Chemistry 12
Worksheet 1-1 - Measuring Reaction Rates

1. A chemist wishes to determine the rate of reaction of zinc with hydrochloric acid. The equation for the reaction is:

$$Zn_{(s)} + 2HCl_{(aq)} \rightarrow H_{2(g)} + ZnCl_{2(aq)}$$

A piece of zinc is dropped into 1.00 L of 0.100 M HCl and the following data were obtained:

Time	Mass of Zinc
0 s	0.016 g
4 s	0.014 g
8 s	0.012 g
12 s	0.010 g
16 s	0.008 g
20 s	0.006 g

a) Calculate the ***Rate of Reaction*** in *grams of Zn consumed per second.*

Answer_____

b) Calculate the ***Rate of Reaction*** in *moles of Zn consumed per second.*

Answer_____

c) Write out the complete ionic equation for the reaction.

_____

d) What will happen to the $[H^+]$ as the reaction proceeds? _____

e) What will happen to the $[Cl^-]$ as the reaction proceeds? _____

2. When magnesium is reacted with dilute hydrochloric acid (HCl), a reaction occurs in which hydrogen gas and magnesium chloride is formed.

a) Write a ***balanced formula equation*** for this reaction.

_____

b) If the rate of consumption of magnesium is 5.0×10^{-9} mol/s, find the *rate of consumption of HCl* in moles/s.

Answer_____

c) If the rate of consumption of magnesium is 5.0×10^{-9} mol/s, find the *rate of production of H_2* in g/s.

Answer_____

d) If the rate of consumption of magnesium is 5.0×10^{-9} mol/s, find the *rate of production of H_2* in L/s (@SLC).

Answer_____

e) If the rate of consumption of magnesium is 5.0×10^{-9} mol/s, find the *mass of Mg consumed in 5.0 minutes.*

Answer_____

3. When butane (C_4H_{10}) is burned in air (*oxygen*), the products *carbon dioxide* and *water* are formed.

a) Write a ***balanced formula equation*** for this reaction.

_____

b) If butane is consumed at an average rate of 0.116 grams/s, determine the rate of production of CO_2 in *g/s*.

Answer_____

4. Given the reaction:

$$\underset{\text{colourless}}{CO_{2(g)}} + \underset{\text{colourless}}{NO_{(g)}} \rightarrow \underset{\text{colourless}}{CO_{(g)}} + \underset{\text{brown}}{NO_{2(g)}}$$

Suggest a method which could be used to *monitor* the rate of this reaction.

Why wouldn't total pressure be a good way to monitor the rate of this reaction?

5. Equal volumes of $Fe^{2+}_{(aq)}$ and $C_2O_4^{2-}{}_{(aq)}$ are individually reacted with 0.10 M $MnO_4^-{}_{(aq)}$, and the following data were obtained:

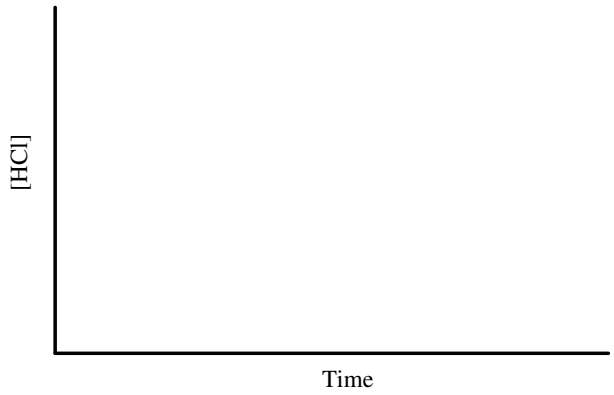
Reactant	Concentration	Temperature	Time for complete reaction
Fe^{2+}	0.20 M	25°C	1.6 s
$C_2O_4^{2-}$	0.40 M	35°C	17.0 s

Explain in detail why these results are obtained.

6. The longer the *time of reaction*, the _____ the *rate of reaction.*

7. On the following set of axes, draw the shape of the curve you would expect if you plotted the ***[HCl]*** *vs.* ***Time***, starting immediately after the two reactants are mixed. The equation for the reaction is:

$$Mg_{(s)} + 2HCl_{(aq)} \rightarrow H_{2(g)} + MgCl_{2(aq)}$$



Explain how you got that particular shape. Be detailed.

