AP® Chemistry
2001 Sample Student Responses

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6A

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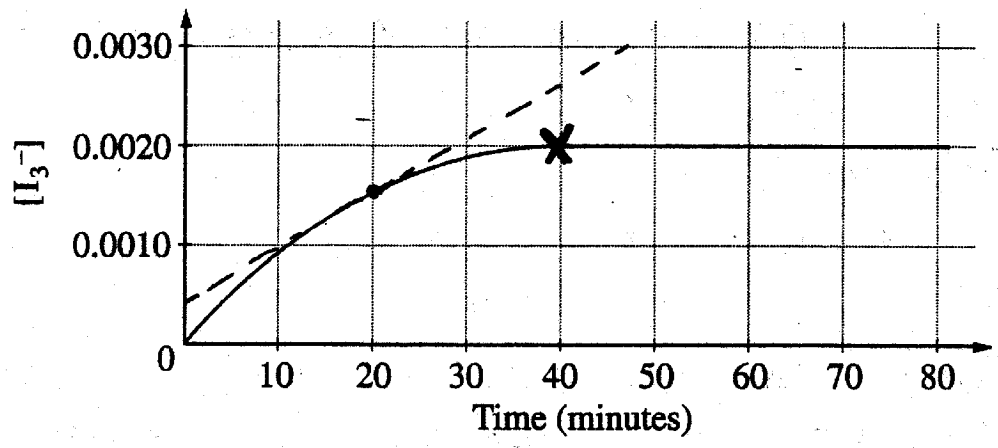
$$3\ I^-(aq) + S_2O_8^{2-}(aq) \rightarrow I_3^-(aq) + 2\ SO_4^{2-}(aq)$$

6. Iodide ion, $I^-(aq)$, reacts with peroxydisulfate ion, $S_2O_8^{2-}(aq)$, according to the equation above. Assume that the reaction goes to completion.

(a) Identify the type of reaction (combustion, disproportionation, neutralization, oxidation-reduction, precipitation, etc.) represented by the equation above. Also, give the formula of another substance that could convert $I^-(aq)$ to $I_3^-(aq)$.

(b) In an experiment, equal volumes of 0.0120 *M* $I^-(aq)$ and 0.0040 *M* $S_2O_8^{2-}(aq)$ are mixed at 25°C. The concentration of $I_3^-(aq)$ over the following 80 minutes is shown in the graph below.



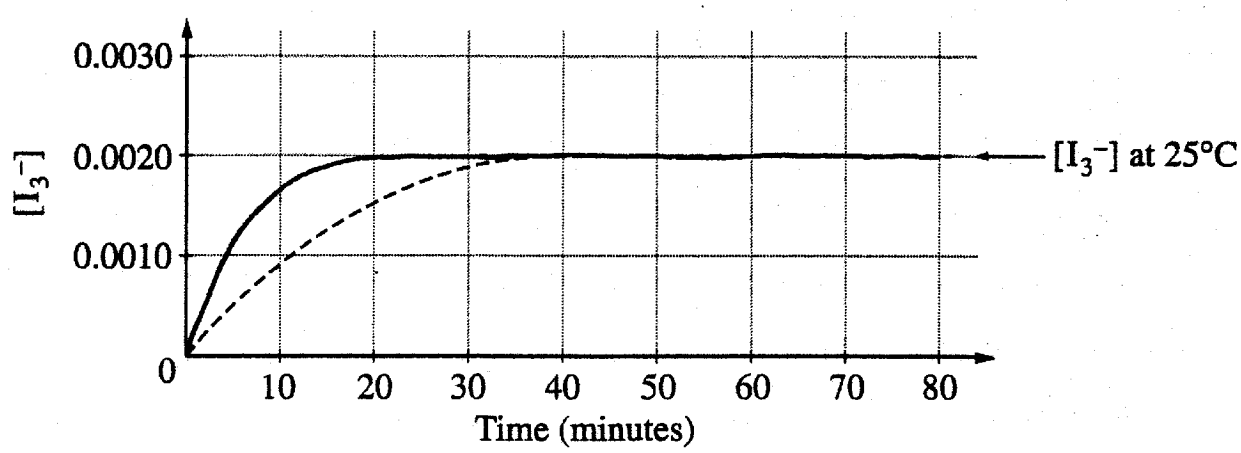
(i) Indicate the time at which the reaction first reaches completion by marking an "X" on the curve above at the point that corresponds to this time. Explain your reasoning.

