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MEMORANDUM Topic : Reaction Rates
Basic Multiple Choice Questions (Level 1 and 2 Learners)

- 1 (D) Only the surface area of the metal reacts with the acid, HCl . Once the metal surface is covered by acid, adding more acid has no further effect.
- 2 (A) Products have more energy in an endothermic reaction.
Eg. Cooking. The food has more energy in it after being cooked.
- 3 (C) Suitable catalysts always speed up any reaction.
- 4 (A) Reverse reaction is opposite to forward reaction.
- 5 (D)
- 6 (A)
- 7 (C) Suitable catalysts increase any reaction rate.
- 8 (A)
- 9 (A) pressure increases the concentration of a gas
- 10 (D) Greater concentration of acid means more H^+ ions to react with the surface atoms of the metal.
- 11 (A)
- 12 (A) pressure only affects the volume of gases
- 13 (B) powdered zinc reacts fastest and so does the more concentrated acid.
- 14 (A) Mg is more active than zinc as it is higher on the E^0 table. Thus Mg makes the H_2 in less time.

MEMORANDUM Difficult Multiple Choice Questions (Level 5 - 7 Learners)

- 1 (C) we must keep adding heat
 - 2 (B) a catalyst increases the rate of both the forward and reverse reactions
 - 3 (B) $100 - 300 = -200$
 - 4 (A) $300 - 100 = 200$
 - 5 (A) $800 - 0 = 800$
 - 6 (B) $600 - 300 = 300$
 - 7 (D) $800 - 100 = 700$
 - 8 (C) $600 - 100 = 500$
 - 9 (A) $600 - 0 = 600$
 - 10 (B) $300 - 0 = 300$
- 11 (D) How far a reaction goes and how fast a reaction is, cannot be predicted from the balanced equation but from experimental data.
- 12 (D) Exothermic reactions are generally faster but not always. ΔH doesn't give reaction speeds.
- 13 (C) Reaction **rates decrease** with time at a **microscopic level** since the concentration of $\text{Na}_2\text{S}_2\text{O}_3$ decreases as the reaction proceeds. The sulfur **colour intensifies** with time indicating **more product is forming** at a **macroscopic level**.
- 14 (C) Both reactions speed up but the **endothermic** reverse reaction which produces cold is **more sensitive** to temperature increases and is **affected more** than the forward reaction.
- 15 (A) As the reagents get used up, oxygen is given off at a slower rate.
A catalysed reaction is faster but also decreases in time as the reagents get used up.
- 16 (C) Concentration of reactants is a maximum at the start and thus the reaction rate is a maximum at the start. Concentration of reactants decreases as the reaction proceeds, and thus the rate decreases.
- 17 (A) As the reaction proceeds the amount of oxygen given off increases and tapers off slowly to a maximum as the reactants get used up.
The slope or gradient of this graph yields the rate.
The gradient get less with time. (so does the gradient of C but its amount of oxygen gets less instead of more)
- 18 (A) Cell potentials are positive so chemical energy is spontaneously converted to electrical energy.
This tells us that the reactions do happen but it says nothing about the rate of each reaction. A positive cell potential may proceed at a rate that is not measurable.
- 19 (D) Temperature increases the average kinetic energy.
20. C We must keep adding heat to achieve thermal decomposition.
21. D $\text{rate} \propto [\text{X}][\text{Y}]$
So changing concentrations doesn't affect the slope.
A new temperature causes a new rate (or slope)
22. C $U + K = \text{a constant value (on the y - axis)}$.
Thus K is the mirror image of U through a horizontal line drawn half way up the y - axis
23. (D) Two NO_2 molecules slow down and combine to form $(\text{NO}_2)_2$ which is N_2O_4
24. A High pressure increases the concentration and thus the rate. High temperature always increases the reaction rate.
25. B Provided that the small piece of magnesium is completely covered, adding more of the same acid will have no effect.
26. A Temperature raises the rate of all reactions.
27. A Heating increases any reaction rate.

