Instructions:

1. Each student is responsible for following instructions. Read this page carefully.

2. PRINT your name on this page and on your two computer answer sheets.

3. CODE your name (LAST NAME FIRST) on both computer answer sheets using an ordinary (No. 2) pencil. It is very important to code the information correctly!!

4. Put all calculations on the examination pages. Do not make any extra marks on the computer answer sheet!!

5. This exam consists of 47 multiple-choice questions worth 5 points each. For each question, choose the ONE best or correct answer and write it both on your exam paper and on the computer answer sheet. The computer answer sheet is the only one that will be graded!

6. This exam booklet consists of 11 pages (including this one), a Periodic Table and Formula/Data Sheet, and 2 sheets of blank paper. Please check to be sure that you have them all!

KEEP YOUR EXAM BOOKLET AND ANSWER SHEET COVERED TO PROTECT THE INTEGRITY OF YOUR WORK!
1. Which is the correct formula for ammonium phosphate?
   (a) AmP
   (b) AmPO_4
   (c) NH_4P
   (d) NH_4PO_4
   (e) (NH_4)_3PO_4

2. Which is the correct formula for potassium dichromate?
   (a) PoCr_2
   (b) KCr_2
   (c) KCrO_4
   (d) K_2CrO_4
   (e) K_2Cr_2O_7

3. What is the name of the compound with the following formula: N_2O_3?
   (a) nitrogen oxide
   (b) nitrogen trioxide
   (c) nitrogen (III) oxide
   (d) dinitrogen oxide
   (e) dinitrogen trioxide

4. What is the name of the compound with the following formula: Co_2O_3?
   (a) cobalt oxide
   (b) dicobalt trioxide
   (c) cobalt (III) oxide
   (d) cobalt trioxide
   (e) cobalt (II) trioxide

5. What is the molar mass of the ionic compound tin (II) sulfide?
   (a) 150.78 g/mol
   (b) 182.85 g/mol
   (c) 214.78 g/mol
   (d) 269.49 g/mol
   (e) 301.56 g/mol

6. For the following reaction, what is the stoichiometric coefficient for HF that balances the equation?
   \[ \text{UO}_2 \ (s) + \_ \text{HF} \ (g) \rightarrow \_ \text{UF}_4 \ (s) + \_ \text{H}_2\text{O} \ (l) \]
   (a) 1
   (b) 2
   (c) 4
   (d) 6
   (e) 8

7. In the reaction in the previous question, what substance is the reducing agent?
   (You can get this question right even if the equation isn’t balanced correctly. Note: There are no peroxides in the reaction.)
   (a) UO_2
   (b) HF
   (c) UF_4
   (d) H_2O
   (e) none; it’s not a redox reaction
8. How many neutrons are in a neutral atom of plutonium-243?
   (a) 78
   (b) 94
   (c) 149
   (d) 165
   (e) 243

9. Which of the following represents the LARGEST mass?
   (a) 1 kg
   (b) 1 Mg
   (c) 1 mg
   (d) 1 μg
   (e) 1 cg

10. Choose the correct conversion factor(s) to convert from m/s² to km/h².
   (a) \((10^3 \text{ m/1 km}) \times (3600 \text{ s/h}^2)\)
   (b) \((1 \text{ km/10}^3 \text{ m}) \times (3600 \text{ s/h}^2)\)
   (c) \((10^3 \text{ m/1 km}) \times (3600 \text{ s/h})^2\)
   (d) \((1 \text{ km/10}^3 \text{ m}) \times (3600 \text{ s/h})^2\)

11. 1.50 liters of a solution contain 147 g of perchloric acid. What is the molarity of the solution?
   (a) 0.976 M
   (b) 1.46 M
   (c) 1.86 M
   (d) 2.69 M
   (e) 2.80 M

