ANSWER KEY.

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Factors Affecting Reaction Rate

Chemistry | ANSWER KEY

Use collision theory: particles must collide, with enough energy (at least E_a), in the right orientation. Anything that makes more effective collisions every second makes a reaction faster. Write full sentences where a question asks why.

1. Is each change faster or slower, and which factor explains it? The first row is done for you.

Change	Faster or slower?	Factor
crushing an antacid tablet before dropping it in water	faster	surface area
putting leftovers in the refrigerator	**slower**	**temperature**
using 3.0 M HCl instead of 1.0 M HCl	**faster**	**concentration**
adding MnO_2 to hydrogen peroxide	**faster**	**catalyst**
lowering the pressure on a gas reaction	**slower**	**pressure (gas concentration)**
using potassium instead of iron in water	**faster**	**nature of reactants**

2. (a) List the three things a collision needs to make products. (b) Give two reasons a higher temperature speeds up a reaction. Which reason matters more?

(a) **The particles must collide, hit with enough energy (at least E_a), and hit in the right orientation.**

(b) **Faster particles collide more often, and more of the collisions have at least E_a. The energy reason matters more.**

3. A zinc cube 4 cm on each edge is cut into eight cubes 2 cm on each edge. Find the total surface area before and after. How does cutting the cube change the rate of its reaction with acid?

Before: $6 \times (4\text{ cm})^2 =$ **96 cm^2**. After: $8 \times 6 \times (2\text{ cm})^2 =$ **192 cm^2**.

The surface area doubles, so more zinc atoms are exposed, there are more collisions per second, and the reaction is faster.

4. Two setups each use 1.0 g of Mg ribbon and 1.0 M HCl. Setup A is at 25 °C and Setup B is at 45 °C. Which reacts faster? Why?

Setup B. At the higher temperature the particles move faster, so they collide more often and more collisions have enough energy to react.

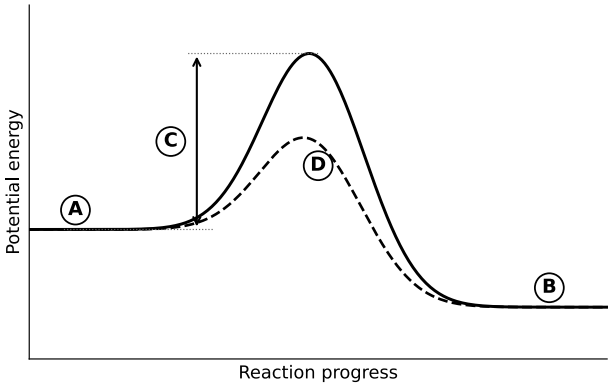
5. Sodium reacts violently with water, but an iron nail rusts very slowly. Which factor explains this? Can you change it in a lab?

The nature of the reactants: sodium gives up its electron very easily, so its E_a is low.

It cannot be adjusted. You can only choose a different reactant.

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6. The energy profile shows the same reaction with and without a catalyst.



(a) Name what each letter shows: A, B, C, and D. (b) How does a catalyst speed up a reaction? Does it change the energy difference between reactants and products (ΔH)? Is it used up?

(a) **A: reactants. B: products. C: the activation energy, E_a, without a catalyst. D: the lower pathway with a catalyst.**

(b) **A catalyst gives a new pathway (mechanism) with a lower E_a, so more collisions are effective. ΔH does not change, and the catalyst is not used up.**

7. An **elementary reaction** happens in one step. Classify each step. The first row is done for you.

Elementary step	Unimolecular or bimolecular?
$O_3 \rightarrow O_2 + O$	unimolecular (one particle breaks apart)
$NO + O_3 \rightarrow NO_2 + O_2$	**bimolecular (two particles collide)**
$NO_2 + NO_2 \rightarrow NO_3 + NO$	**bimolecular (two NO_2 particles collide)**
$N_2O_4 \rightarrow 2NO_2$	**unimolecular (one particle breaks apart)**

Steps that need three particles to hit at the same instant are rare.

8. A student drops the same mass of $CaCO_3$ into HCl and times how long it takes to collect 30 mL of CO_2.

Trial	$CaCO_3$	HCl	Temperature	Time for 30 mL of CO_2
1	chips	1.0 M	20 °C	120 s
2	powder	1.0 M	20 °C	35 s
3	chips	2.0 M	20 °C	60 s
4	chips	1.0 M	40 °C	45 s

(a) Which two trials test the effect of concentration? (b) Which change sped up the reaction the most? (c) Explain that change using collision theory.

(a) **Trials 1 and 3: only the HCl concentration changes.** (b) **Powdering the $CaCO_3$ (Trial 2, 35 s, the shortest time).**

(c) **Powder has more surface area, so more $CaCO_3$ particles are exposed to the acid and there are more collisions every second.**

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