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SECONDARY SCHOOL IMPROVEMENT PROGRAMME (SSIP) 2016



GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

GRADE 12

SUBJECT: PHYSICAL SCIENCE

LEARNERS NOTES

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SESSION NO: 6
TOPIC: DOPPLER EFFECT

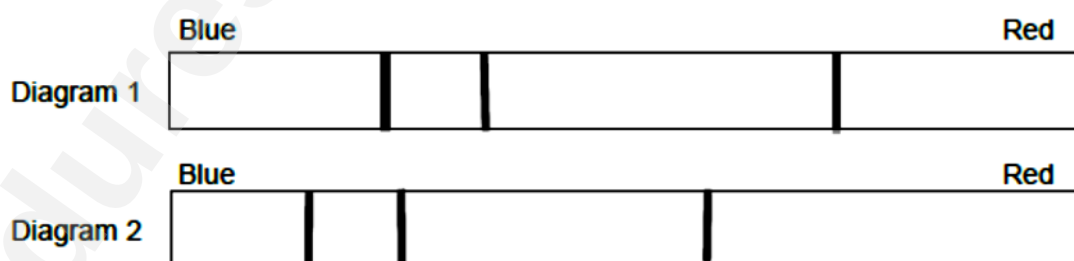
Note to Learner: Always write the equation down exactly as it is given on the information sheet. Always include the $\pm$. Only once you have substituted into the equation do you make the unknown the subject of the formula. It is suggested that you do not substitute the zeros into the equation. Rather leave them out. This is the only time that you do not substitute in the zero values.

SECTION A: TYPICAL EXAM QUESTIONS

QUESTION 1: 15 minutes

(Taken from NSC Nov 2014 Paper 1)

- 1.1 The siren of a stationary ambulance emits a note of frequency 1 130 Hz. When the ambulance moves at a constant speed, a stationary observer detects a frequency that is 70 Hz **higher** than that emitted by the siren.
- 1.1.1 State the Doppler effect in **Standard** words. (2) (2)
- 1.1.2 Is the ambulance moving *towards* or *away from* the observer? Give a reason for the answer. (2)
- 1.1.3 Calculate the speed at which the ambulance is travelling. Take the speed of sound in air as $343 \text{ m}\cdot\text{s}^{-1}$. (5)
- 1.2 A study of spectral lines obtained from various stars can provide valuable information about the movement of the stars. The two diagrams below represent different spectral lines of an element. Diagram 1 represents the spectrum of the element in a laboratory on Earth. Diagram 2 represents the spectrum of the same element from a distant star.



Is the star moving *towards* or *away from* the Earth? Explain the answer by referring to the shifts in the spectral lines in the two diagrams above.

(2)
[11]

QUESTION 2: 15 minutes

(Taken from NSC Nov 2015 Paper 1)

- 2.1 The data below was obtained during an investigation into the relationship between the different velocities of a moving sound source and the frequencies detected by a stationary listener for **each** velocity. The effect of wind was ignored in this investigation.

Experiment number	1	2	3	4
Velocity of sound source in ($\text{m}\cdot\text{s}^{-1}$)	0	10	20	30
Frequency (Hz) of the sound detected by the stationary listener	900	874	850	827

- 2.1.1 Write down the dependent variable for this investigation. (1)
- 2.1.2 State the Doppler effect in words. (2)
- 2.1.3 Was the sound source moving TOWARDS or AWAY FROM the listener? Give a reason for the answer. (2)
- 2.1.4 Use the information in the table to calculate the speed of sound during the investigation. (5)
- 2.2 The spectral lines of a distant star are shifted towards the longer wavelengths of light. Is the star moving TOWARDS or AWAY FROM the Earth? (1)
- [11]

QUESTION 3: 15 minutes

(Taken from NSC Feb/March 2015 Paper 1)

The Doppler effect is applicable to both sound and light waves. It also has very important applications in our everyday lives.

- 3.1 A hooter on a stationary train emits sound with a frequency of 520 Hz, as detected by a person standing on the platform. Assume that the speed of sound is $340 \text{ m}\cdot\text{s}^{-1}$ in still air.