1.
 - 1.1 Rate of reaction is the change in concentration of a product or a reactant in a unit of time.
 - 1.2 Temperature, adding a suitable catalyst, the nature of the reacting substances.
 - 1.3 Surface area, Powdering a solid increases the reaction rate.
 - 1.4 Concentration.
 - 1.5 Pressure
2.
 - 2.1 an atom of fluorine gas.
 - 2.2 an atom of liquid bromine
 - 2.3 an atom of solid potassium.
 - 2.4 an aqueous dissolved sodium ion.
(a hydrated sodium ion)
- 3.1 Chemical potential energy is stored up inside the atoms of a substance and their chemical bonds.
- 3.2 Chemical potential energy is affected by the size and polarity (or charges) of the particles.
- 3.3 The particles move faster and become hotter.
- 3.4 The particles move further away from each other which can enable the bonds between atoms to stretch and finally snap.
4.
 - 4.1 Colliding molecules must have, apart from the correct orientation, a kinetic energy equal to or bigger than the activation energy of a reaction before the reaction can take place.
 - 4.2 Faster particles (have more kinetic energy) and collide harder and more often.
 - 4.3 Heating makes particles move faster. When moving fast enough they can collide with enough energy to overcome the activation energy, E_a , barrier.
 - 4.4 The activation energy barrier.
 - 4.5 Activation energy E_a is the minimum amount of KINETIC energy required to break the bonds in the reacting molecules and thus bring about a reaction.
5.
 - 5.1 Reactants are the chemicals that go into a reaction.
 - 5.2 Change in enthalpy :
 $\Delta H = \text{energy of products} - \text{energy of reactants}$
 - 5.3 The change in enthalpy, ΔH , is the amount of energy absorbed or released during a chemical reaction.
 - 5.4 The heat of reaction is the process of transferring this energy.
 - 5.5 low energy stable products.
 - 5.6 $\Delta H < 0$
 - 5.7 separate
 - 5.8 release
 - 5.9 more
6.
 - 6.1 high energy unstable products.
 - 6.2 $\Delta H > 0$
 - 6.3 absorbed
 - 6.4 release
 - 6.5 less

7.
 - 7.1 hotter
 - 7.2 colder
- 7.3 Exothermic reaction only needs to be heated until the reaction starts. Then the reaction is self-sustaining and the heat source can be removed. An endothermic reaction must be continually heated.
- 7.4 The food has to be continually heated.
- 7.5 Light the fuse and then remove the match. Once the explosion starts it is self sustaining.
8.
 - 8.1 All
 - 8.2 Some
 - 8.3 This is an open system where the evaporated water molecules that have become a gas can escape.
 - 8.4 This is a closed system where the evaporated water molecules that have become a gas cannot escape.
9.
 - 9.1 Concentrated
 - 9.2 Powdered
 - 9.3 Hot
 - 9.4 Catalysed
 - 9.5 Pressurised
- 9.6 Reactants that have positive and negative ions to attract each other as in an acid-base reaction
10.
 - 10.1 Hotter particles move faster and thus collide harder and more often.
 - 10.2 This increases the surface area where the collisions occur and thus more particles experience collisions.
 - 10.3 The extra energy makes the gas particles get hotter and move faster (compressing a gas heats up the gas). Moving faster in a smaller volume will produce more collisions.
 - 10.4 There are more particles per unit volume and thus there will be more collisions.
 - 10.5 The catalyst provides an alternative path of a lower activation energy which allows the reaction to proceed more quickly.
11.
 - 11.1 The water reacts with the O_2 in the air. The spray breaks the water up into fine drops which increases the surface area of the water where the reaction with the O_2 occurs.

11.2 A variable is any factor, condition or property that exists within a situation and can change if the conditions change.

11.3 A fair test only allows the independent and dependent variables to change. All other factors are kept constant.

11.4 The independent variable is what the experimenter changes, usually in regular increments.

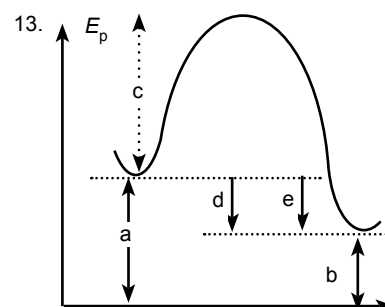
11.5 A dependent variable has changes that are observed by the experimenter as a result of the changes that are made to the independent variable.

11.6 A controlled variable is kept constant in an experiment.

11.7 In a successful experiment, the values of the variables must be easily reassessed (obtained again) if the experiment is repeated.

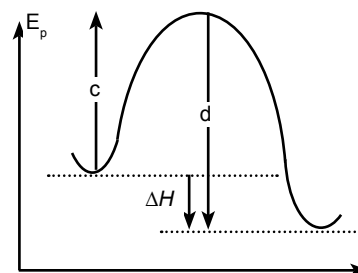
12.1 can ; reactants

12.2 will



14.
 - 14.1 No. The joint energy of the collision may be less than the activation energy. The orientation of the colliding molecules may be incorrect.
 - 14.2 temperature ;
presence of a catalyst
concentration of reactants.

