

GCSE Combined Science: Trilogy

Worksheet: Collision theory and activation energy

TIME 30 min	TOTAL 29 marks	CALCULATOR Allowed	DIFFICULTY Easy, Medium
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Topics: Collision theory and activation energy

NAME	CLASS	DATE
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- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Answer all questions in the spaces provided.
- In all calculations, show clearly how you work out your answer.
- The marks for questions are shown in brackets.

0	1
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0	1	.	1
---	---	---	---

 Which statement correctly and fully explains why increasing the temperature increases the rate of a reaction?

Tick (✓) **one** box.

Particles collide more frequently only

☐

A greater proportion of collisions have enough energy to react only

☐

Particles collide more frequently, and a greater proportion of collisions have enough energy to react

☐

The activation energy of the reaction decreases

☐

[1 mark]

0	1	.	2
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 What is meant by a 'successful' collision?

.....

.....

[1 mark]

0 2

0 2 . 1

Complete the sentence.

Chemical reactions can only happen when reacting particles _____ with each other with enough energy.

.....

.....

.....

.....

[1 mark]

0 2 . 2

What is the name for the minimum amount of energy that particles must have to react?

.....

.....

.....

.....

[1 mark]

0 2 . 3

Why does increasing the concentration of an acid increase the rate of its reaction with a metal?

Tick (✓) **one** box.

The acid particles move faster.

☐

There are more acid particles in the same volume, so collisions are more frequent.

☐

The activation energy is lower.

☐

Each collision has more energy.

☐

[1 mark]

0 2 . 4

Increasing the temperature increases the rate of a reaction.

Give **two** reasons why, in terms of particles.

.....

.....

.....

.....

[2 marks]

0 3

In a model of a reaction between two gases, only a very small fraction of the collisions between reacting particles are successful.

- At 20 °C, about 1 in every 10 000 collisions is successful.
- At 30 °C, about 1 in every 5000 collisions is successful.

Raising the temperature from 20 °C to 30 °C increases the number of collisions per second by less than 2%.

0 3 . 1

Calculate how many times more likely a collision is to be successful at 30 °C than at 20 °C.

.....

.....

.....

.....

Factor = times

[2 marks]

0 3 . 2

Use the information to explain why the rate of the reaction roughly doubles for this 10 °C rise in temperature.

[2 marks]

0 4

Not every collision between reacting particles results in a chemical reaction.

0 4 . 1

Explain why most collisions between reacting particles do **not** result in a reaction.

[2 marks]

0 4 . 2

Increasing the concentration of a reactant increases the rate of reaction, but does not change the proportion of collisions that are successful.
Explain why the rate still increases.

[2 marks]

0 5

A student compared a single 2 cm cube of calcium carbonate with another 2 cm cube that had been cut into eight 1 cm cubes.

0 5 . 1

Calculate the surface area to volume ratio of the single 2 cm cube.

.....

.....

.....

.....

[2 marks]

0 5 . 2

Calculate the total surface area of the eight 1 cm cubes.

.....

.....

.....

Total surface area = cm²

[1 mark]

0 5 . 3

Both samples were added to equal volumes of the same hydrochloric acid.
Explain why the eight small cubes reacted faster than the single cube.

.....

.....

.....

.....

.....

.....

[3 marks]

.....

0 6

A student is investigating how breaking a solid reactant into smaller pieces affects the rate of its reaction with an acid, using pieces of eggshell (calcium carbonate) reacting with vinegar.

0 6 . 1

Predict how crushing the eggshell into a fine powder, rather than using whole pieces, would affect the rate of reaction with the same mass of eggshell. Explain your prediction using collision theory.

.....

.....

.....

.....

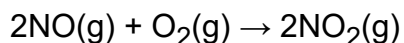
.....

.....

[3 marks]

0 7

Nitrogen monoxide reacts with oxygen to produce nitrogen dioxide.



0 7 . 1

Explain, using collision theory, why increasing the pressure increases the rate of this reaction.

.....

.....

.....

.....

[2 marks]

0 7 . 2

A student says:

'Increasing the pressure increases the rate because the particles collide with more energy.'

Explain why the student is wrong.

[2 marks]

0 7 . 3

Suggest why changing the pressure has no effect on the rate of the reaction between magnesium and hydrochloric acid.

