Reaction Kinetics

1.) A $5.0\ g$ sample of magnesium reacts completely with a hydrochloric acid solution after $150\ s$. Express the average rate of consumption of magnesium, in units of $\frac{g}{min}$.

Answer - $reaction\ rate = \frac{amount\ of\ reactant\ used}{time\ interval}$ $rate = \frac{5.0\ g}{150\ s} \times \frac{60\ s}{1\ min}$ $rate = 2.0\ \frac{g}{min}$

2.) How long will it take to completely react $45.0\ g\ CaCO_{3\ (s)}$ with dilute $HCl_{\ (aq)}$ if the reaction proceeds at an average rate of $\frac{2.35\ g\ CaCO_{3\ (s)}}{min}$ under a given set of conditions?

Answer - $reaction\ rate = \frac{amount\ of\ reactant\ used}{time\ interval}$ $2.35\ \frac{g}{min} = \frac{45.0\ g}{time}$ $time = 19.1\ min$

3.) The electrolysis of water produces oxygen gas at the rate of $\frac{32.5\ mL}{min}$ in a certain experiment. What volume of oxygen gas can be produced in $7.50\ min$?

Answer - $reaction\ rate = \frac{amount\ of\ reactant\ used}{time\ interval}$ $32.5\ \frac{mL}{min} = \frac{reactant}{7.50\ min}$ $reactant = 244\ mL$

4.) Which of the following are acceptable units of expressing reaction rate?

a.) $\frac{moles}{second}$ yes

b.) $\frac{minutes}{metre}$ no

c.) $\frac{\frac{moles}{litre}}{second}$ yes

d.) $\frac{grams}{litre}$ no

e.) $\frac{millilitres}{hour}$ yes

f.) $\frac{grams}{minute}$ yes

5.) Hydrogen and oxygen gas react in a fuel cell to produce water according to the equation:

$$2\ H_{2\ (g)} + O_{2\ (g)} \rightarrow 2\ H_2O_{\ (l)}$$

If the rate of water production is $1.34\ \frac{mol}{min}$, what is the rate of oxygen gas consumption expressed in $\frac{mol}{min}$?

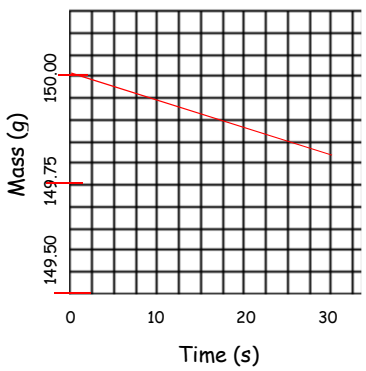
Answer – Use stoichiometry $1.34\ \frac{mol\ H_2O}{min} \times \frac{1\ mol\ O_2}{2\ mol\ H_2O} = 0.670$ $rate = 0.670\ \frac{mol\ O_2}{min}$

6.) When an Alka Seltzer™ tablet is dropped in water, it immediately begins to produce bubbles of CO_2 forming. The reaction is as follows:

$$NaHCO_{3\ (s)} + H^+_{\ (aq)} \rightarrow CO_{2\ (g)} + Na^+_{\ (aq)} + H_2O_{\ (l)}$$

The H^+ is produced in the reaction and the $NaHCO_3$ (baking soda) is an ingredient of the tablet. If the following data was found for the above reaction, plot the data on the graph below.

Time (s)	Mass (g)
0	150.00
10	149.94
20	149.88
30	149.82



Using the graph, you created above, answer the following questions.

a.) Why is the mass decreasing?

Answer – the product is a gas and the container is not sealed. This is allowing the atoms of gas to leave.

b.) What is the slope of the line in the above graph including units?

Answer – the slope is $\frac{rise}{run}$. Therefore, the slope of the line is $\frac{-0.006\ g}{s}$

c.) What units would you expect to use for the rate of this reaction?

Answer – same as in part c ($\frac{g}{s}$).

d.) What relationship exists between the slope of the graph and the rate of the reaction?

Answer – the slope is the average reaction rate.

7.) When measuring the rate at which the mass of copper metal decreases in a reaction with nitric acid, why can't you just put the reaction vessel on a digital balance and record the decrease in mass of the copper?

Answer – If the container is a closed system the mass will not change as the reaction proceeds and products are made. Therefore, one won't be able to measure the change in mass of the copper as a whole reaction. You would need to remove the copper periodically to measure it individually to see the individual change of just the copper.

8.) a.) Solutions of $Cu^{+2}_{(aq)}$ are blue, while solutions of $Ag^{+}_{(aq)}$ are colourless. Use only this information to describe how you would measure the rate of the reaction:

$$2\ Ag^{+}_{(aq)} + Cu_{(aq)} \rightarrow 2\ Ag_{(s)} + Cu^{+2}_{(aq)} + 35\ kJ$$

Answer – as this reaction proceeds the copper ion is being produced. Therefore, as the reaction proceeds more and more blue colour will become present. As such, one would measure the reaction rate using colourimetry to measure the colour intensity from clear to blue.

b.) Suggest two more methods that could be used to determine the reaction rate for the equation above. Be sure to state the property you are monitoring.

Answer – One could measure the decrease in copper metal as the reaction proceeds (mass change).
One could measure the production of silver metal as a product (mass change).
One could measure the heat produced as this reaction is exothermic (temperature change).

9.) a.) You are to measure the rate of this reaction: $H_{2\,(g)} + Cl_{2\,(g)} \rightarrow 2\ HCl_{\,(g)}$. Why is gas pressure NOT a good property to monitor in order to determine the reaction rate?

Answer – both the reactants and the products are gases. As such, there will already be a pressure in before the reaction starts and that pressure won't change as product is made. This is because the reactants are being consumed (thus dropping the pressure) but at the same time product is being made (thus increasing the pressure).

b.) Calculate the reaction rate, in $\frac{mol\ HCl}{s}$, if $1.2\ g$ of HCl $_{(g)}$ are produced in $2.0\ min$.

Answer - $rate = \frac{product\ produced}{time\ interval}$ $rate = \frac{1.2\ \cancel{g}}{2.0\ \cancel{min}} \times \frac{1\ mol}{36.45\ \cancel{g}} \times \frac{1\ \cancel{min}}{60\ s}$ $rate = \frac{0.00027 mol}{s}\ HCl$

c.) If the rate of consumption of hydrogen gas under certain conditions is $0.200 \frac{L}{min}$, what is the rate of production of HCl $_{(g)}$?

Answer – the key is the mole ratio. $\frac{2\ mol\ HCl}{1\ mol\ H_2}$ There is $2\ mol$ of HCl to every $1\ mol$ H_2. As such the rate of production of HCl will be double H_2. Answer is $rate = 0.400 \frac{L}{min}\ HCl$