BioMedical Admissions Test (BMAT)

Section 2: Chemistry

Questions by Topic

C10 - Rates of Reaction

C10: Rates of Reaction - Question by Topic

(Mark Scheme and explanations at the end)

1 Which of the following methods could be used to measure the rate of reaction between zinc metal and dilute hydrochloric acid?

1 using inverted measuring cylinder
2 using gas syringe
3 time taken for cross to disappear
4 measuring loss of mass

A 1 and 2 only
B 1 and 4 only
C 1, 2 and 4 only
D All of the statements

2 Which of the following statements about catalysts is correct?

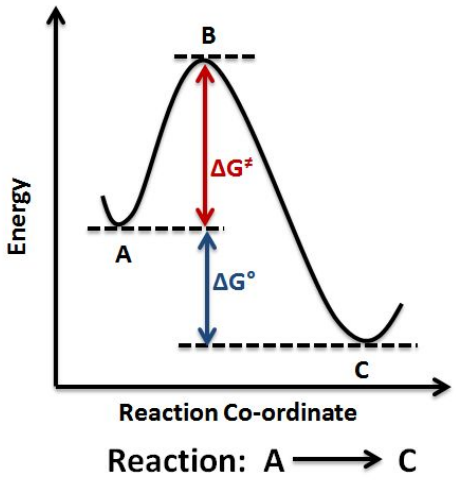
A When a catalyst is used in a reversible reaction, only the rate of the forward reaction is increased
B They increase the number of collisions, and the proportion of these that are successful
C Catalysts do not participate in the reaction, therefore are not used up in the reaction
D They cause the rate of reaction to increase by means of increasing the temperature of the environment
E Catalysts can be used to change the properties of the products of a reaction

3 Which of the following changes will result in the collisions between particles becoming more likely to be successful?

1 increasing concentration
2 increasing temperature
3 catalyst
4 increasing surface area of reactant

A 1 and 2 only
B 2 and 3 only
C 1, 2 and 3 only
D All of the statements

4



Which of the following statements regarding the diagram are false?

A The reaction is exothermic
B $\triangle G^{\neq}$ can be decreased through the use of catalysts
C The products of the reaction are more stable
D The line labelled $\triangle G^{o}$ shows the heat energy transferred in the reaction
E $\triangle G^{\neq}$ is the minimum number of particles that need to successfully collide for a reaction to occur

By AimNature, 10 November 2013, 16:34:10
https://commons.wikimedia.org/wiki/File:Reaction_Coordinate_Diagram.png

5 Which of the following statements best explains the way that increasing temperature increases the rate of reaction?

A It increases the speed at which the particles move, and therefore their activation energy.
B It increases the activation energy of the particles, therefore their speed and as a result the frequency of successful collisions.
C It increases the kinetic energy of the particles, resulting in more frequent collisions (in a given time), however does not affect the likelihood of these being productive.
D It decreases the activation energy of the particles, meaning more collisions have the necessary energy to be successful.
E It increases the kinetic energy of the particles, resulting in a higher frequency of collisions (in a given time), and a greater proportion of these being successful.

6 Which of the following statements are correct about the reaction between hydrochloric acid and sodium thiosulfate?

1 It forms a yellow precipitate of sodium sulfate.
2 Increasing the pressure will increase the rate of reaction.
3 The initial rate of reaction can be found by measuring the time taken for a cross to disappear.
4 The initial rate of reaction can be found by measuring the time taken for a set amount of gas to be produced (e.g. via gas syringe).

A 3 only
B 1 and 3 only
C 1, 2 and 3 only
D All of the statements

7 Magnesium and sulfuric acid react to produce magnesium sulfate and hydrogen gas.

In the following experiments the volume of hydrogen gas is measured to find the rate of reaction.

Experiment 1: Uses an excess of magnesium and 60 cm^3 of 2.00 mol dm^{-3} sulfuric acid. It is carried out at 20°C.

Experiment 2: Uses an excess of magnesium and 120 cm^3 of 1.00 mol dm^{-3} sulfuric acid. It is carried out at 20°C.

