CHEMISTRY ONLINE
— TUITION —

Phone: +442081445350

www.chemistryonlinetuition.com

Email:asherrana@chemistryonlinetuition.com

CHEMISTRY

Physical Chemistry

Level & Board	AQA (A-LEVEL)
TOPIC:	KINETICS
PAPER TYPE:	SOLUTION - 3
TOTAL QUESTIONS	10
TOTAL MARKS	47

Kinetics - 3

1.

(a)

Activation energy minimum energy to start a reaction/ for a reaction to occur for a successful collision.

(2)

(b)

The reaction between hydrogen and chlorine is very slow at room temperature because activation energy is high so, few molecules / particles have sufficient energy to react.

(1)

(c)

An increase in pressure, at constant temperature, increases the rate of reaction between hydrogen and chlorine because molecules are closer together more particles in a given volume therefore collide more often.

(2)

(d)

A small increase in temperature can lead to a large increase in the rate of reaction between hydrogen and chlorine because at high temperature many or more molecules have energy greater than activation energy.

(2)

(e)

A catalyst is a substance that alters the rate of a chemical reaction without undergoing any net chemical change itself at the end of the reaction. It functions by providing an alternative pathway for the reaction, reducing the activation energy required for the reaction to proceed.

(1)

(f)

_Using a solid catalyst in powder form significantly increases the surface area available for reaction, enhances reactivity, improves kinetics, and facilitates practical usage in gas-phase reactions compared to bulk or larger forms of the catalyst.

(1)

2.

(a)

The student did not obtain a straight line because:
Increasing concentration or temperature leads to more frequent collisions between reactant particles.

These collisions have a higher chance of possessing the necessary energy (activation energy) for a successful reaction.
More collisions with sufficient energy result in an increased rate of reaction.

(3)

(b)

The presence of oxide (MgO) or other compounds like magnesium hydroxide on the surface of the magnesium ribbon can significantly impact its reactivity when reacting with hydrochloric acid.
This coating must be removed to allow the underlying magnesium metal to react with hydrochloric acid.
The clean magnesium surface may react at different rates or initially inhibit the reactivity of the magnesium metal until the coating is removed, ensuring a more accurate assessment of the reaction rate between magnesium and hydrochloric acid.

(2)

(c)

Speed of Reaction:
Reaction with hot water: Slower
Reaction with steam: Faster
Products Formed:
Hot water reaction: Produces magnesium hydroxide ($2Mg(OH)_2$)
Steam reaction: Produces magnesium oxide (MgO)
Observation:
Hot water reaction: Shows slower bubbling
Steam reaction: Exhibits a bright white light, flame, or white solid formation

(2)

(d)

Solubility of Group 2 Sulfates:

- Magnesium sulfate ($MgSO_4$) is significantly more soluble in water compared to calcium sulfate (CaSO4).
- $MgSO_4$ is highly soluble and readily dissociates into its constituent ions (Mg^{2+} and SO_4^{2-}) in solution.
- On the other hand $CaSO_4$ is less soluble in water, meaning it has a lower tendency to dissociate into calcium ions (Ca^{2+}) and sulfate ions (SO_4^{2-}) in solution.

Reactions of Magnesium and Calcium with Sulfuric Acid:

- When pure magnesium reacts with dilute sulfuric acid, it undergoes a complete reaction, forming magnesium sulfate ($MgSO_4$) and hydrogen gas (H_2). Since magnesium sulfate is highly soluble, it dissolves readily in the solution, effectively removing it from the reaction site and allowing the reaction to proceed to completion.
- In the case of calcium reacting with sulfuric acid, the initial reaction is rapid, generating calcium sulfate ($CaSO_4$) and hydrogen gas (H_2). As $CaSO_4$ is less soluble than $MgSO_4$, it tends to precipitate or form a solid precipitate (as it is sparingly soluble) during the reaction. This solid $CaSO_4$ coats the remaining calcium metal surface, forming a barrier that prevents further reaction. This layer of calcium sulfate inhibits the continuous reaction between calcium and sulfuric acid, causing the reaction to slow down and eventually stop before all the calcium has reacted.

(3)

3.

1. **Incorrect Orientation of Colliding Molecules:** Most collisions between gas-phase reactants do not result in a reaction because they often occur with incorrect orientations. For a successful reaction to occur, molecules must collide in a specific orientation that allows the necessary bonds to be formed or broken.

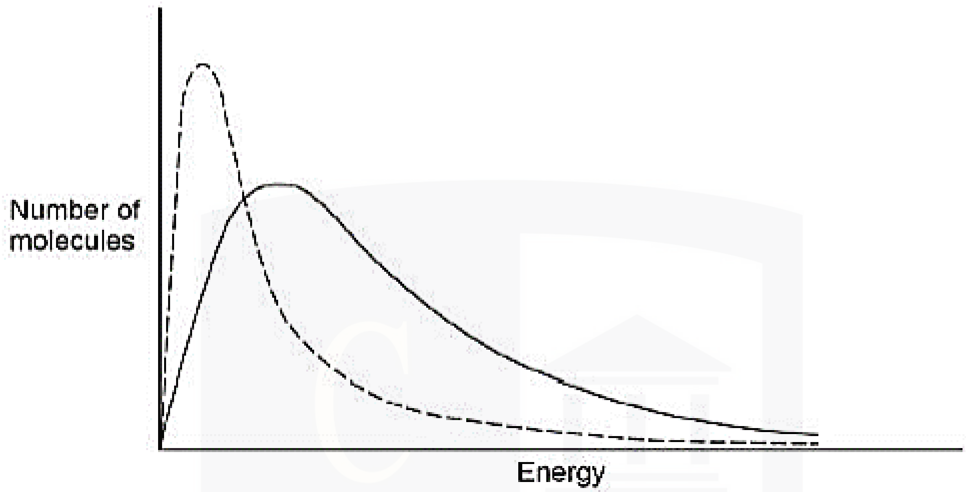
Two ways of speeding up a gas-phase reaction other than by changing the temperature:

