14. In another experiment, a small piece of Mg(*s*) is weighed, then placed in a flask containing excess 1 *M* HCl(*aq*). The student wants to determine number of moles of gas produced. Which of the following is the best way to conduct the experiment for accurate data collection?

    (A) Conducting the experiment at different temperatures to see which generates the most gas

    (B) Completing the entire reaction in a large Erlenmeyer flask of known volume to measure the volume of the gas collected

    (C) Collecting the gas in a eudiometer tube and measuring the volume of the gas collected

    (D) Conducting the reaction in a graduated cylinder and measuring the volume of the gas collected

15. In a third experiment, 0.10 g samples of Mg(*s*) are placed in excess HCl(*aq*) of various concentrations: 0.050 *M*, 0.10 *M*, 0.25 *M*, and 0.50 *M*. The reactions are run in successive order from 0.050 *M* to 0.50 *M*, and the time required for each reaction to go to completion is recorded. As the concentration of HCl(*aq*) increases from 0.050 *M* to 0.50 *M*, which of the following is the expected result?

    (A) The reaction time increases, and the rate of the reaction decreases.

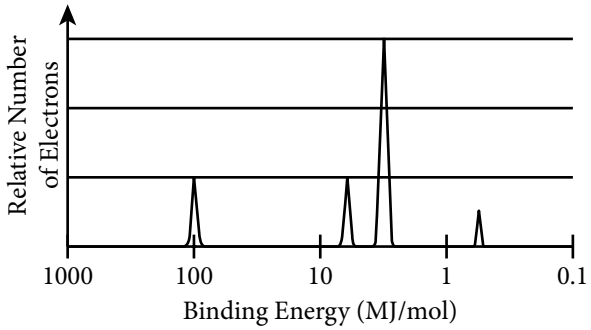
    (B) The reaction time decreases, and the rate of the reaction increases.

    (C) Both the reaction time and the rate of the reaction increase.

    (D) Both the reaction time and the rate of the reaction decrease.

Section II: Free-Response

The following are examples of the kinds of free-response questions found on the exam. Note that on the actual AP Exam, there will be three long free-response questions and four short free-response questions.



1. The complete photoelectron spectrum of an unknown element is given above.

    (a) Draw an X above the peak that corresponds to the orbital with electrons that are, on average, closest to the nucleus. Justify your answer in terms of Coulomb's law.

    (b) Based on the spectrum, write the complete electron configuration of the element.

    (c) On the graph, draw the peak(s) corresponding to the valence electrons of the element that has one more proton in its nucleus than the unknown element has.

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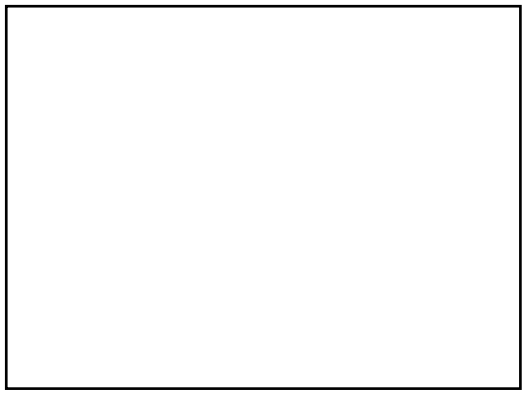
2. The following questions relate to sulfur and some of its compounds.

   (a) Write the balanced equation for the combustion of $S_8(s)$ to form $SO_2(g)$.

   (b) Calculate the volume of $O_2(g)$, measured at 1.00 atm and 298 K, that is required to completely combust a 500.0 g sample of pure $S_8(s)$.

   (c) A student claims that the combustion of S_8 is an oxidation-reduction reaction. Justify the claim by identifying the oxidation numbers of sulfur and oxygen both before and after the reaction.

   (d) In the box below, draw a Lewis electron-dot diagram for one valid resonance structure of SO_2.



   (e) Based on the diagram you drew in part (d), what is the approximate oxygen-sulfur-oxygen bond angle in SO_2?

   SO_2 can be oxidized to form SO_3 according to the following equation.

$$2\ SO_2(g) + O_2(g) \rightarrow 2\ SO_3(g) \quad \Delta H^\circ = -198\ \text{kJ/mol}_{rxn}$$

   (f) Is the value of ΔS° for the reaction represented above positive or negative? Justify your answer.

$$2\ SO_2(g) + O_2(g) \rightarrow 2\ SO_3(l)$$

   (g) Is the magnitude of ΔH° for the reaction to form $SO_3(l)$, represented above, greater than, less than, or equal to the magnitude of ΔH° for the reaction to form $SO_3(g)$? Justify your answer.

   (h) Based on the information above, how does the thermodynamic favorability of the reaction change as the temperature of the reaction system is decreased? Justify your answer.

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