On a graph showing the volume of gas formed against time, what differences will there be between the lines showing Experiment 1 and 2?

A Line 2 will reach a greater height, but both lines will show the same initial rate.
B The lines will ultimately reach the same height, but 2 will show a slower initial rate.
C Line 2 will reach a greater height and will show a faster initial rate.
D The lines will ultimately reach the same height, and will show the same initial rate.
E Line 2 will reach a greater height but show a slower initial rate.

8 To demonstrate the rate of reaction, graphs of change in product against time may be plotted. Which of the following statements regarding these graphs are correct?

1 The average rate of the reaction can be found by calculating the gradient of the tangent to the curve at the start.
2 The reaction has completed when the gradient is 0.
3 To find the rate of reaction at a certain point, find the gradient of a tangent to the curve at this point.

A 1 only
B 2 only
C 3 only
D 1 and 2 only
E 1 and 3 only
F 2 and 3 only
G All of the statements

9 Which of the following statements best explains the collision theory?

A In a smaller space, particles are more likely to collide and therefore react.
B For two particles to react, they must have the required activation energy.
C In a certain space, particles will meet each other at a certain frequency, which may be increased by decreasing the space available or increasing the particles present.
D Two particles must have sufficient energy and collide at the right orientation in order to react.
E Only a proportion of collisions will be successful as some particles will not have the activation energy, the correct orientation or the right speed.

10 One variation of the iodine clock is that using hydrogen peroxide.
A solution of potassium iodide, sodium thiosulfate and starch is added to a solution of hydrogen peroxide and sulfuric acid.

The following reactions occur within the solution formed.

1. $H_2O_2 + 3I^- + 2H^+ \rightarrow I_3^- + 2H_2O$ slow

2. $2S_2O_3^{2-} + I_3^- \rightarrow S_4O_6^{2-} + 3I^-$ fast

Which of these statements are correct?

1 The rate of reaction will be found by measuring the time taken for the solution to turn dark grey- caused by the presence of solid iodine.
2 Equation 1 shows the oxidation of iodide ions under acidic conditions.
3 If the pH of the solution is increased, the colour change will occur sooner.
4 The starch added reacts with the triiodide forming a complex. This complex results in a colour change to blue.

A 1 and 2 only
B 2 and 4 only
C 1, 2 and 3 only
D 2, 3 and 4 only

11 A solution of calcium nitrate is reacted with concentrated, aqueous sodium hydroxide.
What is the most efficient way to measure the rate of this reaction?

A Use a colour chart to estimate the change in colour of the reaction at regular intervals.
B Measure the mass of precipitate formed at regular intervals
C Measure the overall mass change in the reaction container
D Use a gas syringe to measure the rate of gas evolved
E Measure the change in volume of the solution

Answers and Explanations

1 **C is the answer.**

The reaction between metal and acid produces salt and hydrogen gas. The rate of this reaction can therefore be measured by collecting/measuring the gas produced, via

- Gas syringe
- Inverted measuring cylinder
- Measuring loss of mass

The final method involves carrying out the reaction on an electronic (so live) balance in an open container; the gas escapes, resulting in the loss of mass. This can be measured to find the rate of reaction.

The 'cross disappearing' method is not viable for this reaction as the hydrochloric acid is colourless.

2 **E is the answer.**

Catalysts can act by decreasing the activation energy or by changing the mechanism of a reaction. Without a catalyst, more of product A may be produced as there may be a major route towards it (rather than product B). These routes may have different mechanisms, and so a certain catalyst may only speed up the minor route, leading to an increase in product B. Product B may have different properties.

While this isn't in the assumed knowledge specification, you should be able to work by elimination to rule out the other options.

A is incorrect; catalysts do not affect the position of equilibrium so the rate of the forward and backward reaction are increased by the same amount.

B is partially incorrect; catalysts reduce the activation energy. This means that a higher proportion of collisions will be successful, not that there will be more collisions themselves.

C While catalysts are chemically unaltered at the end of the reaction, they do participate; they are remade at the end.