15.
 - 15.1 activation energy of forward reaction.
 - 15.2 change in enthalpy



15.3 exothermic 15.4 $\Delta H < 0$

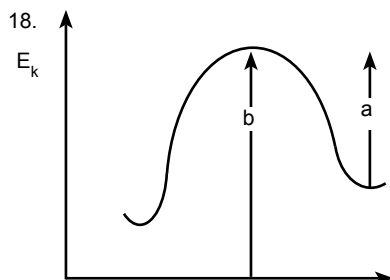
15.5 exothermic 15.6 $\Delta H < 0$

Basic Activities (Level 1 - 2)

16.
16.1 rate increases.
16.2 rate increases.
16.3 rate decreases.

17.
17.1 The **change in enthalpy** is equal to the amount of thermal energy gained or lost in processes that occur at constant external pressure. This transfer of energy is the **heat of reaction**.

- 17.2 break
17.3 form



18.3 Speeds up rate.

19.
An exothermic reaction releases thermal energy to the surroundings.
An endothermic reaction absorbs thermal energy from the surroundings.

20.
20.1
Activation energy is the minimum energy that reactants must have for a reaction to occur.

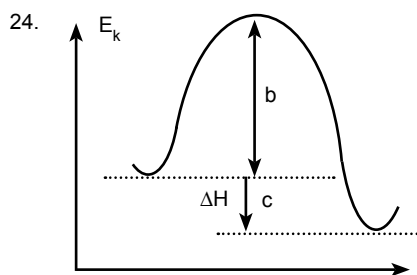
20.2
A catalyst is a substance that increases the rate of a reaction but can be recovered chemically unchanged after the reaction is complete.
A catalyst provides the reactants with an alternative path of lower activation energy.

- 21.1 Activation energy of forward reaction
21.2 Lowering of activation energy due to the alternative lower activation energy path that is provided by a catalyst.
21.3 Activation energy of reverse reaction
21.4 Heat of reaction or change in enthalpy for the forward (endothermic) reaction.
21.5 Heat of reaction or change in enthalpy for the reverse (exothermic) reaction.

- 22
22.1 Y 22.2 Y
22.3 Y 22.4 increase
22.5 increase.

23.1
A catalyst establishes an alternative lower energy path. Thus both the forward and reverse reactions are speeded up.
The products form faster but the yield or quantity of products is unaffected.

23.2
The catalyst speeds up the rate at which equilibrium is established but it does not change the equilibrium as it speeds up both the forward and the reverse reactions



Difficult Activities (Level 5 - 7)

25.1 All chemical reactions

- 25.2
• when petrol burns, it forms water as a product
• high temperature increases reaction rate (Water often drips out of the back of the exhaust pipe in winter when the car has just started and the exhaust pipe is still cold). Water and O_2 combine to rust iron

26.
26.1 e 26.2 a 26.3 e 26.4 b
26.5 a and e 26.6 endothermic

27.
Phosphine and dioxygen.

28.
Exothermic. Once the reaction starts, no further energy is required.
The glowing platinum means that energy is being released.

29.
All answers have the unit $\text{kJ} \cdot \text{mol}^{-1}$.
29.1 $50 - 150 = -100$

- 29.2 $150 - 50 = 100$
29.3 $400 - 0 = 400$
29.4 $300 - 150 = 150$
29.5 $400 - 50 = 350$
29.6 $300 - 50 = 250$
29.7 $300 - 0 = 300$

30.
30.1 What is the relationship between the mass of gas bubbling off from an acid-carbonate experiment and the time taken for the reaction to occur?
30.2 If the time of the reaction increases then the amount of gas bubbling off will increase because the reaction will continue to produce gas until the calcium carbonate is used up.
30.3 Time (as it increases regularly)
30.4 Repeat the experiment at least three times and take the average of the results.

30.5 Mass of CaCO_3 .
Size of the CaCO_3 granules.
Concentration of acid.
Temperature of the reactants.

- 30.6 The mass of the gaseous product CO_2 (g) which has bubbled off.
30.7 All the CaCO_3 has reacted.
30.8 Reaction rate increases.
30.9 No. It is an open system as the CO_2 escapes into the air and is not available to cause the reverse reaction.

Difficult Activities (Level 5 - 7)

31. Endothermic 32. Exothermic

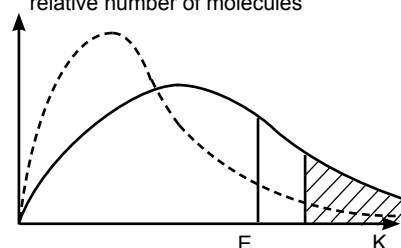
33.
33.1 We adjust the independent variable by fixed increments but we have no control over the changes in the dependent variable.
33.2 The variables that we keep constant for the purpose of the experiment.
33.3 A hypothesis is an educated guess by which we try to predict the relationship between two variables.
33.4 Only experimental evidence can confirm a hypothesis.
33.5 Some presently unknown experiment may be performed in the future that will contradict our hypothesis.

