

C6: The Rate and Extent

of chemical change

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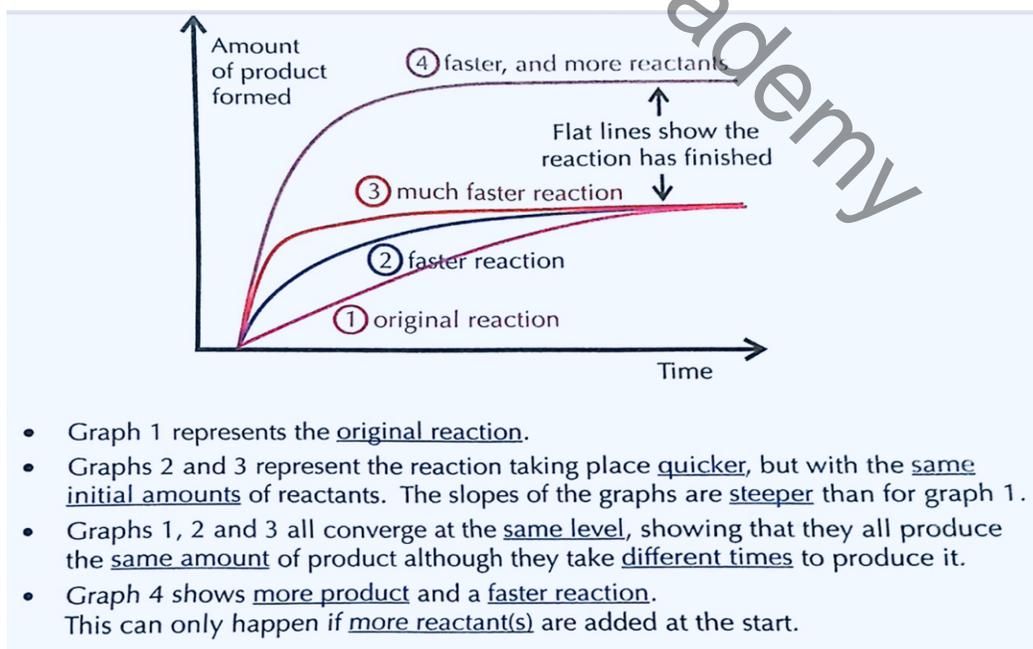
Rates of Reactions

Calculating rates of reactions

- Reactions take place at different rates depending on the chemicals involved and the conditions.
- Some are extremely slow e.g. **rusting of iron and chemical Weathering** is the slow reactions in which **acid rain** damage to limestone buildings.
- Some are moderate reaction e.g. **Metal magnesium reacting with an acid** to produce gentle stream of bubbles.
- Some are extremely fast reactions e.g. **Explosions and burning** reactions but Explosions are much faster reaction than burning in which release a lot of gases happens.

Graph for the Rate of Reactions

- You can find the speed of reaction by recording the amount of product formed or the amount of reactant used up over time
- The **steeper the line** on the graph shows the **fastest** reaction.
- As the reactant used up the line become **less steep** over the time
- The **quickest reactions** have the steepest line and become **flat** in the least time
- The graph below uses the amount of product formed over time.



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Collision Theory and Activation Energy