Calculate the:

- 3.1.1 Wavelength of the sound detected by the person. (2)
- 3.1.2 Wavelength of the sound detected by the person when the train moves towards him/her at a constant speed of $15 \text{ m}\cdot\text{s}^{-1}$ with the hooter still emitting sound. (6)
- 3.2 Explain why the wavelength calculated in QUESTION 3.1.1 differs from that obtained in QUESTION 3.1.2. (2)

3.3 Use your knowledge of the Doppler effect to explain *red shifts*.

(2)
[12]

QUESTION 4: 15 minutes

(Taken from Gauteng Prep Exam 2014 Paper 1)

- 4.1 Keenan standing at the top of the Leaning Tower of Pisa accidentally drops his cell phone when it starts ringing at a frequency of 497×10^3 Hz. The height of the tower is 56 m.



- 4.1.1 Calculate the speed of the cell phone at a height of 18 m by using the law of conservation of mechanical energy. (4)

Nerisse standing at the bottom of the tower hears the phone ringing as it falls towards her. Ignore the effects of air friction.

- 4.1.2 Calculate the frequency of the sound observed by Nerisse when the phone is at the height of 18 m above ground. Take the speed of sound in air as $340 \text{ m}\cdot\text{s}^{-1}$ (4)

- 4.1.3 Explain in terms of wavelength and frequency of sound why Keenan who is at the top of the tower, observes a lower frequency of sound than the value calculated in QUESTION 4.1.2. (3)

- 4.1.4 How will the frequency of sound observed by Nerisse compare at a height of 18 m to that at 3 m? Write only HIGHER, LOWER or STAYS THE SAME. (1)
[12]

SECTION B: NOTES ON CONTENT

The frequency of a wave is the number of waves that pass a given point in one second.

The pitch is an indication of the wave's frequency. The higher the frequency, the higher the pitch and the lower the frequency, the lower the pitch.

The speed of sound will be given in the question and it is related to the frequency and the wavelength of a wave. Do not assume the value for the speed of sound, either it will be given in the question or refer to the information sheet.

The Doppler Effect is the observed change in the frequency of a sound due to the observer or the source of the sound moving relative to each other.

The Doppler Effect is used in ultrasound waves in medicine e.g. to measure the rate of blood flow or the heartbeat of a foetus in the womb.

Light emitted from stars is shifted toward the red or longer wavelength end of the spectrum due to the movement of the source of light. This is known as "red shift" and thus we can conclude that the universe is expanding as thus most stars are moving away from the Earth.

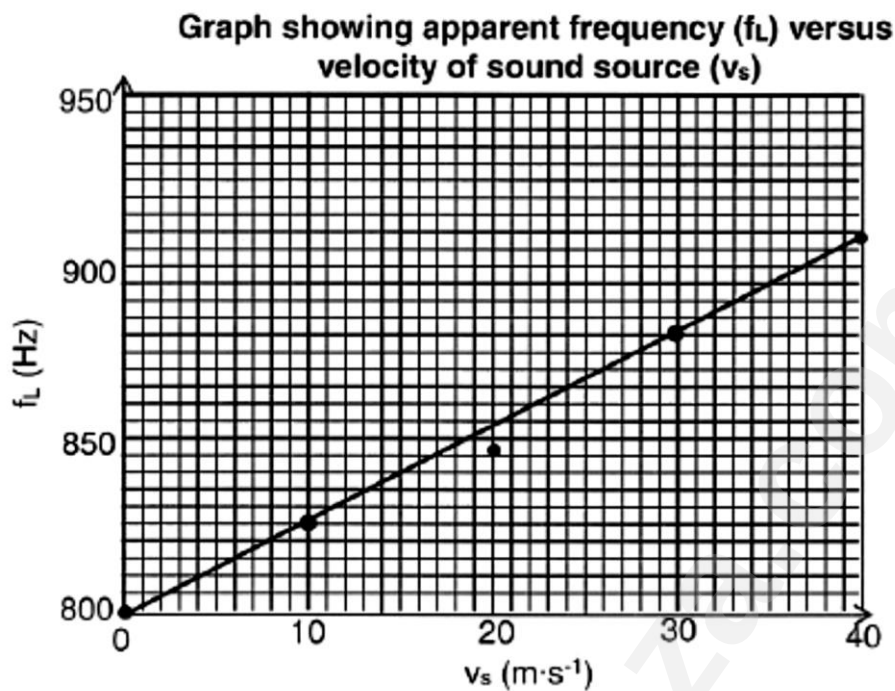
When doing Doppler Effect calculations:

