Chemistry 12
Worksheet 1-1 - Measuring Reaction Rates

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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:

rate = Δmass / Δt

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.*

$= \frac{0.006g - 0.016g\ Zn}{20s - 0s} =$ Answer $-0.0005\ g\ Zn/s$

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

$= \frac{-0.0005g\ Zn}{s} \times \frac{1\ mol\ Zn}{65.39\ g\ Zn} =$ Answer $-7.65 \times 10^{-7}\ mol\ Zn/s$

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

$2Cl^-_{(aq)} + Zn_{(s)} + 2H^+_{(aq)} \rightarrow H_{2(g)} + Zn^{2+}_{(aq)} + 2Cl^-_{(aq)}$ (spectator ions)

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

e) What will happen to the $[Cl^-]$ as the reaction proceeds? stays the same bec not a reacting species

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.

$Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$ (2+ 1−)

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.

$-\frac{5.0 \times 10^{-9} \text{ mol Mg}}{1 \text{ s}} \times \frac{2 \text{ mol HCl}}{1 \text{ mol Mg}} =$

Answer 1.0×10^{-8} mol HCl/s

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.

$-\frac{5.0 \times 10^{-9} \text{ mol Mg}}{1 \text{ s}} \times \frac{1 \text{ mol } H_2}{1 \text{ mol Mg}} \times \frac{2 \text{ g } H_2}{1 \text{ mol } H_2} =$

Answer 1.0×10^{-8} g H_2/s

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 (@STP).

$-\frac{5.0 \times 10^{-9} \text{ mol Mg}}{1 \text{ s}} \times \frac{1 \text{ mol } H_2}{1 \text{ mol Mg}} \times \frac{22.4 \text{ L } H_2}{1 \text{ mol } H_2} =$

Answer 1.1×10^{-7} L H_2/s

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.*

$5.0 \text{ min} \times \frac{60 \text{ s}}{1 \text{ min}} \times \frac{-5.0 \times 10^{-9} \text{ mol Mg}}{1 \text{ s}} \times \frac{24.3 \text{ g Mg}}{1 \text{ mol Mg}} =$

Answer 3.6×10^{-5} g Mg

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.

$C_4H_{10(g)} + \frac{13}{2}O_{2(g)} \rightarrow 4CO_{2(g)} + 5H_2O_{(l)}$

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*.

$-\frac{0.116 \text{ g } C_4H_{10}}{1 \text{ s}} \times \frac{1 \text{ mol } C_4H_{10}}{58 \text{ g}} \times \frac{4 \text{ mol } CO_2}{1 \text{ mol } C_4H_{10}} \times \frac{44 \text{ g } CO_2}{1 \text{ mol } CO_2}$

Answer 0.352 g CO_2/s

4. Given the reaction:

R | P
2 moles gas | 2 mol gas

$CO_{2(g)}$ + $NO_{(g)}$ → $CO_{(g)}$ + $NO_{2(g)}$
colourless colourless colourless brown

rate = Δ colour / t

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

colorimeter = measures intensity of the coloured gas as it is produced.

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

X can't do at this time! # moles of gas don't change

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 faster rate
$C_2O_4^{2-}$	0.40 M higher	35°C higher	17.0 s slower rate

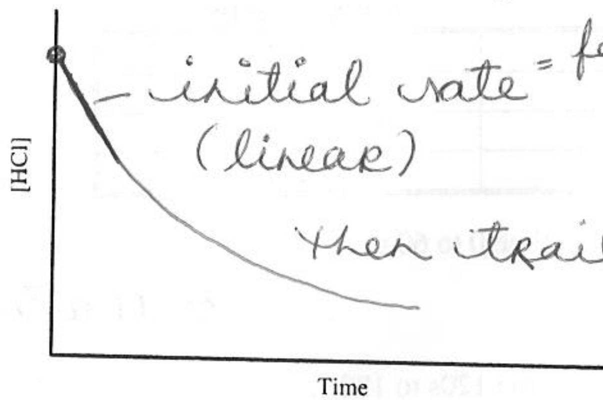
Explain in detail why these results are obtained.

- nature of the reactants = more bonds to break with $C_2O_4^{2-}$
- more bonds = usually slower even though the $[C_2O_4^{2-}]$ is higher and the T was higher

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:

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



- initial rate = faster = steeper slope (linear)

Explain how you got that particular shape. Be detailed.

then trails off as R disappears ∴ rate slows

8. Give some examples of situations where we might want to ***increase*** the rate of a particular reaction.
   - burning fuels for higher performance
   - breakdown of a pollutant eg NO_x
   - production of an essential chemical
   - decomposition of a toxin

9. Give some examples of situations where we might want to ***decrease*** the rate of a particular reaction.
   - fire when unwanted
   - rotting / decomposition of food
   - rusting of metals (corrosion)
   - ageing!!! of personal interest to me

10. Give *two* reasons why *water* is effective at putting out fires. Use concepts learned in this unit so far.
    - the evap of water absorbs HE
    - "blankets the fuel" = stops collisions btw the O_2 molecules and the fuel

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.

$\frac{22.0g - 36.2g}{180.0s - 0.0s} =$ 0.11 g Zn/s

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

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

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

As it goes by the concentration of Acid ↓ ∴ fewer R particles = fewer collisions. = slower rate

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 (all rxn). Explain your answer.

Can ↑ rate by ↑ T of particles of HCl (aq) and Fe = ↑ eff colls.

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

There are no gaseous R.

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

Can ↑ rate by ↑ surf area of Fe(s). this is a heterogeneous rxn = S and aq.

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.

Can ↑ T of an aqueous soln.

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

no gaseous R.

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

R are all (aq). there is no "surface".

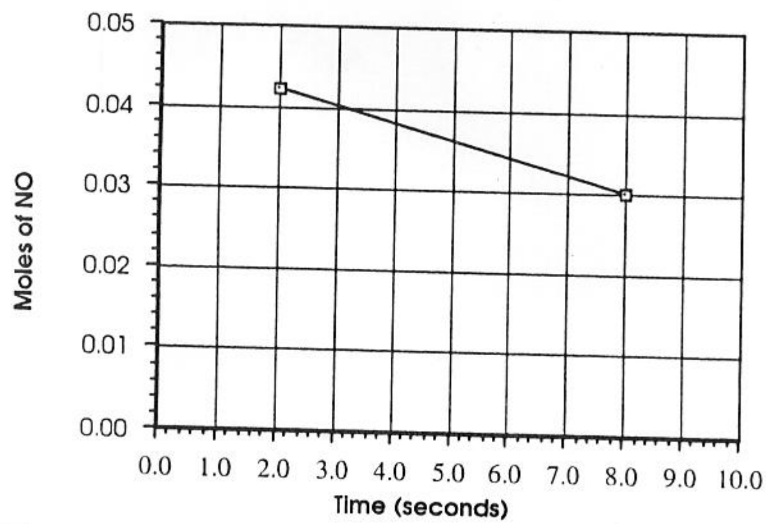
c) Is rate dependent on *[NaOCl]*? yes. Explain your answer.

↑ [NaOCl] = ↑ # particles = ↑ # coll.

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.*

$$\text{slope} = \frac{0.030 \text{ mol NO} - 0.042 \text{ mol NO}}{8.0\text{s} - 2.0\text{s}}$$

$$= -0.0020 \text{ mol } \frac{NO}{s}$$