D is incorrect. Catalysts work by providing an alternative route with a lower activation energy.

3 **B is the answer.**

Remember that collisions are successful when

a) Collide at correct orientation
b) Have sufficient energy

Increasing concentration increases the likelihood of collisions occurring (as smaller space but the same number of particles), and therefore the likelihood of successful collisions occurring, but not that these will be successful.

Increasing temperature means that the particles will have more energy, therefore more particles will have the required activation energy and so a greater proportion of the collisions occurring will be successful.

The use of a catalyst lowers the activation energy needed by particles to successfully collide, therefore resulting in a greater proportion of particles meeting this demand.

Increasing surface area again only increases the likelihood of the particles meeting, not that these collisions will be productive.

4 **E is the answer**

$\triangle G^{\neq}$ is the activation energy: the minimum amount of energy a particle must have to successfully react upon collision.

5 **E is the answer.**

A Increasing temperature increases the kinetic not activation energy of the particles.
B See above.
C The increase in kinetic energy also increases the proportion of reactions that are successful as more particles will have the required activation energy.
D Temperature does not affect the activation energy.

6 **A is the answer.**

The balanced equation for the reaction is:

$$Na_2S_2O_3\ (aq) + 2HCl\ (aq) \rightarrow 2NaCl\ (aq) + H_2O\ (l) + SO_2\ (aq) + S\ (s)$$

Statement 1 is incorrect; the yellow precipitate formed in the reaction is sulfur not sodium sulfate.
Statement 2 is incorrect: the reactants are aqueous/in solution, not gaseous. Increasing concentration would increase the rate of reaction in this instance.
Statement 3 is correct: a yellow precipitate is formed, which will eventually conceal the cross.
Statement 4 is incorrect: no gas is produced in this reaction.

Therefore, only statement 3 is correct and A is the answer.

7 **B is the answer.**

From experiment 1 to 2, the concentration of sulfuric acid halves but the volume doubles; there are the same amount of moles present so the total volume of hydrogen gas produced will not change and the two lines will reach the same height.

However, the particles in experiment 1 are in half the volume, therefore resulting in a higher frequency of collisions, and so a higher initial rate of reaction.

8 **F is the answer.**

Statement 1 is incorrect; this is how you find the initial rate of reaction.
Statement 2 is correct: a line with a gradient of 0 is horizontal; there is no further product being formed as the reactants have been used up.
Statement 3 is correct: the gradient is a measure of rate of reaction.

Therefore only statements 2 and 3 are correct so the answer is F.

9 **D is the answer.**

A is incorrect; the collision theory concerns the fact that a proportion of collisions will not be successful. This statement describes how increasing decreasing volume may affect the frequency of collisions.
B is incorrect; while the statement is true, this is not the only requirement for a successful reaction: they must also have the correct orientation.
C Again, this concerns the effect of volume and concentration on collision theory rather than the nature of some collisions being unsuccessful.
E is incorrect; a certain speed is not also specifically required- it is the activation energy that is needed (this will influence the speed.)

10 **B is the answer.**

Statement 1 is incorrect; as soon as the triiodide is formed it reacts with starch to form a complex, resulting in a blue/black colour.
Statement 2 is correct; the iodide ions are oxidised by hydrogen peroxide to triiodide ions (remember oxidation is the loss of electrons).
The triiodide ions are reduced by thiosulfate ions in equation 2, once again forming iodide ions.
Statement 3 is incorrect; the first reaction is the rate-determining step as it is slow. However, increasing the pH means decreasing the concentration of hydrogen ions, therefore reducing the reactant available and slowing down the reaction instead.
Statement 4 is correct.

Therefore only statements 2 and 4 are correct so the answer is B.

11 **The answer is B**

No gas is evolved in this reaction, rendering Options C, D and E of no use. Option 1 is qualitative, not quantitative and so will not give us a rate of reaction. However, we **can** measure the mass of insoluble white precipitate (calcium hydroxide) formed at different intervals, and record the time taken at each interval using a stopwatch