- Write the original formula
- Allocate symbols (+ or -) to the velocities of the listener and source:
 - Source and listener towards each other $\frac{+}{-}$ for greater frequency
 - Source and listener away from each other $\frac{-}{+}$ for smaller frequency
- Substitute values
- Solve for the unknown quantity

SECTION C: HOMEWORK QUESTIONS

QUESTION 1: 10 minutes (Taken from Senior Certificate June 2015 Paper 1)

The graph below shows the relationship between the apparent frequency (f_L) of the sound heard by a STATIONARY listener and the velocity (v_s) of the source travelling TOWARDS the listener.

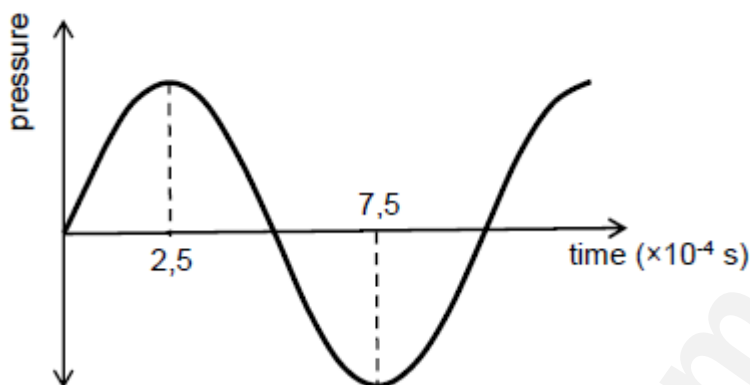


- 1.1 State the Doppler Effect in words. (2)
 - 1.2 Use the information in the graph to calculate the speed of sound in air. (5)
 - 1.3 Sketch a graph of apparent frequency (f_L) versus velocity (v_s) of the sound source if the source was moving AWAY from the listener. It is not necessary to use numerical values for the graph. (2)
- [9]**

QUESTION 2: 15 minutes

(Taken from Mpumalanga Prep Exam 2015)

A man mounts a siren, which produces a constant frequency of 800 Hz, on the roof of his car. He drives at a constant speed up and down a straight road while a stationary learner measures the observed sound. At a certain stage of the journey, the learner obtains the following pressure-time graph of the sound wave:



- 2.1 What is the period of the detected sound wave? (1)
 - 2.2 Calculate the frequency of the detected sound wave. (3)
 - 2.3 State the Doppler-effect in words. (2)
 - 2.4 Calculate the speed of the moving car. Take the speed of sound in air as $340 \text{ m}\cdot\text{s}^{-1}$. (5)
 - 2.5 While the car is stationary, the frequency of the siren is changed to 900 Hz. Will the wavelength of the detected sound wave INCREASE, DECREASE or REMAIN THE SAME? Explain the answer. (3)
- [14]**

SESSION NO: 7

TOPIC: RATES OF REACTIONS

Note to Learner: You need to revise some of your Grade 11 content such as exothermic and endothermic reactions. You must be able to draw these graphs and label them as well as being able to read off these graphs and answer questions on them. You will need to know the definitions of bond energy, activation energy and enthalpy. It will be expected of you to recognise which factors affect the rates of reactions and what changes will result when the factors are changed.

SECTION A: TYPICAL EXAM QUESTIONS

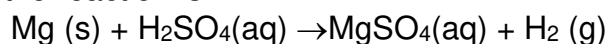
QUESTION 1: 25 minutes

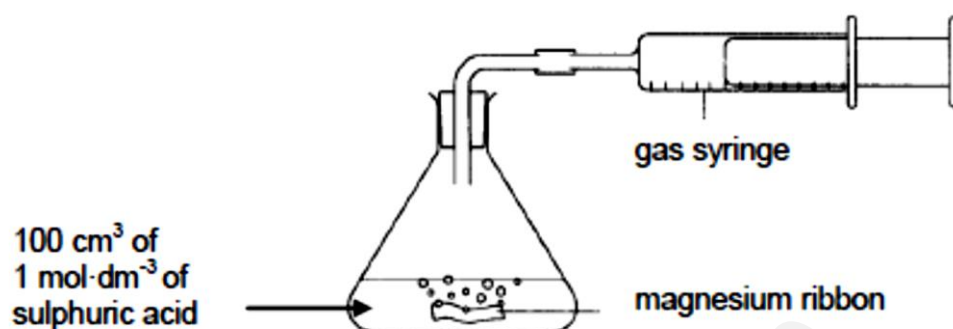
(Taken from GDE PREP EXAM 2014 Paper 2)

The following apparatus was used by a group of learners in an investigation to find out how surface area affects the rate of reaction between solid magnesium metal and 100 cm^3 dilute sulfuric acid with a concentration of $1 \text{ mol}\cdot\text{dm}^{-3}$.