Collision Theory

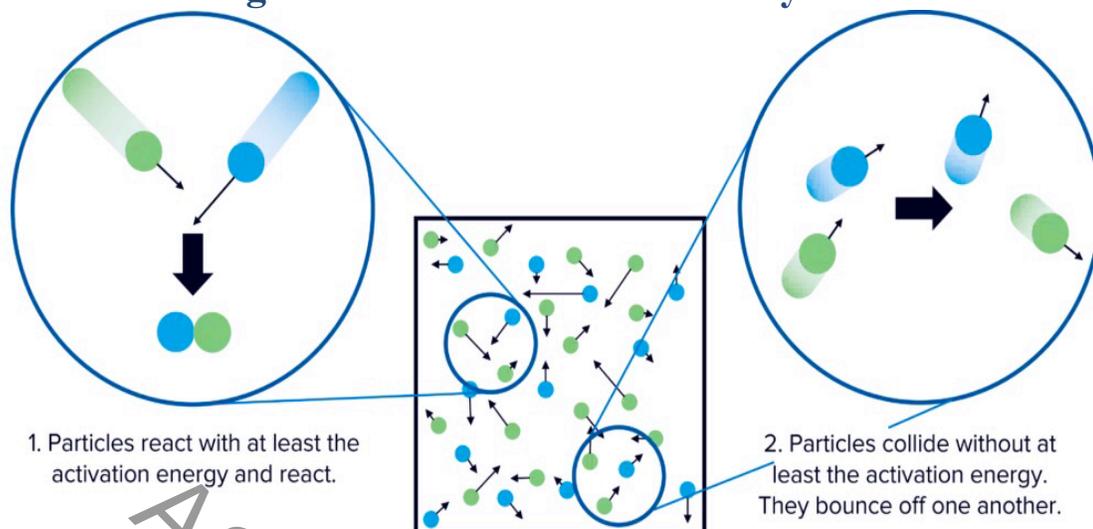
- ▶ When particles undergo **chemical reactions**, they move around **randomly** in the reaction mixture with **lots of different energies**. These randomly moving particles will often **collide** with each other and, if the right conditions are met, they **will react with one another**. This model of chemical reactions is known as **collision theory**.
- ▶ In **collision theory**, collisions between particles that lead to a reaction are referred to as **successful collisions**. The **more successful collisions** there are in a reaction, the **higher the rate of reaction** will be. To **increase the rate of reaction**, it is desirable to do anything that will increase the **frequency of successful collisions** between particles.

Activation Energy - making Successful Collisions

- ▶ For a collision to be successful, the particles must collide with **enough energy**.
- ▶ The **minimum** amount of energy required for a collision to be successful is known as the **activation energy of the reaction**.
- ▶ The **activation energy** is the energy needed to **break the bonds of the reactants** so that **products** can be formed.
- ▶ The requirement for particles to have at least the activation energy for a collision to be successful creates two scenarios.
 1. **Successful Collision:** Particles in the reaction collide at high speed. They have energy that is **at least equal to the activation energy** of the reaction. The **bonds in these particles are broken** and new ones formed to produce reaction products. This is a **successful collision**.
 2. **Unsuccessful Collision:** Particles in the reaction mixture collide at slower speed. They **do not have enough energy to meet the activation energy** of the reaction. They **do not react** and so simply bounce off one another. This is an **unsuccessful collision**.

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The Effects of Different Conditions on Rate of Reaction

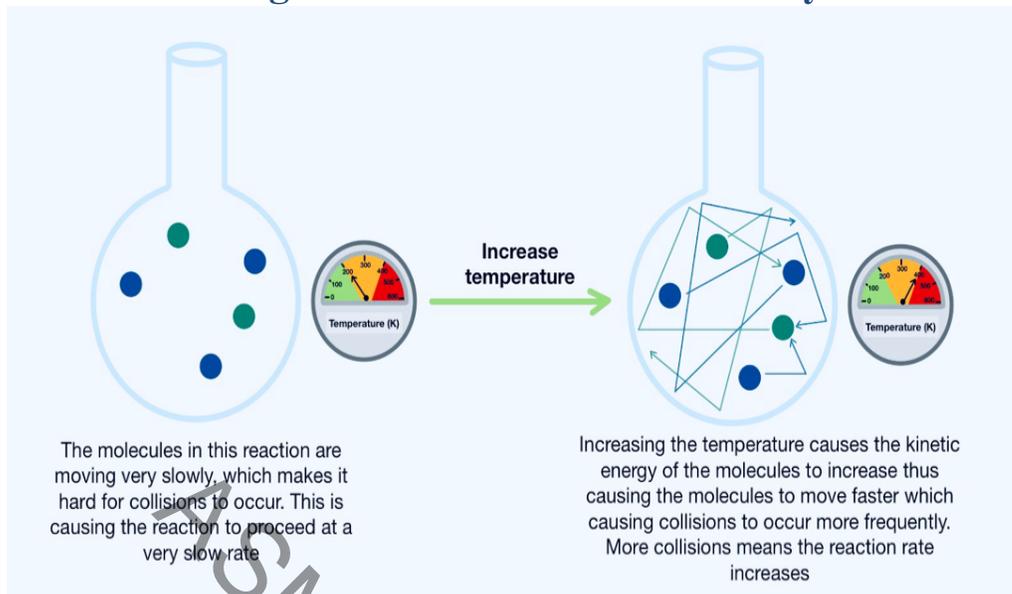
The rate of a chemical reaction can be **increased** by **increasing the number of successful collisions** happening in a given time. This is called the **frequency of successful collisions**. Anything that **increases the frequency of successful collisions** will **increase the rate of reaction**. There are a number of different factors that will affect this frequency, including