34.
34.1 Does the concentration of dibromine affect the reaction rate?
34.2 A change in temperature will produce a change in reaction rate.
34.3 The concentration of the ketone.
34.4 $\frac{-\Delta[\text{Br}_2]}{\Delta t} = \frac{0,01}{100} = 0,0001$

Initial [Br_2] ($\text{mol} \cdot \text{dm}^{-3}$)	Time (s) for 75% of light to be transmitted	Reaction rate $\frac{-\Delta[\text{Br}_2]}{\Delta t}$
0,01	100	0,0001
0,02	91	0,00022
0,03	75	0,0004
0,04	50	0,0008

34.5 As the concentration of dibromine increases, the reaction rate increases.
34.6 There are more Br_2 molecules per unit volume when the concentration increases. This increases the number of successful collisions between the Br_2 and the ketone molecules. Thus the products form at a faster rate.

35.
35.1 The temperature was raised.
35.2 A bigger fraction of the molecules move faster and have more kinetic energy at a higher temperature. They collide harder and more often to produce more effective collisions. Thus fewer molecules have a slower speed and a lower kinetic energy.
35.3 There is a lower limit of zero energy for a stationary particle. There is no upper limit to the speed of faster molecules. Thus there can always be a few particles with a very high speed that are far along the kinetic energy axis.
35.4 There is an alternative lower activation energy.
relative number of molecules



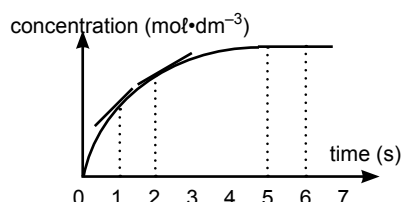
35.5 A catalyst provides an alternative lower activation energy pathway or route so that the more energetic particles can produce effective collisions faster.

35.6 Yes, The food was frozen and not spoiled. At lower temperatures the average kinetic energy of the particles decreases. The particles move slower and thus collide less often and more gently. Thus fewer effective collisions occur.

36.

At a higher temperature there are more molecules with the minimum kinetic energy needed for the dissolving process. Thus more molecules can overcome the activation energy. The molecules move faster, collide more often and hence the rate of reaction increases.

37.1



Draw a tangent to the graph at $t = 1$ s and $t = 2$ s.

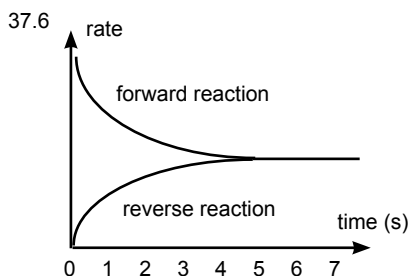
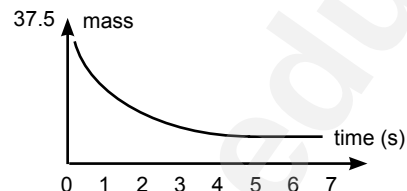
Determine the slope or gradient of the tangent.

37.2 The slope gets flatter, so the reaction rate is decreasing.

37.3 Equilibrium is reached where the rate of the forward reaction is equal to the rate of the reverse reaction.

37.4 The reverse reaction rate is zero at $t = 0$ s.

Then it does the opposite to the forward reaction rate, so it increases but when the graph flattens out at $t = 5$ s then the reverse reaction rate is constant.



$$38.1 \text{ Rate} = - \frac{\Delta [\text{H}_2]}{\Delta t}$$

$$= - \frac{(7 - 9)}{10 - 0} = \frac{2}{10}$$

$$= 0,2 \text{ mol} \cdot \text{dm}^{-3} \cdot \text{s}^{-1}$$

$$38.2 \text{ Rate} = - \frac{\Delta [\text{Br}_2]}{\Delta t}$$

$$= - \frac{(5 - 7)}{10 - 0} = \frac{2}{10}$$

$$= 0,2 \text{ mol} \cdot \text{dm}^{-3} \cdot \text{s}^{-1}$$

The concentration of the reactants decreases so to get a positive value we must include a negative sign.

$$38.3 \text{ Rate} = \frac{\Delta [\text{HBr}]}{\Delta t}$$

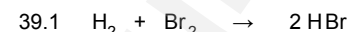
$$= \frac{(4 - 0)}{10 - 0} = \frac{4}{10}$$

$$= 0,4 \text{ mol} \cdot \text{dm}^{-3} \cdot \text{s}^{-1}$$

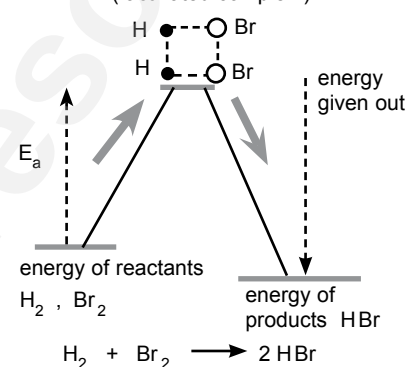
38.4 The reaction rate of the two reactants is the same.