[1 mark]

END OF QUESTIONS

Original practice questions written to match the specification. Not produced by, affiliated with or endorsed by AQA.

Mark scheme

GCSE Combined Science: Trilogy · Worksheet: Collision theory and activation energy · 29 marks

Question 1 (2 marks)

01.1 [1 mark]

Correct: Particles collide more frequently, and a greater proportion of collisions have enough energy to react

01.2 [1 mark]

Answer: A collision between particles that has at least the activation energy, so a reaction happens.

- a collision (between reacting particles) with energy greater than or equal to the activation energy, so that a reaction occurs (1)
-

Question 2 (5 marks)

02.1 [1 mark]

Answer: collide

- collide (1)
-

02.2 [1 mark]

Answer: Activation energy

- activation energy (1)
-

02.3 [1 mark]

Correct: There are more acid particles in the same volume, so collisions are more frequent.

02.4 [2 marks]

Answer: Particles move faster so collide more often; collisions are more energetic, so more particles have at least the activation energy.

- particles move faster, so they collide more frequently (1)
 - collisions are more energetic / more particles have energy greater than or equal to the activation energy (1)
-

Question 3 (4 marks)

03.1 [2 marks]

Answer: 2 times

- $1 \div 5000$ compared with $1 \div 10\,000$ / $10\,000 \div 5000$ (1)
 - 2 (times) (1)
-

03.2 [2 marks]

Answer: The proportion of collisions with enough energy to react (at least the activation energy) doubles, while the number of collisions per second increases only slightly, so the number of successful collisions per second (and the rate) roughly doubles.

- the proportion of collisions that are successful (with energy at least equal to the activation energy) doubles (1)
 - while the frequency of collisions increases only slightly (by less than 2%), so the number of successful collisions per second, and so the rate, roughly doubles (1)
-

Question 4 (4 marks)

04.1 [2 marks]

Answer: Most colliding particles do not have enough energy (less than the activation energy) for the reaction to happen.

- most colliding particles have less energy than the activation energy (1)
 - so bonds cannot be broken and the collision does not lead to a reaction (1)
-

04.2 [2 marks]

Answer: Although the proportion of successful collisions stays the same, there are more collisions overall per second, so the number of successful collisions per second increases.

- there are more particles in the same volume, so the total frequency of collisions increases (1)
 - so, even though the same proportion are successful, the number of successful collisions per second increases (1)
-

Question 5 (6 marks)

05.1 [2 marks]

Answer: 3 : 1

- surface area = $6 \times 2 \times 2 = 24 \text{ (cm}^2\text{)}$ and volume = $2 \times 2 \times 2 = 8 \text{ (cm}^3\text{)}$ (1)
- $(24 : 8 =) 3 : 1$ (1)

05.2 [1 mark]

Answer: 48 cm^2

- $48 \text{ (cm}^2\text{)}$ (1)

05.3 [3 marks]

Answer: The small cubes have a larger surface area to volume ratio (6 : 1 instead of 3 : 1), so more particles are exposed to the acid and collisions are more frequent.

- the small cubes have a larger surface area to volume ratio (6 : 1 compared with 3 : 1) (1)
- so more calcium carbonate particles are exposed to the acid (1)
- so there are more frequent collisions (1)

Question 6 (3 marks)

06.1 [3 marks]

Answer: The rate would be much faster: crushing increases the total surface area exposed to the acid, so acid particles collide with the calcium carbonate more frequently, increasing the number of successful collisions per second.

- the rate would be (much) faster with the powder (1)
 - crushing the eggshell increases its total surface area (surface area to volume ratio) for the same mass (1)
 - so acid particles collide with calcium carbonate particles more frequently, increasing the number of successful collisions per second (1)
-

Question 7 (5 marks)

07.1 [2 marks]

Answer: There are more particles in the same volume, so they collide more frequently.

- (the same number of) particles in a smaller volume / more particles in the same volume (1)
 - so the particles collide more frequently (1)
-

07.2 [2 marks]

Answer: Increasing the pressure does not change the energy of the particles (the temperature is the same); it only increases the frequency of collisions.

- increasing the pressure does not change the energy of the particles (at the same temperature) (1)
 - it only increases the frequency of collisions (1)
-

07.3 [1 mark]

Answer: There are no gaseous reactants.

- there are no gaseous reactants / the reactants are a solid and a solution (1)
-