1. **Temperature**
2. **pressure**
3. **concentration.**
4. **Catalyst**
5. **Surface Area**

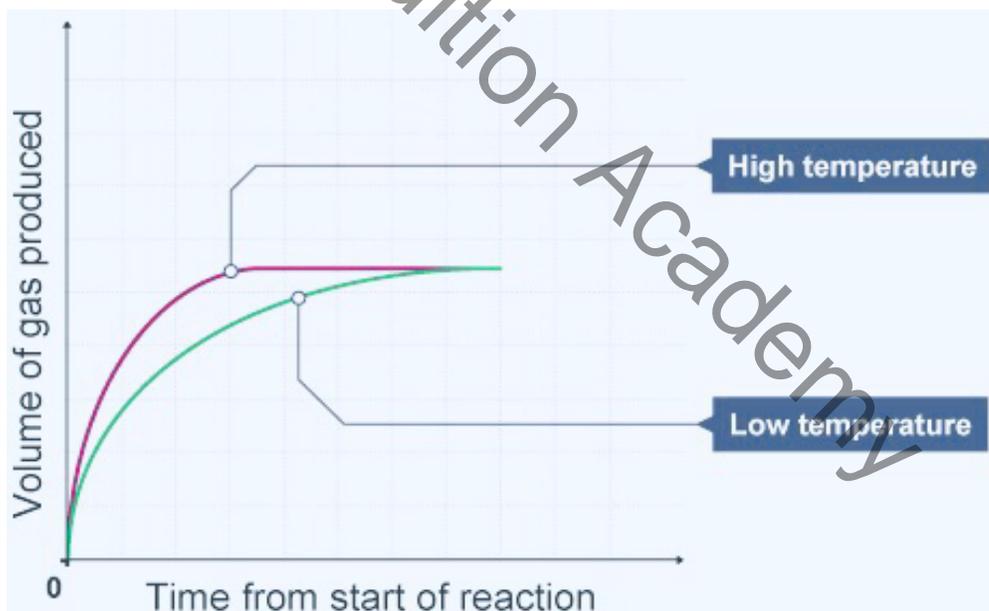
1. Temperature

- **Increasing the temperature** of a reaction will **increase the energy** of the particles with in it which lead to increase the rate of reaction.
- This in turn **increases the proportion** of particles colliding with at least **enough energy** to meet the **activation energy** of reaction.
- By increasing the energy of the particles the frequency of successful collisions is increased.
- On the other hand, **reducing the temperature** of a reaction will **decrease the energy** of the particles, lowering the frequency of successful collisions and hence **lowering the rate of reaction**.

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- Compared to a reaction at a low temperature, the graph line for the same reaction but at a higher temperature: It has a steeper gradient at the start but becomes horizontal sooner
- This graph below shows that the rate of reaction was greater at the **higher temperature**.