12. If 5.00 mol of Al is mixed with 2.00 mol of Fe₂O₃, what is the theoretical yield of Fe?
    \[ 2 \text{ Al (s)} + \text{ Fe}_2\text{O}_3 (s) \rightarrow \text{ Al}_2\text{O}_3 (s) + 2 \text{ Fe (s)} \]
   (a) 140 g
   (b) 167 g
   (c) 223 g
   (d) 279 g
   (e) 475 g

13. When a solution of nickel (II) nitrate is added to a solution of sodium carbonate, a precipitate is formed. What are the spectator ions in this reaction?
   (a) sodium ion and carbonate ion
   (b) sodium ion and nitrate ion
   (c) sodium ion and nickel (II) ion
   (d) nitrate ion and carbonate ion
   (e) nickel (II) ion and nitrate ion
14. What is the oxidation number of nitrogen in the following, respectively: \( \text{NH}_3, \text{N}_2\text{O}_3, \text{NO}_3^- \)
   (a) +3, +3, −5
   (b) −3, +3, +5
   (c) +3, −3, −5
   (d) −3, +3, +6
   (e) −3, −3, +6

15. What volume of 2.00 \( \text{M} \text{MgSO}_4 \) solution would need to be diluted with water to make 375 mL of a 0.240 \( \text{M} \text{MgSO}_4 \) solution?
   (a) 0.090 mL
   (b) 45 mL
   (c) 90 mL
   (d) 780 mL
   (e) none of these.

16. How many significant zeros are there in 0.05080?
   (a) 0
   (b) 1
   (c) 2
   (d) 3
   (e) 4

17. Which statement includes only exact numbers?
   (a) The speed of light in a vacuum is a physical constant; to six significant figures, it is \( 2.997923 \times 10^8 \) m/s.
   (b) The density of mercury at 25°C is 13.53 g/mL.
   (c) There are 3600 s in 1 h.

18. Identify the mass law(s) demonstrated by the experimental results:
   A student heats 1.27 g of copper and 3.50 g of iodine to produce 3.81 g of a white compound, and 0.96 g of iodine remains.
   (a) Law of Definite Composition
   (b) Law of Conservation of Mass
   (c) Law of Multiple Proportions
   (d) all of the above
   (e) (a) and (b) only

19. Atoms of different elements have different chemical properties because atoms of different elements have different numbers of:
   (a) protons.
   (b) electrons.
   (c) neutrons.
   (d) alpha particles.
   (e) quarks.
20. Calculate the percent by mass of oxygen in the mineral vanadinite, which has the formula Pb₅(VO₄)₃Cl.
(a) 2.50%
(b) 10.79%
(c) 13.56%
(d) 57.14%
(e) 73.15%

21. Two objects have the same density, but one has more mass than (is heavier than) the other. Which object has the smaller volume?
(a) the heavier object.
(b) the lighter object.
(c) both objects have the same volume.
(d) it is impossible to tell without additional information.

22. Which of the following adjectives describes a physical property of a substance?
(a) toxic
(b) flammable
(c) colorless
(d) corrosive
(e) reactive

23. Consider the following postulates of Dalton’s 1808 atomic theory:
I. Elements are composed of microscopic, indivisible atoms that can not be created or destroyed.
II. Atoms of an element are identical in mass and other properties.
III. A compound is formed when atoms of different elements combine in a specific ratio.
IV. Atoms of an element can not be converted into atoms of other elements.
Which of these postulates have not required modification since 1808?
(a) IV only.
(b) III only.
(c) II and III only.
(d) I, II, and III only.
(e) None of these.