The concentration of the products increases so the reaction rate is positive and is double the value of the reactants reaction rate because twice as much product is made compared with the amount of each reactant that is used up.

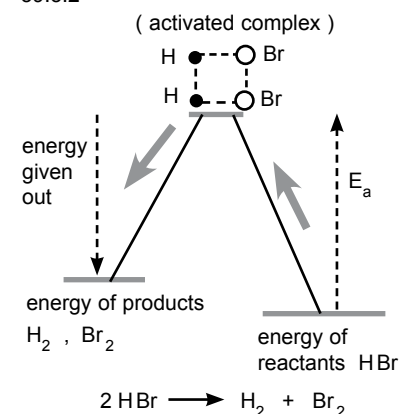
39.



39.3.1 (activated complex)



39.3.2



40.

The activated complex

is a highly unstable, high energy state that exists briefly between reactants and products as it is an intermediate stage of partial bonds

It is the short-lived combination of reacting atoms, molecules or ions.

41.

Activation energy E_a is the **minimum kinetic energy** that reacting molecules must have for a reaction to occur.

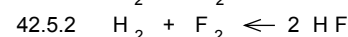
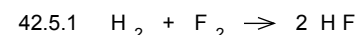
42.

42.1 How fast reactants turn into products.

42.2 Amount of products formed compared to the amount of uncombined reactants.

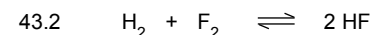
42.3 Reactants to make products.

42.4 Products to make reactants.



43.

43.1 The forward reaction turning reactants into products takes place at the same time as the reverse reaction where products break up to reform the reactants.



43.3 The reaction is reversible.

The forward reaction turning reactants into products takes place at the same time as the reverse reaction where products break up to reform the reactants.

The double arrows do not represent equilibrium.

43.4 The products are continually forming and breaking up at the same rate.

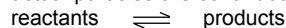
The number of particles stays constant but the actual particles are continuously changing.



43.5 A system that has no outside agencies.

43.6 One second.

43.7.1 The products are continually forming and breaking up at the same rate. The number of particles stays constant but the actual particles are continuously changing.



43.7.2 No visible changes seem to happen.

43.8 rate.

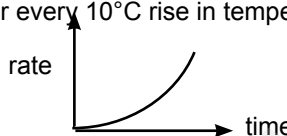
44.