(ii) Explain how to determine the instantaneous rate of formation of $I_3^-(aq)$ at exactly 20 minutes. Draw on the graph above as part of your explanation.

(c) Describe how to change the conditions of the experiment in part (b) to determine the order of the reaction with respect to $I^-(aq)$ and with respect to $S_2O_8^{2-}(aq)$.

(d) State clearly how to use the information from the results of the experiments in part (c) to determine the value of the rate constant, *k*, for the reaction.

(e) On the graph below (which shows the results of the initial experiment as a dashed curve), draw in a curve for the results you would predict if the initial experiment were to be carried out at 35°C rather than at 25°C.



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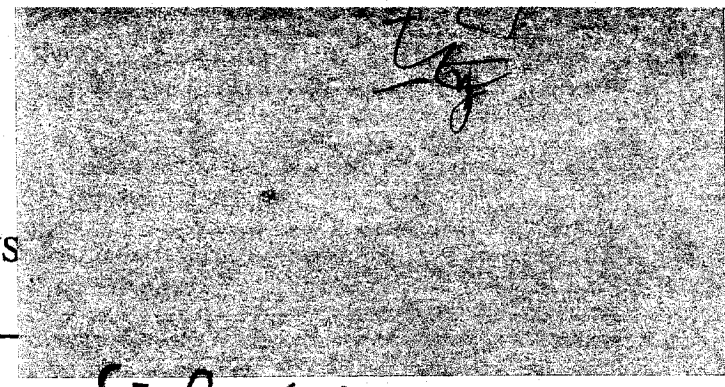

a. OXIDATION-REDUCTION Cr_2O_7 (aq)

b. i THE REACTION SEEMS TO HAVE REACHED COMPLETION BY THIS POINT BECAUSE THERE ARE NO ADDITIONAL PRODUCTS CREATED LATER ON.

ii SINCE THE GRAPH DEPICTS THE CONCENTRATION OF I_3^- OVER TIME, THE INSTANTANEOUS RATE OF FORMATION AT 20 MINUTES IS EQUAL TO THE SLOPE OF THE LINE AT THAT POINT. THIS SLOPE CAN BE CALCULATED RATHER EASILY WITH THE AID OF A TANGENT LINE.

c. INSTEAD OF CONDUCTING A SINGLE EXPERIMENT ~~WHERE THE~~, A SERIES OF EXPERIMENTS COULD BE PERFORMED. IN EACH THE CONCENTRATION OF I_3^- VERSUS TIME WOULD BE GRAPHED TO FIND THE REACTION RATE. IN THE FIRST, .0120 M I^- AND .0040 M $S_2O_8^{2-}$ COULD BE USED. FOR THE SECOND $[S_2O_8^{2-}]$ WOULD BE HELD CONSTANT BUT $[I^-]$ WOULD BE DOUBLED. IN THE THIRD, $[I^-]$ WOULD BE HELD CONSTANT WHILE $[S_2O_8^{2-}]$ WAS DOUBLED. BY ANALYZING THE DEGREE TO WHICH A CHANGE IN INITIAL CONCENTRATION AFFECTED THE INITIAL REACTION RATE, ~~THE DEGREE~~ ORDER OF EACH REACTANT COULD BE DETERMINED.

d. RATE $= K \cdot [I^-]^X \cdot [S_2O_8^{2-}]^Y$

X = ORDER OF I^- IN THE REACTION

Y = ORDER OF $S_2O_8^{2-}$ IN THE REACTION

TO FIND K, USE THE VALUES OBTAINED FOR $[I^-]$, $[S_2O_8^{2-}]$, AND THE INITIAL RATE FOR ONE OF THE REACTIONS PERFORMED AND SOLVE ~~ALGEBRAICALLY~~ FOR K.

e. THE CHANGE I DEPICTED WAS TOO DRAMATIC, BUT IT CONVEYS THE GENERAL IDEA THAT MORE PARTICLES WILL HAVE SUFFICIENT ENERGY TO REACT.