2. Pressure

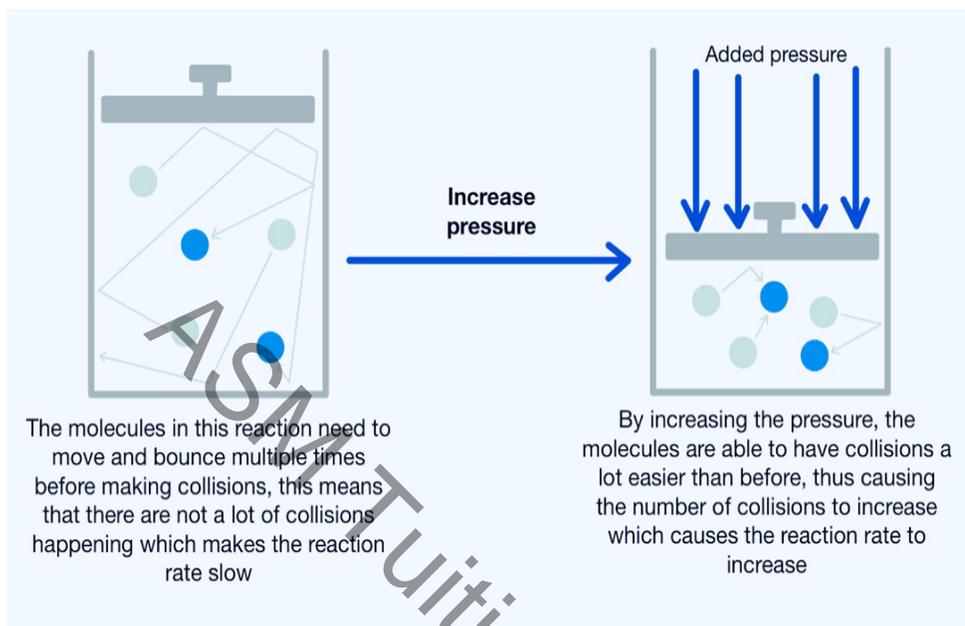
- **Increasing the pressure** under which a reaction is taking place will lead to an **increase in the frequency of successful collisions**.

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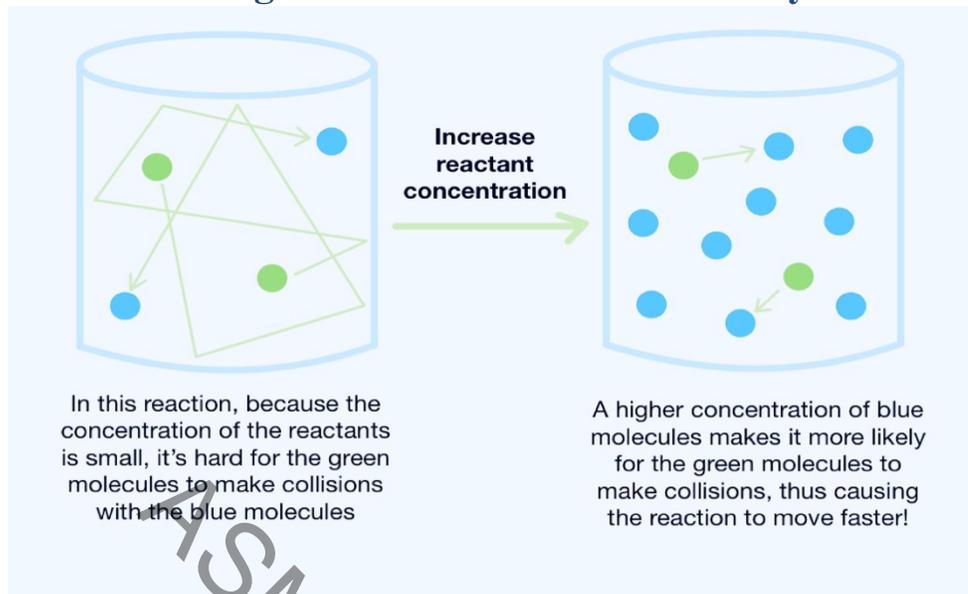
- For Example a container containing two reacting gasses. The particles of gas are able to **move around** inside the container, **colliding with each other** as well as the walls of the container.
- As increase the pressure no of collision increases which lead to increase in rate of reaction.