1. **Catalysis:** Using a catalyst is a way to accelerate a gas-phase reaction without changing the temperature significantly. A catalyst provides an alternate pathway for the reaction, lowering the activation energy required for the reaction to proceed.
2. **Increase in Pressure:** By increasing the pressure, the concentration of gas molecules is augmented. This increased concentration leads to more frequent collisions between the gas molecules in a given volume. According to collision theory, an increase in pressure leads to a higher frequency of collisions. This higher frequency of collisions enhances the likelihood of effective collisions occurring, consequently speeding up the rate of the gas-phase reaction.

(5)

4.

(a)



(3)

(b)

Reason for Decreased Rate :

- Fewer molecules have sufficient energy ($E \geq Ea$) to react.

Effect on Collisions :

- Results in fewer effective collisions, reducing the reaction rate.

(2)

5.

(a)

The rate equation:

$Rate = k[A]^x[B]^y$

The x term signifies the order of reaction with respect to substance A.

(1)

(b)

When the concentrations of A and B are doubled:

$Rate = k[A]^x[B]^y$

If the initial rate increases by a factor of 4 (2^2) when both concentrations are doubled (2[A] and 2[B]), it implies that the combined effect of doubling both concentrations results in a total order of 2 (second-order reaction).

In mathematical terms:

$(2[A])^x \times (2[B])^y$
$= 2^x \times 2^y [A]^x [B]^y$
$= 4[A]^x[B]^y$
For $2x \times 2y = 4$,
$x+y=2$ because $2^2=4$
$x+y=2$

The orders of the reaction with respect to A (x) and B (y) must sum up to 2 to account for the observed fourfold increase in the initial rate when concentrations of both A and B are doubled.

(1)

(c)
i.
Order with respect to A: 2
Order with respect to B: 0

(2)

ii.
Rate equation: (rate =) k $[A]^2$
Units for rate constant: $mol^{-1}\ dm^3\ s^{-1}$

(2)

6.
(a)
Catalyst: yeast or zymase
Name of the organic product of the reaction: ethanol

(2)

(b)
Catalyst: (Concentrated) H_3PO_4 (Concentrated) H_2SO_4
Name of the organic product of the reaction: butan-2-ol

(2)

7.
(a)
The formation of hydrogen iodide from hydrogen and iodine is exothermic. So, ΔH is negative.

(1)

(b)

The diagram suggests that:
Σ bond (enthalpy) reactants < Σ bond (enthalpy) products
So, the sum for H_2 and I_2/reactants is less than /smaller than the sum for 2HI/products

(1)

8. (B)

(Total 1 mark)

9.

Increasing Reactant Concentration: *This change does not involve a different activation energy.*
When reactant concentration increases, it affects the rate constant (k) in the Arrhenius equation ($k = A \cdot e^{-Ea/RT}$) but not the activation energy (Ea). The Arrhenius equation doesn't alter the activation energy but influences the rate constant by changing the frequency of collisions between reactant molecules. It enhances the rate by providing more molecules that can overcome the existing activation energy barrier.
Adding a Catalyst: *Catalysts work by providing an alternative reaction pathway with a lower activation energy. They facilitate the reaction by offering a different mechanism, reducing the energy required for the reaction to occur.*
Increasing Temperature: *This change does involve a different activation energy. When temperature increases, it affects the activation energy required for the reaction. The higher temperature provides more kinetic energy to the molecules, allowing a larger proportion of them to possess energies equal to or greater than the activation energy.*
So, among the changes mentioned, increasing temperature is the one that involves a different activation energy. The other changes - increasing reactant concentration and adding a catalyst - influence the rate of the reaction without altering the activation energy, while the temperature change directly affects the activation energy required for the reaction to occur.

(5)

10. (D)

(Total 1 mark)

DR. ASHAR RANA

M.B.B.S / MS. CHEMISTRY

CHEMISTRY ONLINE
TUITION

Phone: +442081445350
www.chemistryonlinetuition.com
Email: asherrana@chemistryonlinetuition.com

- Founder & CEO of Chemistry Online Tuition Ltd.
- Completed Medicine (M.B.B.S) in 2007
- Tutoring students in UK and worldwide since 2008
- CIE & EDEXCEL Examiner since 2015
- Chemistry, Physics, Math's and Biology Tutor

CONTACT INFORMATION FOR

CHEMISTRY ONLINE TUITION

- UK Contact: 02081445350
- International Phone/WhatsApp: 00442081445350
- Website: www.chemistryonlinetuition.com
- Email: asherrana@chemistryonlinetuition.com

Address: 210-Old Brompton Road, London SW5 OBS, UK