6B

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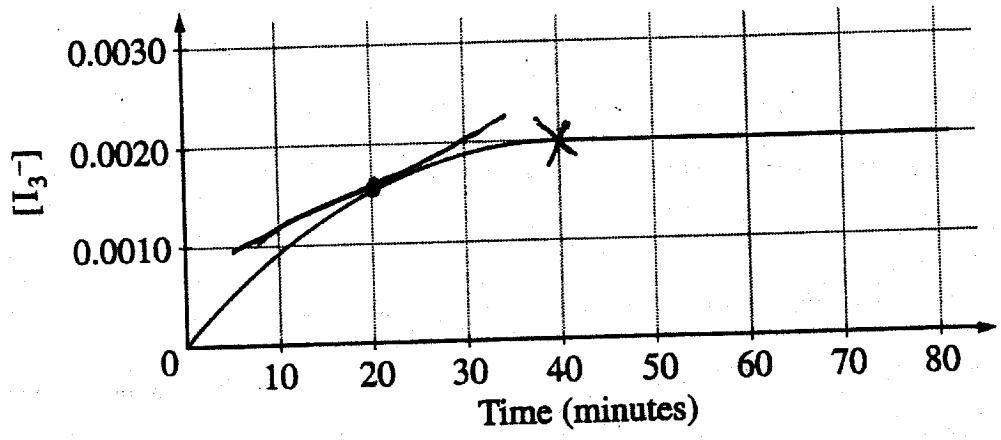

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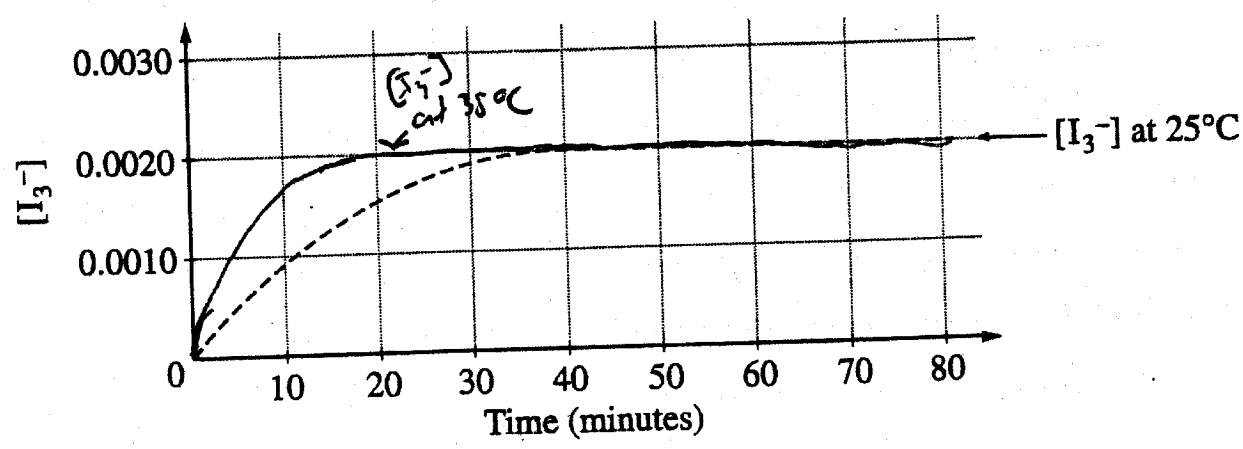

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a) oxidation-reduction
F_2 also functions as an oxidizing agent and could convert I^- to I_3^-

b) i) The $[I_3^-]$ has stopped changing at the X.
ii) One could find the slope of the line tangent to the graph at 20 minutes. This value would be the reaction rate at that point.

c) One would double ~~each~~ on the ~~concentration~~ $[I_3^-]$ and see how the rate changed. If it increased by a factor of 2, the reaction is first order. If it changed by a factor of 4, it is second-order, etc. Do the same with the $[S_2O_8^{2-}]$ while holding $[I_3^-]$ constant.

d) Find the rate law by raising the power of each concentration to the order with respect to that particular concentration. Then, multiply those concentrations together. Divide the rate by that quantity to find k.

e) The rate will be greater at a higher temperature because particles will collide more frequently and with a greater chance of having enough energy to react.