During the reaction, the gas that forms is collected in the gas syringe which measures the volume of gas produced.

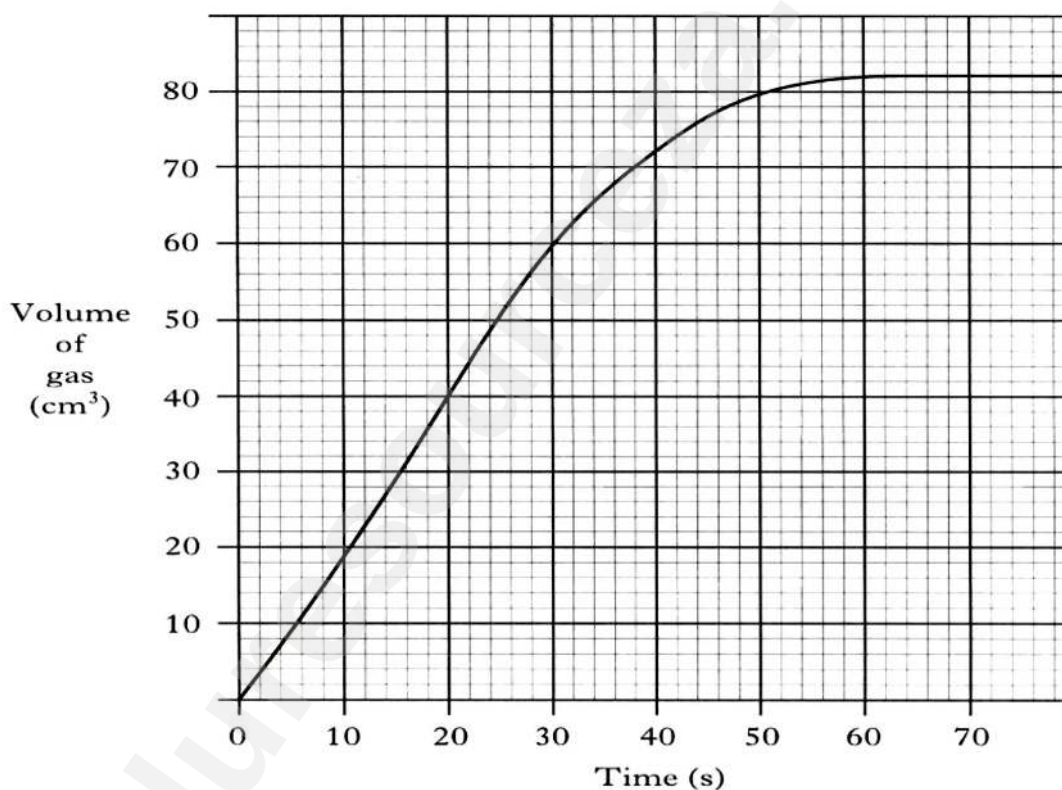
The equation for the reaction is:





In EXPERIMENT I, 20 g of magnesium, in the form of 5 small pieces, was used.
In EXPERIMENT II, 20 g of magnesium, in the form of one big piece was used.

The learners performed the experiments and plotted a graph of their results for experiment one, which is represented below.