44.1 reactants

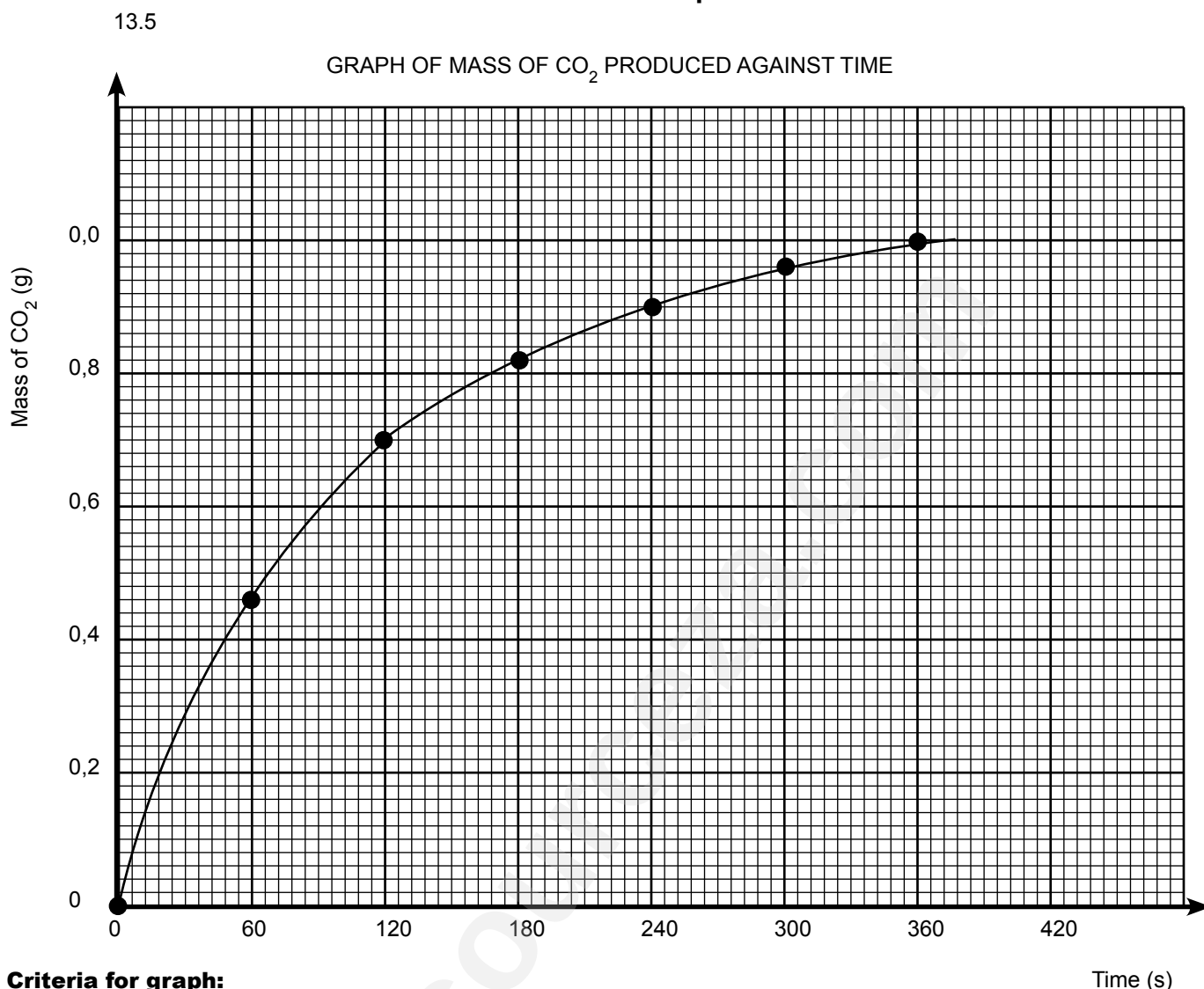
44.2 products

44.3 slower

44.4 faster

1. B
 - 2.
 - 2.1 The oxygen molecules now collide more frequently with the wood.
 - 2.2 He can chop his wood into smaller pieces, thereby increasing the surface area.
 - 2.3 A wind may blow the fire on and cause a veld fire.
 - 2.4 Activation energy
 - 3.
 - 3.1.1 Higher temperature
 - 3.1.2 At higher temperature a bigger fraction of the molecules (or, more molecules) move faster and have more kinetic energy, leading to more effective collisions.
 - 3.2.1 He added a catalyst
 - 3.2.2 P : ΔH , heat of reaction or change in enthalpy
Q : activation energy P
 4. A
 5. Gradient of a volume or amount graph indicates the rate of reaction.
Faster rate is due to increasing the concentration of the acid, increasing the temperature, increasing the surface area of the zinc by powdering it, adding a suitable catalyst like CuSO_4 .
 6. B Once the Zn is covered by the acid, there is no more surface area for more acid to react with.
 7. A
 8. A
 9. C $\Delta H = \text{change in enthalpy} = \text{final enthalpy (y)} - \text{initial enthalpy (k)}$
 - 10.1 Temperature
 - 10.2 Same mass of CaCO_3
Same concentration of HCl
Same particle size (powder) of CaCO_3
Same time (50 s) (Any 2)
Volume of HCl is NOT relevant as it has no effect on rate.
 - 10.3 CO_2 gas given off.
 - 10.4 The reaction had stopped since all of the CaCO_3 had reacted.
 - 10.5 No, reaction rate is not directly proportional. Doubling the temperature does not double the rate.
For every 10°C rise in temperature the reaction rate doubles. Not a linear relationship ($y \neq kx$)
- 

2,2 g at 20°C becomes 8,8 g at 40°C .
 4,4 g at 30°C becomes 17,6 g at 60°C
 Doubling temperature does not double mass loss.
- (Just because rate increases with temp it does not mean they are directly proportional)
- 11.
 - 11.1 The effect of a catalyst on reaction rate.
 - 11.2 L.
 - 11.3 There is no catalyst MnO_2 so the reaction takes longer.
 - 11.4 No change
 - 11.5 increases as more catalyst produces a bigger surface area and thus a faster reaction rate.
 - 12.
 - 12.1 enthalpy change / heat of reaction
 - 12.2 catalyst
 - 12.3 True
 - 13.1 Question must refer to independent variable and dependent variable.
- Examples :
- What is the relationship between the reaction rate and size of particles?
- Does the rate of reaction depend on surface area / particle size of reactants?
- How will the rate of reaction change when the surface area of particles change?
- 13.2 The initial mass of the conical flask and its contents.
 - 13.3 To ensure a fair test.
 - 13.4 The time must be taken from the moment the calcium carbonate is added to the acid.