6C

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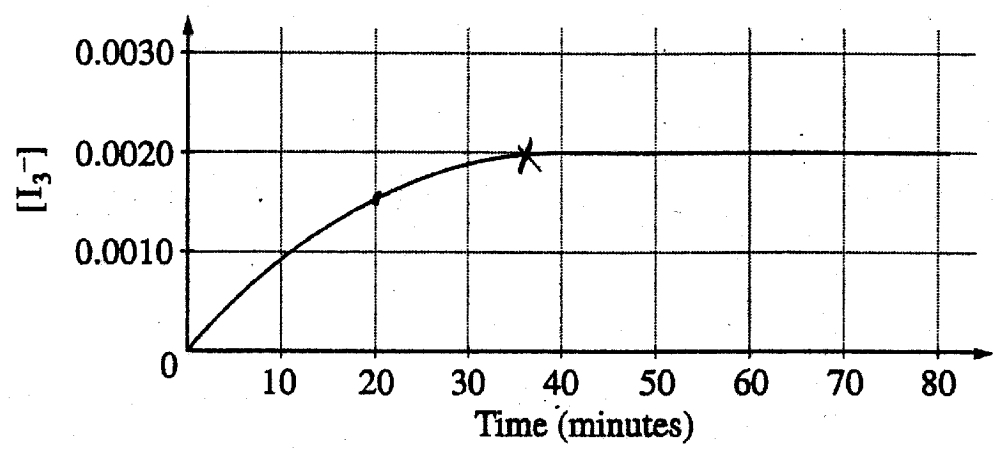

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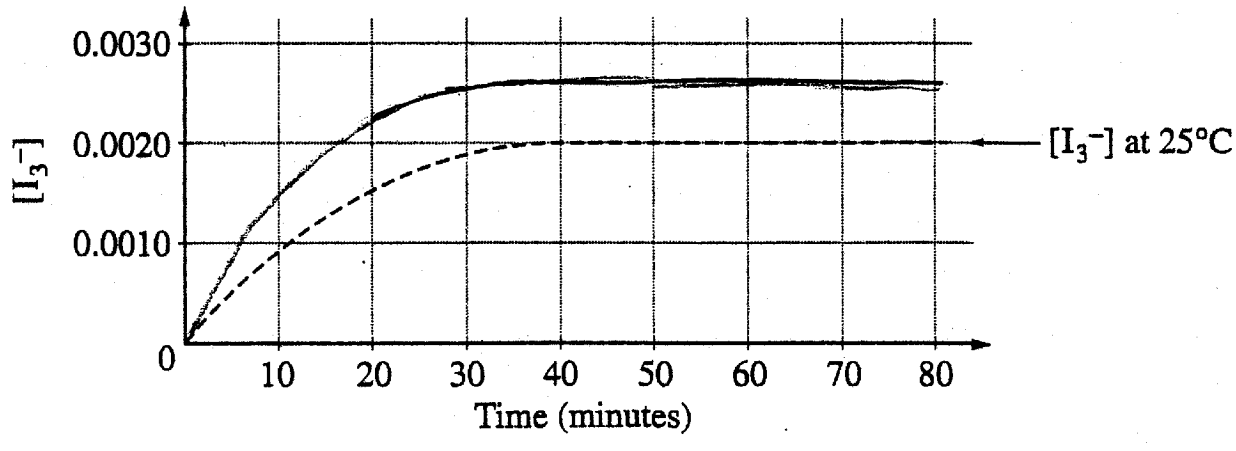

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FIRST PAGE FOR ANSWERING QUESTION 6.

(a) Oxidation-Reduction

(b) i) it reaches equilibrium at that point.

ii) $rate = k[I_3^-]$

Find the concentration of I_3^-, which equals about .0015 M.

(c) First, double $[I^-]$ and see how the rate changes. Then double $[S_2O_8^{-2}]$ and see how the rate changes again. As you are doubling either concentration, keep the other the same.

(d) Divide the rate by the concentrations to their respective n powers. $Rate = k[I^-]^n[S_2O_8^{-2}]^n$

(e)