24. Consider the diagram below. Which of the following is symbolized by the diagram?

(a) ^{81}_{39}Y
(b) ^{50}_{39}Y^{2-}
(c) ^{98}_{39}Y
(d) ^{89}_{39}Y^{2-}
(e) ^{89}_{36}Kr
25. Naturally occurring boron consists of only two stable isotopes, boron-10 and boron-11. The abundance of boron-11 is closest to: (Hint: consult periodic table)

(a) 5%
(b) 20%
(c) 50%
(d) 80%
(e) 95%

26. Which of the following quantities contains the SMALLEST number of cobalt atoms?

(a) 59.24 g Co (s)
(b) 1.687 mol CoCl₃ (s)
(c) 1.555 mol Co (s)
(d) 0.628 mol Co₂O₃ (s)
(e) 7.256 \times 10^{23} \text{ Co atoms}

27. What is the concentration of a sulfuric acid solution if 5.78 g of solid sodium carbonate were required to completely react with 35.26 mL of the acid solution? The reaction produces carbon dioxide gas, water, and sodium sulfate. (More challenging question!)

(a) 0.773 M
(b) 0.976 M
(c) 1.55 M
(d) 1.95 M
(e) 13.09 M

28. What is the limiting reactant when 10.0 g of solid iodine reacts with 10.0 g of chlorine gas?

I₂ (s) + Cl₂ (g) \rightarrow 2 ICl (g)

(a) I₂
(b) Cl₂
(c) neither I₂ nor Cl₂
(d) both I₂ and Cl₂

29. Which would definitely lead to calculating a reaction percent yield that is greater than 100%?

(a) Splattering of the reactants as they are heated.
(b) Spilling some of the products on the benchtop before weighing.
(c) Weighing the product sample while wet.
(d) Random errors in the analytical balance.
(e) Exactly two of the above.

30. Which is the general formula of a compound of an alkali metal (M) and a chalcogen (X)?

(a) MX
(b) M₂X
(c) MX₂
(d) M₃X
(e) MX₃
31. In the process of balancing the equation
\[ \text{Al} + \text{Cl}_2 \rightarrow \text{AlCl}_3 \]
Student I writes: \( \text{Al} + \text{Cl}_2 \rightarrow \text{AlCl}_2 \)
Student II writes: \( \text{Al} + \text{Cl}_2 + \text{Cl} \rightarrow \text{AlCl}_3 \)
Student III writes: \( 2\text{Al} + 3\text{Cl}_2 \rightarrow 2\text{AlCl}_3 \)
Which student has written the correct balanced chemical equation for the reaction?
(a) Student I
(b) Student II
(c) Student III
(d) all three students
(e) Students II and III

32. Which of the following diagrams represents a microscopic view of a gaseous mixture of one element and one compound?

33. Which should NOT react in any way with a solution of silver nitrate?
(a) Ni (s)
(b) Pt (s)
(c) HI (aq)
(d) HNO₃ (aq)
(e) two of these

34. Which salt could be produced by the reaction of a strong acid with a weak base?
(a) RbCl
(b) NH₄F
(c) SrBr₂
(d) NH₄I
(e) NaCH₃COO
35. Given the following information about the yields of the following steps in a series of reactions, what is the percent yield for the overall reaction $2 \text{ A} + \text{ B} \rightarrow \text{ D}$?

- $\text{A} + \text{ B} \rightarrow \text{ C}$ yield = 80.0%
- $\text{C} + \text{ A} \rightarrow \text{ D}$ yield = 40.0%
- $2 \text{ A} + \text{ B} \rightarrow \text{ D}$ yield = ????

(a) 2.00%
(b) 32.0%
(c) 40.0%
(d) 80.0%
(e) 120.0%

36. How many grams of calcium chloride are needed to make 100.0 mL of a 1.5 $M$ solution?

(a) 7.55 g
(b) 11.1 g
(c) 11.3 g
(d) 16.6 g
(e) none of these

37. Speaking of a 1.5 $M$ solution of calcium chloride, which of the following is correct?

- concentration of "calcium chloride" units
- concentration of calcium ions
- concentration of chloride ions

(a) $1.5 \text{ M}$ $0.0 \text{ M}$ $0.0 \text{ M}$
(b) $1.5 \text{ M}$ $1.5 \text{ M}$ $1.5 \text{ M}$
(c) $0.0 \text{ M}$ $1.5 \text{ M}$ $1.5 \text{ M}$
(d) $0.0 \text{ M}$ $3.0 \text{ M}$ $1.5 \text{ M}$
(e) $0.0 \text{ M}$ $1.5 \text{ M}$ $3.0 \text{ M}$

