Chemistry Lab - Round 1
2014-2015

Name:_____ Score:_____/38

Instructions: This is the first round of Chemistry Lab testing for the 2014 - 2015 Science Olympiad season. You will have 30 minutes to complete this exam which covers topics in chemical reactions, stoichiometry, and chemical kinetics. In your responses, please use the appropriate amount of significant figures. Also, you may use the provided periodic table and a scientific calculator.

True or False

Please circle the correct answer.

1. True / False: The coefficients of a balanced chemical equation show the stoichiometric ratio of masses.
2. True / False: The mole is a fundamental SI unit.
3. True / False: The study of the tendency of a reaction to occur is known as "chemical kinetics."
4. True / False: Avogadro's constant has an order of magnitude (i.e. the power of 10) of 32.
5. True / False: The molar mass of a substance describes the number of grams in one mole of that substance.

Multiple Choice

Please write the letter of the best answer next to the problem number.

1. How many moles of compound are in 20.15 g of $CuSO_4 \cdot 5\,H_2O$?
   (a) 3.216×10^3 mol (b) 8.070×10^{-2} mol (c) 1.262×10^{-1} mol (d) 2.49×10^2 mol
2. When the chemical reaction for the combustion of propane is balanced with the smallest possible whole-number coefficients, what is the sum of its coefficients?
   (a) 12 (b) 13 (c) 14 (d) 25 (e) 26
3. A sample of an unknown substance containing carbon, hydrogen, and oxygen was analyzed and found to contain 40.00% carbon and 6.71% hydrogen. Determine the empirical formula of this compound.
   (a) CH_2O (b) $C_2H_3O_2$ (c) CHO (d) CH_2 (e) None of these
4. Collision theory states that which of the following *must* be true for a reaction to occur?

   I. Colliding particles must have sufficient kinetic energy.
   II. Colliding particles must hit each other from the correct direction and with the correct orientation.
   III. The total energy of the colliding particles must not exceed the activation energy.

   (a) I Only (b) II Only (c) I and II Only (d) I and III Only (e) I, II, and III

Free Response

Please show your work and box numerical answers.

Part I - Stoichiometry

1. The following reaction is used in commercial Breathalyzer^{TM}tests:
   $3\,C_2H_5OH + 2\,K_2Cr_2O_7 + 8\,H_2SO_4 \longrightarrow 2\,Cr_2(SO_4)_3 + 3\,CH_3COOH + 2\,K_2SO_4 + 11\,H_2O$
   What mass of ethanol is required to react completely with 6.35 g of potassium dichromate.

2. The following unbalanced reaction shows the thermal decomposition of sodium bicarbonate (baking soda): $NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2$

   (a) Write the balanced chemical equation.

   (b) When doing this decomposition in a lab, how can you tell when all the $NaHCO_3$ has decomposed? (Note: Both Na_2CO_3 and $NaHCO_3$ are white powders.)

   (c) Suppose you started with 25.000 g of $NaHCO_3$ and found that the mass of Na_2CO_3 produced through the reaction is 13.813 g, what was your percent yield?

   (d) If during the final massing of the product, some dirt fell on the balance, how would the resulting percent yield differ from the actual percent yield? Explain.

Part II - Chemical Kinetics

3. Consider the generic reaction $aA + bB \longrightarrow cC$ with an activation energy of 10.0 kJ/mol. The following experiment was done at 298K to determine the rate law. Different initial concentrations of reactants were used and the initial rate was recorded. All concentrations are measured in mol/L.

[A]	[B]	Initial rate (M/s)
2.0	3.0	13.5
4.0	3.0	27.0
4.0	6.0	108.0

   (a) Write the rate law for this reaction using k as the rate constant.

   (b) If [A] is doubled and [B] is tripled, how will the rate of reaction change?

   (c) Find k at 25° C (298K).

   (d) Find k at 64° C (Assume frequency factor is constant with temperature for (d) and (e)).

   (e) At what temperature does $k = 0.88$? (Note: units excluded for testing purposes)

4. Write the balanced chemical equations for the following processes. Include state symbols.

   (a) A strip of magnesium is burned.

   (b) Solutions of silver nitrate and sodium chloride are mixed.

   (c) Hydrogen chloride gas is bubbled through water.

   (d) Powdered sodium bicarbonate is added to aqueous acetic acid.

   (e) Butane is burned in air.