{O}_3 (g) + \text{NO} (g) \rightarrow \text{O}_2 (g) + \text{NO}_2 (g) \]

A. If 0.740 g of ozone react with 0.670 g of nitrogen oxide, how many grams of nitrogen dioxide will be produced (Hint: Determine limiting reactant first!).

B. Calculate the amount of reactant in excess at the end of the reaction.

41. A compound \( \text{X} \) contains 63.3% manganese (Mn) and 36.7% oxygen (O) by mass. When \( \text{X} \) is heated, oxygen gas (\( \text{O}_2 \)) is evolved and a new compound \( \text{Y} \) is formed, which contains 72.0% Mn and 28.0% O.

A. (3 pts) Determine the empirical formulas of \( \text{X} \) and \( \text{Y} \).

B. (2 pts) Write a balanced equation for the conversion of \( \text{X} \) to \( \text{Y} \).