Monday, July 14 R&R Worksheet

1) In the basement of Park you stumble upon the abandoned laboratory of the infamous Dr. Max Judish. Resting in a fume hood you find his personal notebook, which contains evidence of a newly discovered element, Judishtonium (J). Dr. Judish has performed rigorous testing on this element and notes that it is incredibly reactive, with one of the following reactions being:

$$2\ JH_3(aq) + OCl^-(aq) \rightarrow J_2H_4(aq) + Cl^-(aq) + H_2O(\ell)$$

a) You find this data table which corresponds to the reaction above. However, the research appears incomplete as there is no rate law. Using your chemical intuition, determine the experimental rate law for this reaction.

$[JH_3]$ (M)	$[OCl^-]$ (M)	Initial Rate (M/s)
0.21	0.13	0.00023
0.21	0.325	0.000575
0.84	0.13	0.00368
0.84	0.26	0.00736

b) By what factor does the rxn rate change if $[JH_3]$ is reduced to ⅔ of the initial amount and $[OCl^-]$ is tripled?

c) Since the probability of a termolecular reaction is low, Dr. Judish proposes the following reaction mechanism. Does the rate law derived from this mechanism match the experimental rate law?

1. $\mathrm{JH_3}(aq) + \mathrm{OCl^-}(aq) \rightleftharpoons \mathrm{JH_2Cl}(aq) + \mathrm{OH^-}(aq)$ (fast)
2. $\mathrm{JH_2Cl}(aq) + \mathrm{JH_3}(aq) \rightleftharpoons \mathrm{J_2H_5^+}(aq) + \mathrm{Cl^-}(aq)$ (fast)
3. $\mathrm{J_2H_5^+}(aq) + \mathrm{OH^-}(aq) \rightarrow \mathrm{J_2H_4}(aq) + \mathrm{H_2O}(\ell)$ (slow)

d) What effect will increasing the concentration of the product Cl^- have on the reaction rate?

2) There's also a reaction involving the decomposition of Judishtonium which has the following data:

Time (s)	[J] (M)
0	2.30
2	0.64
8	0.203
15	0.113
800	0.00223

Can you determine the order and rate constant of this reaction from this graph? If not, perform the necessary analysis to determine the order and rate constant?

3) In the corner of the lab you discover a radioactive protein shake which may explain Dr. Judish's superhuman teaching ability. The shaker bottle appears half-way filled, with a radius of 5 cm and a height of 20 cm. Based on the size of the protein scooper you approximate that the bottle contains 20 grams of protein (molar mass = 4.5 g/mol). Assuming the radioactive decay of protein is a first order reaction with a half-life of 35 minutes, what is the concentration of protein after 5 hours (***in units of molarity***)?

4) During R&R you confront Dr. Judish about his protein powder, appealing to the fact that it gives him an unfair advantage. He vehemently denies that it contains a special protein, and instead claims that it is simply a harmless mixture of 30% salt (NaCl) and 70% glucose ($C_6H_{12}O_6$). You decide to test his claim by dissolving 10.00 grams of the mixture into 500.0 g of water. What would be the change in boiling point of the "shake" if he was telling the truth? (K_b is 0.512°C/m).

5) Changing gears back to Judishtonium, recall the second step of the overall reaction $2JH_3(aq) + OCl^-(aq) \rightarrow J_2H_4(aq) + Cl^-(aq) + H_2O(\ell)$:

$$\mathrm{JH_2Cl}(aq) + \mathrm{JH_3}(aq) \rightleftharpoons \mathrm{J_2H_5^+}(aq) + \mathrm{Cl^-}(aq) \text{ (fast)}$$

a) Write the equilibrium constant expression for the reaction. K_c = ?

b) Suppose you dissolve 2 moles of JH_2Cl, 3 moles of JH_3, 1 mole of $J_2H_5^+$, and 1 mole of Cl^- in water so that the total volume of the solution is 2L. Given a K_c value of 0.4, predict in which direction the net reaction will proceed toward equilibrium (left, right, or no net reaction)?