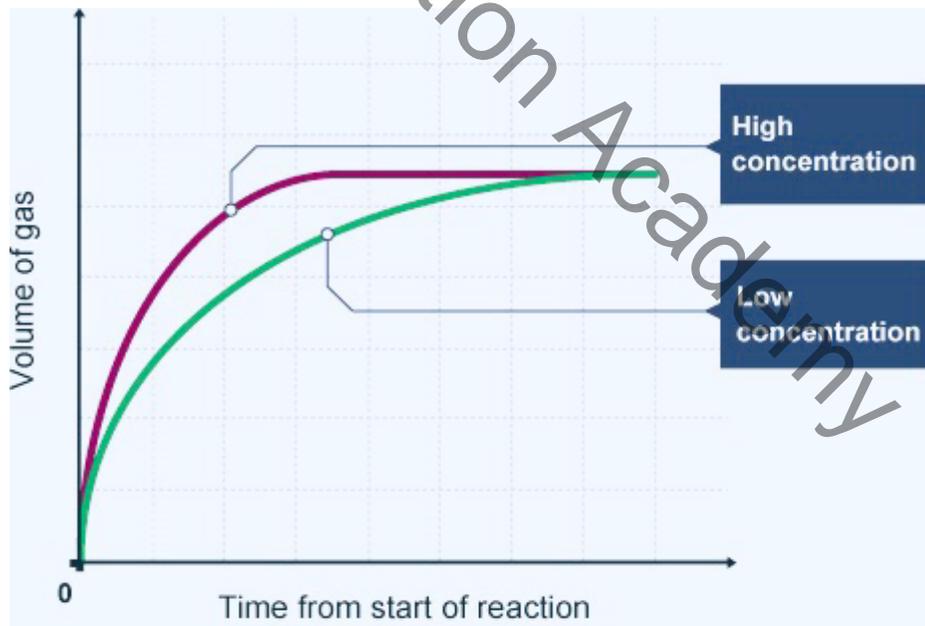
3. Concentration

- **Increasing the concentration** of reactants will also **increase the total number of collisions**. In this case, imagine a container containing reacting gasses.
- Instead of reducing the size of the container, we **double the concentrations** of the reacting gasses. This will **double the number of particles present** in the container.
- This will **reduce the space that each particle has to move around** in and will lead to an **increase in the total number of collisions**. Therefore, **increasing the concentration of reactants will increase the frequency of successful collisions**.

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- Compared to a reaction with a reactant at a low concentration (if a solution), the graph line for the same reaction but at a higher concentration: It has a steeper gradient at the start but becomes horizontal sooner.
- This graph below shows that the rate of reaction was greater at the **higher concentration**.



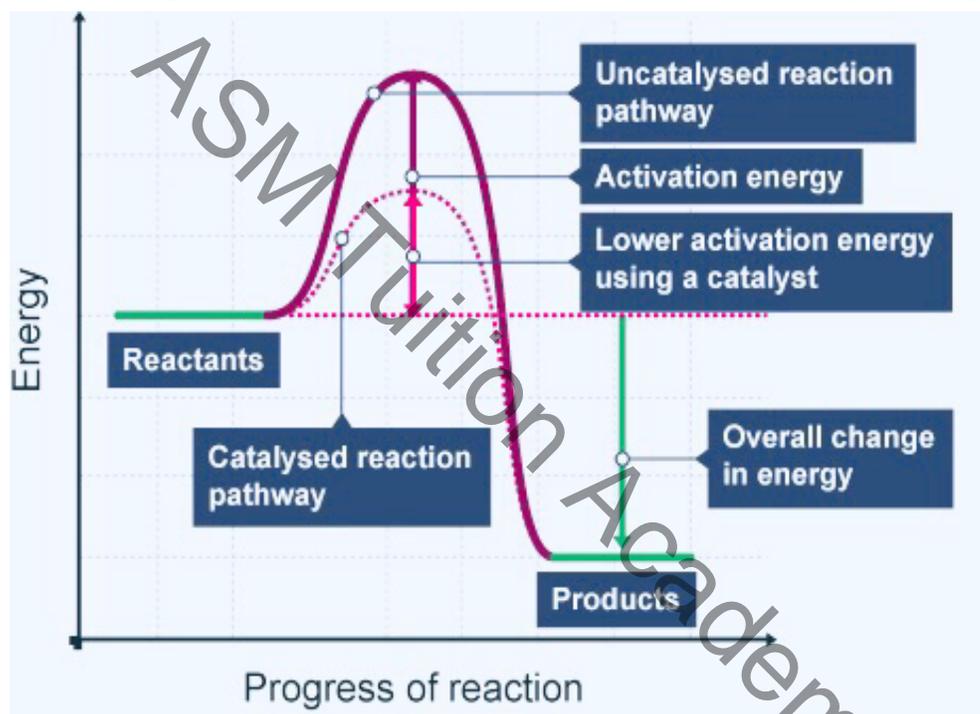
4. Catalysts

- The rate of a reaction can be increased by adding a suitable **catalyst**. A catalyst is a substance which increases the rate of a chemical reaction but it is not used up (remains chemically unchanged at the end).