13.6 The mass of CO₂ produced each time interval decreases as the concentration of reactants decreases until the reaction stops and no CO₂ is produced.

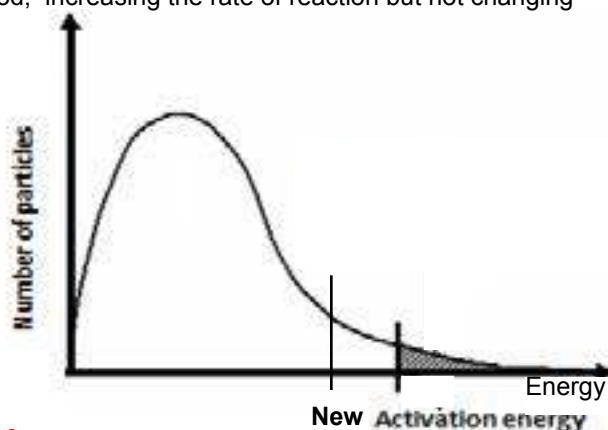
OR The rate of the reaction for the production of CO₂(g) decreases as the reaction proceeds.

14.

14.1.1 The catalyst provides an alternative pathway or route for the reaction with a lower activation energy. The same number of effective collisions occur in a shorter time period, increasing the rate of reaction but not changing the amount of products that form..

14.1.2

14.2 At higher temperature, average kinetic energy of molecules increases and the number of effective collisions increase hence the spoiling process goes faster than at lower temperatures.

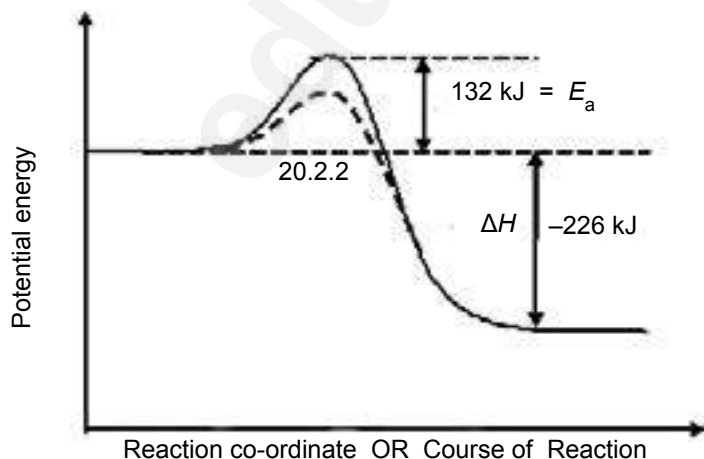


15.
 15.1 activated complex
 15.2 catalyst
16.
 16.1 Any statement that refers to the relationship between the dependent and independent variables.
 For example:
 A larger mass of metal will produce more gas OR A larger mass of metal will produce less gas
 16.2 Temperature
 Same concentration of acid
 (**Not** state of division)
 16.3 Any mass bigger than 1,6 g will not influence the volume of gas produced.
 16.4 160 - 170 cm³

17.
 At higher temperatures, the number of molecules with the minimum E_k needed for a reaction increases.
 The number of molecules that can overcome the activation energy increases.
 The molecules move faster and collide harder and more often, thus the frequency of effective collisions increases and hence the rate of reaction increases.

18.
 18.1 It is easier to form products from reactants because the activation energy is much less than the energy required to form reactants from products.
 18.2 CO is poisonous
 18.3 It ensures that converting products to CO₂ minimises the danger of CO poisoning.
 19.1 Endothermic
 19.2 mol·s⁻¹
 19.3 During the catalytic oxidation of ammonia the platinum ensures an increase in the rate of the reaction.
 OR
 During the catalytic oxidation of ammonia the platinum ensures an increase in the rate of production of products
 OR
 During the catalytic oxidation of ammonia the platinum ensures a higher concentration per second
 OR The platinum provides an alternative path of lower activation energy
 19.4 C

20.
 20.1.1 Sufficient kinetic energy (molecules move fast enough) of molecules A and B for the collisions.
 Molecules A and B must be correctly orientated.
 20.1.2 Increase in temperature means:
 More molecules move fast enough or have sufficient E_k .
 There are more effective collisions.
 20.2.1



(The x-axis has no real meaning. It just enables us to draw a graph)

21.
 21.1 Activation energy
 21.2 Reaction rate
 21.3 True

22. C

23.1 Neutralisation / acid-base reaction

23.2.1 What is the relationship between temperature and the reaction rate of an antacid tablet with water?

OR

What happens with the reaction rate of the antacid tablet with water when the temperature changes?

OR

How does temperature influence the time of dissolution of an antacid tablet in water?

