Please answer all questions in the space provided. Circle the letter corresponding to your answer on the multiple-choice section. A periodic table is provided at the end of the exam. You have 50 minutes. Proper calculators are permitted.

Question I – Multiple Choice (20 marks)   Circle the letter corresponding to your answer.

1. Which number correctly shows the result of the *molecular mass calculation* for H_2SO_4?

    4 x 15.9994 + 32.066 + 2 x 1.0079

    a) 98.08   b) 98.079   c) 98.074   d) 98.838   e) 98.84

2. Which atom has the smallest number of neutrons?

    a) carbon-14   b) nitrogen-14   c) oxygen-16   d) fluorine-19   e) neon-20

3.   Which pair of elements would you expect to exhibit the greatest similarity in their physical and chemical properties?

    a) O, S   b) C, N   c) K, Ca   d) H, He   e) Si, P

4. Which pairs of compounds do not have the same empirical formula?

    a) C_2H_2, C_6H_6

    b) $C_2H_4O_2$, $C_6H_{12}O_6$

    c) CO, CO_2

    d) C_2H_4, C_3H_6

    e) $C_2H_5COOCH_3$, CH_3CHO

5. A 22.5 g sample of ammonium carbonate contains _____ mol of ammonium ions

   a) 3.47   b) 2.14   c) 0.234   d) 0.288   e) 0.468

6. The spectator ions in the reaction between aqueous perchloric acid and aqueous barium hydroxide are _____?

    a) OH^- and ClO_4^-

    b) H^+, OH^-, ClO_4^-, and Ba^{2+}

    c) H^+ and OH^-

    d) ClO_4^- and Ba^{2+}

    e) H^+ and Ba^{2+}

7. How many grams of NaOH are there in 500.0 mL of a 0.175 M NaOH solution?

    a) 2.19×10^{-3} b) 114   c) 14.0   d) 3.50   e) 3.50×10^3

8. The value of $\Delta H°$ for the reaction below is -482 kJ. Calculate the heat (kJ) released to the surroundings when 12.0 g of CO(g) reacts completely.

$$2CO(g) \quad + \quad O_2(g) \quad \rightarrow \quad 2CO_2(g)$$
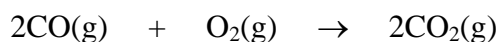
a) 2.89×10^3 b) 207   c) 103   d) 65.7   e) -482

9. Which of the following statements is true?

    a) Enthalpy is an intensive property.

    b) The enthalpy change for a reaction is independent of the state of the reactants and products.

    c) Enthalpy is a state function.

    d) H is the value of q measured under conditions of constant volume.

    e) The enthalpy change of a reaction is the reciprocal of the ΔH of the reverse reaction.

10. Which compound has the atom with the highest oxidation number?

    a) CaS   b) Na_3N c) $MgSO_3$ d) $Al(NO_2)_3$ e) NH_4Cl

Question II – (20 marks)

Balance the following equation in basic solution.

$$I_2\,(s) \quad + \quad ClO^-\,(aq) \quad \longrightarrow \quad IO_3^-\,(aq) \quad + \quad Cl^-\,(aq)$$
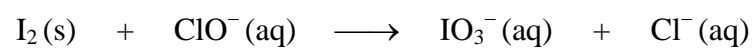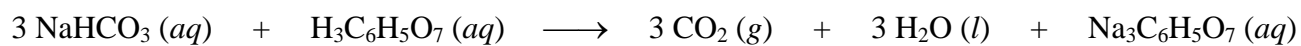
Question III – (20 marks)

Vanillin, the dominant flavoring in vanilla, is composed of C, H, and O. A 1.05 g sample of the compound is combusted, producing 2.43 g of CO_2 and 0.500 g of H_2O.

a) What is the empirical formula for vanillin? (18 marks)

b) If the compound has a molar mass of 152 g mol^{-1}, what is its molecular formula? (2 marks)

Question IV – (20 marks)

The fizz produced when an Alka-Seltzer® tablet is dissolved in water is due to the reaction between sodium bicarbonate ($NaHCO_3$) and citric acid ($H_3C_6H_5O_7$):

$$3\ NaHCO_3\ (aq)\quad +\quad H_3C_6H_5O_7\ (aq)\quad \longrightarrow \quad 3\ CO_2\ (g)\quad +\quad 3\ H_2O\ (l)\quad +\quad Na_3C_6H_5O_7\ (aq)$$

In a certain experiment 1.00 g of sodium bicarbonate and 1.00 g of citric acid are allowed to react.

a) Calculate which is the *limiting* reagent.

b) How many grams of carbon dioxide form?

c) How many grams of the excess reagent remain after the limiting reactant is completely consumed?

Question V – (11 marks)

a) Fully name the following (2 marks each): i) $Ti(ClO_3)_3$ ii) NaIO

b) Write the chemical formulas for the following (2 marks each):   i) ammonium hydroxide
                                                                     ii) mercury(I) iodide

c) Rank the following in order of increasing number of *atoms*: 0.50 mol H_2O, 23 g Na, 6.0 x 10^{23} N_2 molecules (3 marks).

Question VI – (9 marks)

An oxybromate compound, $KBrO_x$, where x is unknown, is analyzed and found to contain 52.92% Br. What is the value of x?