8. Give some examples of situations where we might want to ***increase*** the rate of a particular reaction.

_____

_____

_____

9. Give some examples of situations where we might want to ***decrease*** the rate of a particular reaction.

_____

_____

_____

10. Give ***two*** reasons why *water* is effective at putting out fires. Use concepts learned in this unit so far.

_____

_____

11. The following table relates the ***time*** and the ***mass of Zn*** during the reaction between Zn and 0.5M HNO_3 :

$$Zn_{(s)} + 2HNO_{3\,(aq)} \rightarrow H_{2(g)} + Zn(NO_3)_{2(aq)}$$

Time	Mass of Zn (g)
0.0 s	*36.2 g*
60.0 s	*29.6 g*
120.0 s	*25.0 g*
180.0 s	*22.0 g*

a) Calculate the reaction rate, in g/s, from time 0 to 60 s.

b) Calculate the reaction rate, in g/s, from time 120s to 180 s.

c) Explain why the rate in calculation "b" is less than that of calculation "a".

12. Consider the *rate* of the following reaction:

$$Fe_{(s)} + 2HCl_{(aq)} \rightarrow H_{2(g)} + FeCl_{2(aq)}$$

a) Is rate dependent on *temperature*? _____. Explain your answer.

_____

b) Is rate dependent on *pressure*? _____. Explain your answer.

_____

c) Is rate dependent on *surface area*? _____. Explain your answer.

_____

13. Consider the *rate* of the following reaction:

$$2NaOCl_{(aq)} \rightarrow 2NaCl_{(aq)} + O_{2(g)}$$

a) Is rate dependent on *temperature*? _____. Explain your answer.

_____

b) Is rate dependent on *pressure*? _____. Explain your answer.

_____

c) Is rate dependent on *surface area*? _____. Explain your answer.

_____

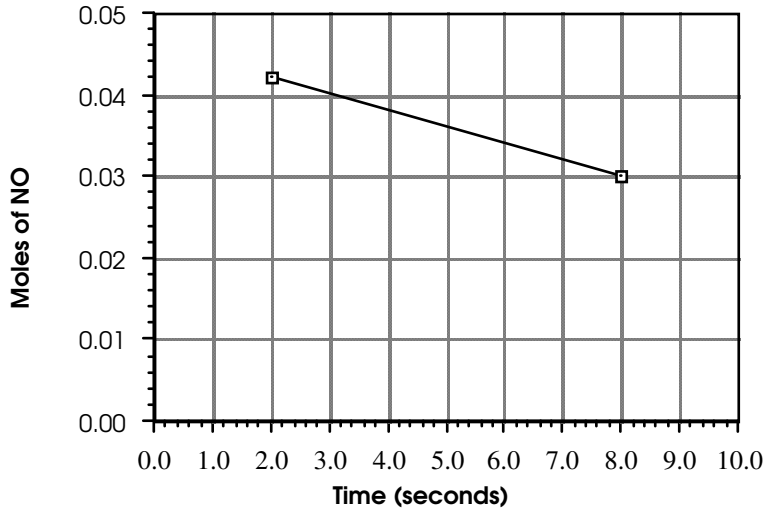
c) Is rate dependent on *[NaOCl]*? _____. Explain your answer.

_____

14. Consider the following reaction:

$$2NO_{(g)} + 2H_{2(g)} \rightarrow N_{2(g)} + 2H_2O_{(g)}$$

Data collected for the above reaction was used to construct the following graph:



From this graph, determine the ***rate of reaction*** in *moles of NO consumed per second*.

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A piece of zinc is dropped into 1.00 L of 0.100 M HCl and the following data were obtained:

Time	Mass of Zinc
0 s	0.016 g
4 s	0.014 g
8 s	0.012 g
12 s	0.010 g
16 s	0.008 g
20 s	0.006 g

a) Calculate the ***Rate of Reaction*** in *grams of Zn consumed per second.*

$\frac{0.016 - 0.006}{20} = 0.0005$ g/s

Answer 5×10^{-4} g/s

b) Calculate the ***Rate of Reaction*** in *moles of Zn consumed per second.*

$n(Zn) = \frac{m}{M} = \frac{0.01}{65.4} = 0.0001529$ mol

$\therefore 0.0001529$ mol / 20 sec

7.645×10^{-6} mol/s

Answer 8×10^{-6} mol/s

c) Write out the complete ionic equation for the reaction.

$Zn(s) + 2H^+(aq) \rightarrow H_2(g) + Zn^{2+}(aq)$

d) What will happen to the $[H^+]$ as the reaction proceeds? Concentration decreases

e) What will happen to the $[Cl^-]$ as the reaction proceeds? Concentration increases

2. When magnesium is reacted with dilute hydrochloric acid (HCl), a reaction occurs in which hydrogen gas and magnesium chloride is formed.

a) Write a ***balanced formula equation*** for this reaction.