23.2.2 If the temperature increases then the reaction rate of an antacid tablet in water will increase because a higher temperature means faster moving molecules that collide harder and more often and thus produce more effective collisions.

23.2.3

1. Use the measuring cylinder and measure a fixed volume of water and transfer it to the beaker.
2. Record the temperature of the water with a thermometer.
3. Add one antacid tablet to the water and measure the time it takes to dissolve or react completely. [time trial 1]
4. Rinse the solution down the sink and repeat the experiment at at least five more different temperatures.
5. Repeat steps 1 to 4 at least once more for accuracy and to compensate for experimental error. [time trial 2]
6. Determine the average time for both time trials at each temperature.

23.2.4

Temperature (°C)	time trial 1 (s)	time trial 2 (s)	average time (s)

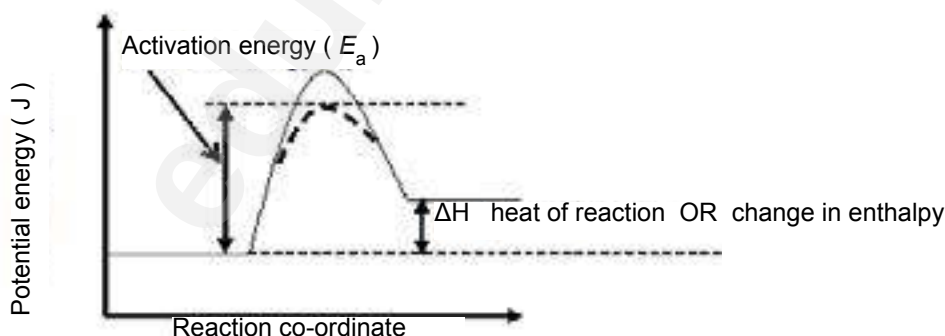
23.3 Warm water

24. The rate at which it will bring relief will be faster at a higher temperature

24.1 During exercise more air is breathed and more toxic ozone and nitrogen dioxide will be inhaled, resulting in lung problems and poor performance due to oxygen deficiency.

- 24.2
- Supply more and safe public transport to decrease cars on road. eg. Gautrain
 - Make catalytic converters compulsory in exhaust systems of cars.

24.3



25. A catalyst increases the rate of a reaction by providing an alternative path of lower activation energy.

26.

26.1 The change in concentration of reactants or products per unit time.

26.2 What is the relationship between reaction rate and surface area of an antacid tablet.

Criteria for investigative question : refers to relationship between dependent and independent variables.

It is a question – not stated as an aim.

26.3 Concentration of acid. Mass of antacid. Temperature of acid.

26.4 Any two pieces of apparatus with purpose.

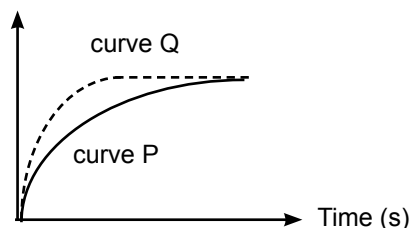
Thermometer to measure temperature.

Pestle and mortar to grind up antacid tablet to a powder.

Massmeter to measure the mass of the tablet.

26.5 Gas syringe.

26.6 Volume CO_2 (g)
(cm^3)



26.7 Chewing the tablet increases its surface area and results in a faster rate of reaction.

27.

27.1 Collision theory

27.2 Activation energy

27.3 A catalyst increases the rate of a chemical reaction.

28.

28.1 Smaller than

28.2 Criteria for hypothesis:

Refers to relationship between dependent and independent variables.

Statement that can be proved correct or incorrect. – prediction based on prior knowledge.

28.2 Examples:

- Reaction rate or volume of hydrogen gas produced per unit time increases with increase in concentration.

OR

- Reaction rate or volume of hydrogen gas produced per unit time decreases with increase in concentration.

OR

- The higher the concentration of HCl the faster the rate of the reaction.

28.3 To make a fair comparison or fair test.

OR Magnesium is a controlled variable because magnesium is a constant.

OR To ensure that there is only one independent variable, the concentration.

28.4 Magnesium is the limiting reagent.

OR When Mg is used up, the reaction will stop.

OR The same amount (mass/volume) of Mg will react with the same amount of acid in each experiment.

28.5.1 60 cm^3

28.5.2 42 cm^3

28.6 Experiment 1 : The gradient / slope of tangent to graph is steeper.

28.7 The number of moles or amount or mass of Mg used in both experiments were the same.

28.8 Reaction rate increases with increase in concentration.

OR

Reaction rate (volume of hydrogen gas formed per unit time) decreases with decrease in concentration.

28.9.1 Remains the same

28.9.2 Increases

29.1 Activation energy

29.2 Homogeneous