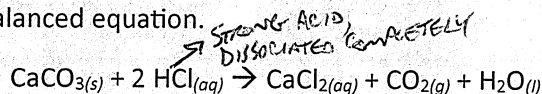
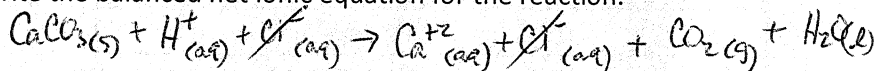


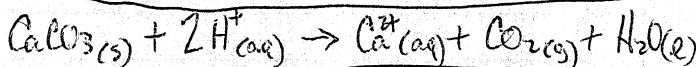
3. Answer the following questions about an experiment in which $\text{CaCO}_3(s)$ is combined with $\text{HCl}_{(aq)}$, represented by the following balanced equation.



a) Write the balanced net ionic equation for the reaction.



1 Pt.



A student performs an investigation to study factors that affect the rate of the reaction. In each trial the student combines 50.0 mL of $\text{HCl}_{(aq)}$ at 21.2°C with 1.00 g of $\text{CaCO}_3(s)$ and measures the time required for the reaction to go to completion. The data are given in the following table.

Trial	Concentration of $\text{HCl}_{(aq)}$ (M)	Particle Size of $\text{CaCO}_3(s)$	Time of Reaction (s)
1	1.00	Fine powder	67
2	1.00	Small chunks	112
3	1.00	Large chunk	342
4	3.00	Fine powder	22
5	3.00	Small chunks	227
6	3.00	Large chunk	114

b) The student correctly identifies that trial 5 is inconsistent with the other trials. Explain why the student's claim is correct using the data the table.

TRIALS 4-6 ALL INCLUDE 3M HCl. WOULD EXPECT SMALL CHUNKS TO TAKE LESS TIME TO REACT THAN THE LARGE CHUNK BECAUSE SMALL PARTICLES REACT MORE QUICKLY THAN LARGER PARTICLES. THE STUDENT IS CORRECT IN QUESTIONING THE DATA IN TRIAL 5.

1 Pt

c) Based on the reaction conditions and the collisions that occur between particles, explain the reason for the difference in the reaction times for trial 2 and trial 3.

THE LARGE CHUNK USED IN TRIAL 3 HAS A LARGER PARTICLE SIZE THAN THE SMALL CHUNKS IN TRIAL 2. SMALLER CHUNKS CONTAIN MORE ACTIVE SITES FOR A CHEMICAL REACTION TO TAKE PLACE. AS A RESULT, THERE ARE MORE EFFECTIVE COLLISIONS TO TAKE PLACE BETWEEN REACTANTS, INCREASING THE REACTION RATE.

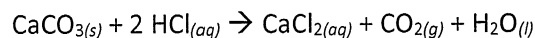
1 Pt

d) The student claims that the reaction is zero order with respect to $\text{HCl}_{(aq)}$. Do you agree or disagree with the student's claim? Justify your answer using the student's data.

I DISAGREE. FROM TRIAL 1 TO TRIAL 4, THE CONCENTRATION OF HCl WAS TRIPLED, WHILE THE TIME OF REACTION WAS CUT TO $\frac{1}{3}$ (RATE OF REACTION TRIPLED). THE SAME IS TRUE FROM TRIAL 3 TO TRIAL 6. THEREFORE, THE REACTION MUST BE FIRST ORDER WITH RESPECT TO HCl.

IF IT WAS ZERO ORDER, RATE OF REACTION FOR 1M VS. 3M SHOULD BE THE SAME WHEN IT ACTUALLY TRIPLES.

1 Pt



A student performs an investigation to study factors that affect the rate of the reaction. In each trial the student combines 50.0 mL of $\text{HCl}_{(aq)}$ at 21.2°C with 1.00 g of $\text{CaCO}_{3(s)}$ and measures the time required for the reaction to go to completion. The data are given in the following table.

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e) The $\text{HCl}_{(aq)}$ was present in excess in all trials of the experiment. Determine the molarity of the $\text{HCl}_{(aq)}$ in the beaker after the reaction is complete in trial 2. Assume that the volume of the mixture remains constant at 50.0 mL throughout the trial. (The molar mass of CaCO_3 is 100.09 g/mol.)

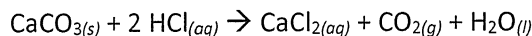
2pts

$$\frac{1.00\text{g CaCO}_3}{100.09\text{g/mol}} \times \frac{2\text{mol HCl}}{1\text{mol CaCO}_3} = 0.0200\text{ mol HCl used/needed in reaction. (1pt)}$$

$$\frac{0.0500\text{ mol HCl}}{1\text{L soln}} = 0.0500\text{ mol HCl available}$$

$$0.0500\text{ mol HCl avail} - 0.0200\text{ mol HCl used} = 0.0300\text{ mol excess}$$

$$\frac{0.0300\text{ mol}}{0.0500\text{ L}} = 0.600\text{M HCl (1pt)}$$



In order to measure the enthalpy in the reaction shown, the student repeats trial 1 by mixing 50.0 mL of $\text{HCl}_{(aq)}$ with 1.00 g of $\text{CaCO}_{3(s)}$ using a coffee cup calorimeter. The student records the temperature of the system every 20 seconds. The data are given in the following table.

Time (s)	Measured Temperature of Solution ($^\circ\text{C}$)
0	21.20
20	21.51
40	21.70
60	21.85
80	21.90
100	21.90

f) Is the reaction endothermic or exothermic? Justify your answer using the information in the table.

1pt

THE REACTION IS EXOTHERMIC, FOR THE TEMPERATURE OF THE SURROUNDING SOLUTION IS INCREASING, DEMONSTRATING A RELEASE OF HEAT ENERGY.

g) Based on the experimental data, the mass of the system is 51.0 g, and the specific heat of the reaction mixture is 4.0 J/(g·°C)

(i) Calculate the magnitude of heat transfer, q , in joules.

$$q = mC\Delta t$$

$$q = (51.0 \text{ g}) \left(\frac{4.0 \text{ J}}{\text{g} \cdot ^\circ\text{C}} \right) (21.90 - 21.20)$$

$$q = 140 \text{ Joules}$$

(ii) Calculate the enthalpy of reaction in units of kJ/mol_{rxn}. Include the algebraic sign on your answer.

$$\frac{1.00 \text{ g CaCO}_3}{100.09 \text{ g CaCO}_3} = 9.99 \times 10^{-3} \text{ mol CaCO}_3$$

$$140 \text{ Joules} = 0.140 \text{ kJ}$$

EXOTHERMIC MEANS ΔH IS NEGATIVE!

$$\frac{-0.140 \text{ kJ}}{9.99 \times 10^{-3} \text{ mol}}$$

$$= \frac{-14 \text{ kJ}}{\text{MOLE}}$$

1 PT For NEGATIVE

1 PT For CORRECT VALUE