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

b) If the rate of consumption of magnesium is 5.0 x 10^{-9} mol/s, find the *rate of consumption of HCl* in moles/s.

$2 \times 5.0 \times 10^{-9}$ mole/s

10×10^{-9} mole/s

Answer 1.0×10^{-8} mole/s

c) If the rate of consumption of magnesium is 5.0 x 10^{-9} mol/s, find the *rate of production of* H_2 in g/s.

$n(H_2) = n(Mg)$

$\therefore$ rate $H_2 = 5.0 \times 10^{-9}$ mol/s

Answer 5.0×10^{-9} mol/s

d) If the rate of consumption of magnesium is 5.0 x 10^{-9} mol/s, find the *rate of production of* H_2 in L/s (@SLC).

$n = \frac{V}{24.8}$ $\therefore$ $V = 5.0 \times 10^{-9} \times 24.8$

$= 1.24 \times 10^{-7}$ L

Answer 1.24×10^{-7} L/s

e) If the rate of consumption of magnesium is 5.0 x 10^{-9} mol/s, find the *mass of Mg consumed in 5.0 minutes.*

$m(Mg)$ consumed $= 5.0 \times 10^{-9} \times 5 \times 60 \times 24.3 = 1.5 \times 10^{-6}$ g

Answer 3.6×10^{-5} g

3. When butane (C_4H_{10}) is burned in air (*oxygen*), the products *carbon dioxide* and *water* are formed.

a) Write a ***balanced formula equation*** for this reaction.

$2\,C_4H_{10}(l) + 13O_2 \rightarrow 8\,CO_2(g) + 10\,H_2O(l)$

b) If butane is consumed at an average rate of 0.116 grams/s, determine the rate of production of CO_2 in *g/s*.

$n = \frac{m}{M}$ $\therefore$ $n_{butane} = \frac{0.116}{58}$

$= 0.002$ mol

$\therefore$ rate(butane) $= 0.002$ mol/s

$\therefore$ rate $(CO_2) = 4 \times 0.002$

$= 0.008$ mol/s

$n(CO_2) = \frac{m}{M}$

$\therefore$ $m = 0.008 \times 44$

$= 0.352$ g

$\therefore$

Answer 0.352 g/s

4. Given the reaction:

$$\underset{\text{colourless}}{CO_{2(g)}} + \underset{\text{colourless}}{NO_{(g)}} \rightarrow \underset{\text{colourless}}{CO_{(g)}} + \underset{\text{brown}}{NO_{2(g)}}$$

Suggest a method which could be used to *monitor* the rate of this reaction.

Colour. Monitor the rate of change in colour as solution changes from colourless to brown.

Why wouldn't total pressure be a good way to monitor the rate of this reaction?

As amount of gas on each side of equation is the same.

5. Equal volumes of $Fe^{2+}_{(aq)}$ and $C_2O_4^{2-}{}_{(aq)}$ are individually reacted with 0.10 M $MnO_4^-{}_{(aq)}$, and the following data were obtained:

Reactant	Concentration	Temperature	Time for complete reaction
Fe^{2+}	0.20 M	25°C	1.6 s
$C_2O_4^{2-}$	0.40 M	35°C	17.0 s

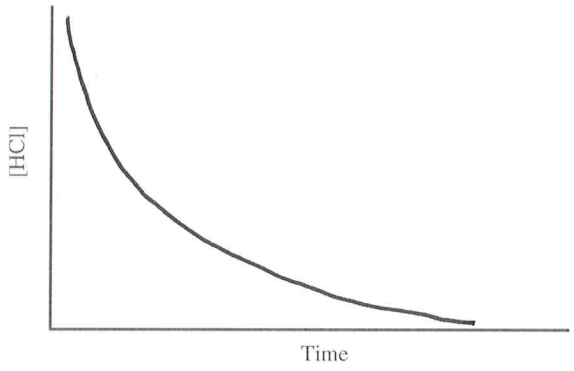
Explain in detail why these results are obtained.

The reaction involving Fe^{2+} has a lower activation energy barrier and therefore does not require as high a temperature or concentration as $C_2O_4^{2-}$ to react.

6. The longer the *time of reaction*, the _____slower_____ the *rate of reaction.*

7. On the following set of axes, draw the shape of the curve you would expect if you plotted the ***[HCl]** vs. **Time***, starting immediately after the two reactants are mixed. The equation for the reaction is:

$$Mg_{(s)} + 2HCl_{(aq)} \rightarrow H_{2(g)} + MgCl_{2(aq)}$$



Explain how you got that particular shape. Be detailed.