38. Isopropyl alcohol has a density of 0.786 g/cm³. Calculate the mass of isopropyl alcohol in a 1.00-pint bottle.

(a) 19 g
(b) 24 g
(c) 186 g
(d) 237 g
(e) 250 g

39. A student prepares 100.0 mL of 0.100 $M$ KOH in a volumetric flask and spills 50 mL of the solution on the bench top. What is the concentration of the KOH solution that remains in the flask?

(a) 0.200 $M$
(b) 0.100 $M$
(c) 0.050 $M$
(d) none of these
(e) it is impossible to tell without additional info.

40. Which outcome of throwing four darts at a dartboard shows high precision but low accuracy?

(a)  
(b)  
(c)  
(d)  

41. Consider the following molecular-level “cartoons”. Note: Solvent water molecules are not shown.

These “cartoons” best represent (from left to right):

(a) a strong electrolyte, a weak electrolyte, and a nonelectrolyte, respectively.
(b) a strong electrolyte, a nonelectrolyte, and a weak electrolyte, respectively.
(c) a weak electrolyte, a strong electrolyte, and a nonelectrolyte, respectively.
(d) a weak electrolyte, a nonelectrolyte, and a strong electrolyte, respectively.
(e) a nonelectrolyte, a weak electrolyte, and a strong electrolyte, respectively.

42. A 1.587 g sample of a compound containing only sulfur and chlorine is analyzed and found to contain 0.754 g S. What is the empirical formula of the compound?

(a) SCl
(b) SCl_{1.10}
(c) S_2Cl_2
(d) S_2Cl
(e) SCl_2

43. A mixture of two liquids, hydrazine (N\textsubscript{2}H\textsubscript{4}) and dinitrogen tetroxide, can be used as a fuel in rockets. How many grams of nitrogen gas can be formed when 100.0 grams of hydrazine and 200.0 grams of dinitrogen tetroxide react?

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

(a) 662 g
(b) 331 g
(c) 183 g
(d) 131 g
(e) 31 g

44. In lecture, you observed a demonstration of an apparatus for qualitatively measuring electrical conductivity of solutions which used a light bulb. Which of the following, when used to complete the circuit, would give the brightest glow in the bulb?

Note: C\textsubscript{12}H\textsubscript{22}O\textsubscript{11} is table sugar. NH\textsubscript{3} is ammonia, a weak base.

(a) NH\textsubscript{3} (aq)
(b) C\textsubscript{12}H\textsubscript{22}O\textsubscript{11} (s)
(c) C\textsubscript{12}H\textsubscript{22}O\textsubscript{11} (aq)
(d) NaCl (s)
(e) none of these would make the bulb glow.
45. The circle on the left shows a magnified view of a very small portion of liquid water in a closed container. What would the magnified view show after the water evaporates?

Key
- Water
- Oxygen
- Hydrogen

Liquid Water

Evaporated Water

A B C D E

46. Which is FALSE about a chemical system at equilibrium?

(a) There is no change in the masses or concentrations of products or reactants.
(b) The reaction stops occurring in both the forward and reverse directions.
(c) The system must be closed if it contains gaseous products.
(d) The forward and reverse reactions proceed at the same rate.
(e) The ratio of products to reactants is constant.
47. Consider the thermal decomposition of calcium carbonate shown below.

This system can not reach equilibrium because:

(a) solids and gases can not establish an equilibrium.
(b) the carbon dioxide is allowed to escape the open container.
(c) the decomposition requires heat.
(d) the reaction vessel is not insulated.

END OF EXAM

Check to see that you have entered 47 answers on your scan sheet.
Proofread your work.
You may take this exam booklet with you but you must return your scan sheet before leaving the room!