If 2.50 g of Ca reacts completely in 30.0 s, what is the rate of production of H_2 gas in mL/s? Assume STP conditions.

$$1\,Ca_{(s)} + 2H_2O_{(l)} \rightarrow Ca(OH)_{2(aq)} + 1\,H_{2(g)}$$

$$? \frac{H_2\ mL}{s} = \left(\frac{2.50\ g\ Ca}{30.0\ s}\right)\left(\frac{1\ mol\ Ca}{40.1\ g}\right)\left(\frac{1\ mol\ H_2}{1\ mol\ Ca}\right)\left(\frac{22.7\ L}{mol}\right)\left(\frac{1000\ mL}{L}\right)$$

$$\therefore = 47.2\ \frac{mL}{s}\ H_2\ \text{produced}$$

Factors Affecting Reaction Rates

1. **Temperature**
   > ↑ temperature ↑ rate
   > for a slow reaction, a 10°C increase in temperature doubles the reaction rate

If the rate of a slow reaction is 7.34 x 10^{-3} mol/min at 20°C, what would the rate be at 60°C and at 0°C?

20°C → $\left(7.34\times10^{-3}\ \frac{mol}{min}\right)\times16 = 0.117\ \frac{mol}{min}$

60°C

20 30 40 50 60

2 × 2 × 2 × 2 = 16

0°

20 10 0

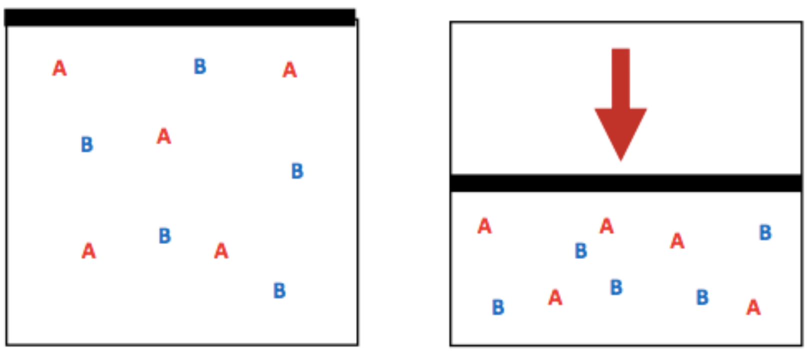
$\frac{1}{2}\times\frac{1}{2}$

$\left(7.34\times10^{-3}\ \frac{mol}{m}\right)\left(\frac{1}{4}\right) = 1.84\times10^{-3}\ \frac{mol}{min}$

2. **Concentration**
- ↑ concentration ↑ rate

3. **Pressure** (gas ONLY!)

- partial pressure of a gas is proportional to the moles of a gas when temperature is constant
- increasing the partial pressure of a gas is equivalent to increasing concentration, therefore, reaction rate increases



4. **Nature of reactants**

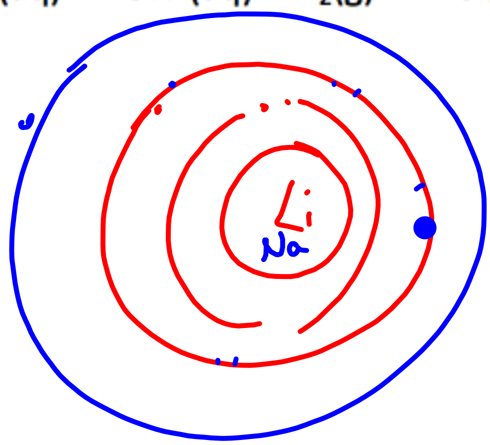
- this has to do with the chemical properties of the reactants
- some reactants are naturally faster than others
- reactions that involve breaking weak bonds or transferring electrons that are weakly held are faster than those in which bonds are strong and electrons are held strongly
- we have no control over this!!!

a) Consider the reaction of alkali metals with water:

$$2Li(s) + 2H_2O(l) \rightarrow 2Li^+(aq) + 2OH^-(aq) + H_2(g) + Energy$$
$$2Na(s) + 2H_2O(l) \rightarrow 2Na^+(aq) + 2OH^-(aq) + H_2(g) + Energy$$

Na faster

outer e- is farther from nucleus so held more loosely



b) Consider the oxidation of the iron (II) ion and oxalate ions by the permanganate ion:

permanga

$$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$$

purple — colourless

— faster e- is removed

oxalate

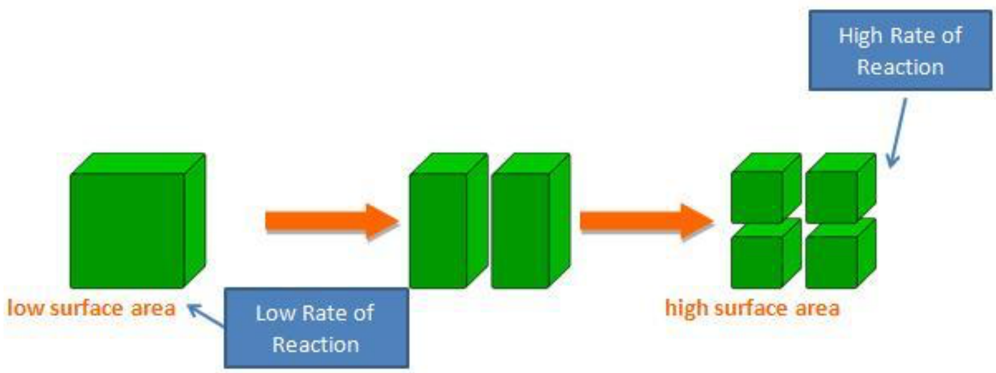
$$5C_2O_4^{2-} + 2MnO_4^- + 16H^+ \rightarrow 10CO_2 + 2Mn^{2+} + 8H_2O$$

purple — colourless

bonds broken slower

5. **Surface area**

- affects rate of heterogenous reactions (reactants are in different phases - ex. solid & liquid or solution)
- ↑ exposed area (surface area) ↑ rate
- how? crushing, grinding, powdering, etc.



6. **Catalysts & Inhibitors**

- **catalyst** = chemical which increases reaction rate but is regenerated in its original form at the end of the reaction
- **inhibitor** = chemical which reduces reaction rate by combining with a catalyst or one of the reactants in such a way that it prevents the reaction from occuring

7. **Phase of reactants** also important . . .

- reactants with oppositely charged aqueous ions are very fast

aqueous ions > gases or liquids > solids

- reactants with few bonds or weak bonds are faster than those with many bonds or strong bonds
- reactants in homogeneous phases are faster than those in heterogeneous phases
- undergoing a 2 particle collision are faster than those involving 3 or more particles

Which of the following reactions would you expect to be the (a) fastest and (b) slowest?

a) $2Fe(s) + O_2(g) \rightarrow 2FeO(s)$

b) $CaO(s) + 3C(s) \rightarrow CaC(s) + CO_2(g)$

Slowest

both solids

c) $SnO_2(s) + 2CO(g) \rightarrow Sn(s) + 2CO_2(g)$

d) $2AgNO_3(aq) + Na_2CrO_4(aq) \rightarrow Ag_2CrO_4(s) + 2NaNO_3(aq)$

fastest

aq