The higher the concentration of HCl, the more frequently particles come into contact, the greater the number of effective collisions ∴ the rate will be higher.

8. Give some examples of situations where we might want to ***increase*** the rate of a particular reaction.

Production of chemicals

9. Give some examples of situations where we might want to ***decrease*** the rate of a particular reaction.

Formation of acid rain

Rate at which fire burns

10. Give ***two*** reasons why *water* is effective at putting out fires. Use concepts learned in this unit so far.

water will decrease the temperature ∴ rate decreases

water will remove O_2 as a reactant ∴ rate decreases

11. The following table relates the ***time*** and the ***mass of Zn*** during the reaction between Zn and 0.5M HNO_3 :

$$Zn_{(s)} + 2HNO_{3\,(aq)} \rightarrow H_{2(g)} + Zn(NO_3)_{2(aq)}$$

Time	Mass of Zn (g)
0.0 s	*36.2 g*
60.0 s	*29.6 g*
120.0 s	*25.0 g*
180.0 s	*22.0 g*

a) Calculate the reaction rate, in g/s, from time 0 to 60 s.

$\text{rate} = \frac{\Delta \text{mass}}{\Delta \text{time}} = \frac{36.2 - 29.6}{0 - 60.0} = 0.11\ g/sec$

b) Calculate the reaction rate, in g/s, from time 120s to 180 s.

$\frac{25.0 - 22.0}{180.0 - 120.0} = 0.050\ g/sec$

c) Explain why the rate in calculation "b" is less than that of calculation "a".

The $[HNO_3]$ is decreasing ∴ fewer effective collisions
∴ rate of reaction is decreasing.

12. Consider the *rate* of the following reaction:

$$Fe_{(s)} + 2HCl_{(aq)} \rightarrow H_{2(g)} + FeCl_{2(aq)}$$

a) Is rate dependent on *temperature*? Yes. Explain your answer.

↑ Temp ↑ effective collisions ↑ rate

b) Is rate dependent on *pressure*? NO. Explain your answer.

None of the reactants are gases.

c) Is rate dependent on *surface area*? Yes. Explain your answer.

↑ SA ↑ contact ↑ effective collisions ↑ rate

13. Consider the *rate* of the following reaction:

$$2NaOCl_{(aq)} \rightarrow 2NaCl_{(aq)} + O_{2(g)}$$

a) Is rate dependent on *temperature*? Yes. Explain your answer.

↑ Temp ↑ contact ↑ effective collisions ↑ rate

b) Is rate dependent on *pressure*? No. Explain your answer.

There are no gaseous reactants

c) Is rate dependent on *surface area*? No. Explain your answer.

Reactant is a solution

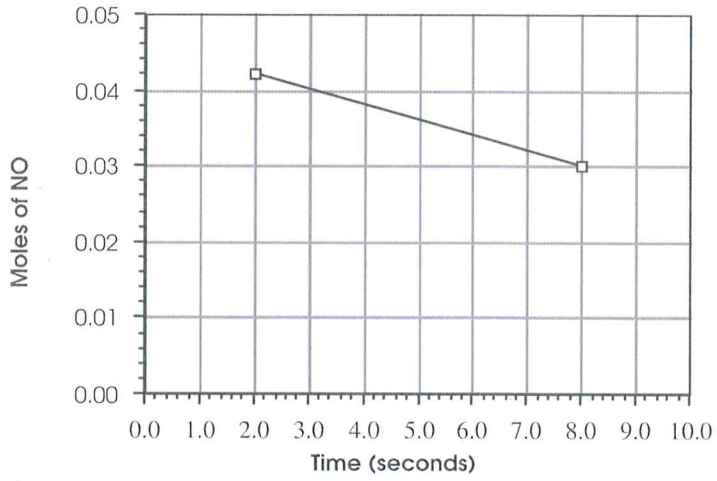
c) Is rate dependent on *[NaOCl]*? Yes. Explain your answer.

↑ [NaOCl] ↑ contact ↑ effective collisions ↑ rate

14. Consider the following reaction:

$$2NO_{(g)} + 2H_{2(g)} \rightarrow N_{2(g)} + 2H_2O_{(g)}$$

Data collected for the above reaction was used to construct the following graph:



From this graph, determine the ***rate of reaction*** in *moles of NO consumed per second.*

$$\text{rate} = \frac{\Delta \text{moles NO}}{\Delta \text{time}} = \frac{0.042 - 0.03}{8.0 - 2.0} = 0.002 \text{ mol/s}$$