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- Only a very **small amount** of catalyst is needed to increase the rate of reaction between large amounts of reactants.
- A catalyst is **specific** to a particular reaction:
 - ① Different catalysts catalyse different reactions
 - ② Not all reactions have suitable catalysts
- The amount of catalyst not used up provides an alternative reaction pathway of lower activation energy (**Activation energy** is the minimum energy needed for a reaction to occur when two particles collide).
- The diagram below shows **that a catalyst provided a reaction pathway of lower activation energy**. This makes more of the collisions successful at a given temperature.



5. Surface Area:

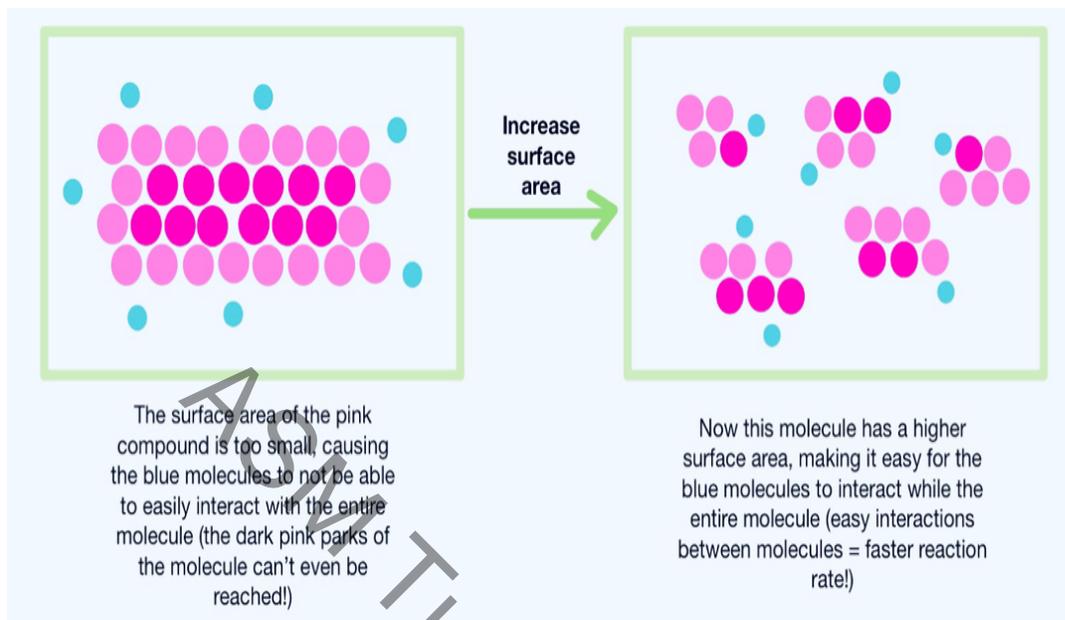
- Most chemical reactions take place in the **liquid** or **solution** phases, where all the particles of the reactants are able to move around and collide.
- However, in some reactions (such as the thermal decomposition of calcium carbonate) one or more of the reactions is in the **solid phase**. In these cases, the **majority of the particles** of the solid reactants are found in the **centre of the solid**. These particles are unable to react as **no particles of the other reactants can collide with them**.
- So increases the rate of a chemical reaction by using smaller solid particles which increases the surface area of a solid reactant. This is done by cutting the substance into small pieces, or by grinding it into a powder. If the surface area of a reactant is increased:
 - ① More particles are exposed to the other reactant

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- ② There are more successful collisions per unit time
- ③ The rate of reaction increases



- Compared to a reaction with lumps of reactant, the graph line for the same reaction but with powdered reactant: It has a steeper gradient at the start but becomes horizontal sooner.



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