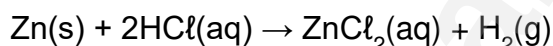


- 1.1 Besides the mass and the volume of the reactants, give ONE other variable that must be kept constant in this investigation. (1)
- 1.2 Name the dependent variable for EXPERIMENT I. (1)
- 1.3 **Use the graph** to calculate the average rate of the reaction (in cm³·s⁻¹) for the first 30 seconds. (3)
- 1.4 Will the rate of the reaction at 50s be GREATER THAN, LESS THAN or EQUAL TO that rate calculated in QUESTION 1.3? (1)
- 1.5 Give a reason for your answer in QUESTION 1.4. (1)

- 1.6 Predict how the gradient of EXPERIMENT II results would compare to EXPERIMENT I plotted above.
Write only INCREASE, DECREASE or NO CHANGE. (1)
- 1.7 Use the collision theory to explain how the increase in surface area of the magnesium metal affects the rate of the reaction. (3)
- 1.8 Calculate the mass of magnesium metal that remains after the reaction has stopped. (5)
- 1.9 Catalytic converters are substances that are coated onto surfaces of car exhausts to act as positive catalysts.
Define a *positive catalyst*. (2)
- 18]**

QUESTION 2: 20 minutes*(Taken from NSC Feb/March 2015 Paper 2)*

A group of learners uses the reaction of EXCESS hydrochloric acid (HCl) with zinc (Zn) to investigate factors, which influence reaction rate. The balanced equation for the reaction is:



They use the same volume of hydrochloric acid and 1,2 g of zinc in each of five experiments. The reaction conditions and temperature readings before and after completion of the reaction in each experiment are summarised in the table below.

Experiment	REACTION CONDITIONS				Time (s)
	Concentration of HCl (mol·dm ⁻³)	Temperature (°C)		State of division of the 1,2 g of Zn	
		Before	After		
1	0,5	20	34	granules	50
2	0,5	20	35	powder	10
3	0,8	20	36	powder	6
4	0,5	35	50	granules	8
5	0,5	20	34	granules	11

- 2.1 Is the reaction between hydrochloric acid and zinc EXOTHERMIC or ENDOTHERMIC? Give a reason for the answer by referring to the data in the table. (2)
- 2.2 Give a reason for the difference in reaction rate observed for **Experiments 1 and 2**. (1)
- 2.3 The learners compare the results of **Experiments 1 and 3** to draw a conclusion regarding the effect of concentration on reaction rate. Give a reason why this is not a fair comparison. (1)
- 2.4 How does the rate of the reaction in **Experiment 5** compare to that in **Experiment 1**? Write down FASTER THAN, SLOWER THAN or EQUAL TO.

- Write down the factor responsible for the difference in the rate of reaction and fully explain, by referring to the collision theory, how this factor affects reaction rate. (5)
- 2.5 Calculate the rate at which the hydrochloric acid reacts in **Experiment 4** in $\text{mol}\cdot\text{s}^{-1}$. (6)
- [15]

QUESTION 3: 20 minutes

(Taken from NSC Nov 2014 Paper 2)

- 3.1 Define the term *reaction rate* in words. (2)

Learners use the reaction between IMPURE POWDERED calcium carbonate and excess hydrochloric acid to investigate reaction rate. The balanced equation for the reaction is:

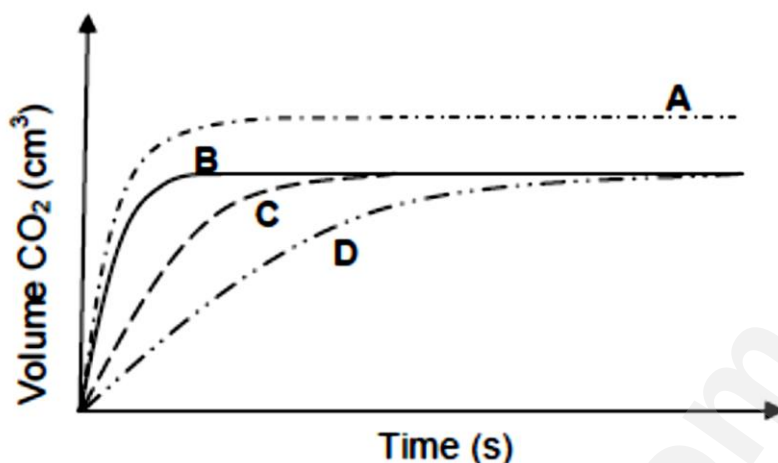


They perform four experiments under different conditions of concentration, mass and temperature as shown in the table below. They use identical apparatus in the four experiments and measure the volume of gas released in each experiment.

	EXPERIMENT			
	1	2	3	4
Concentration of acid ($\text{mol}\cdot\text{dm}^{-3}$)	1	0,5	1	1
Mass of impure calcium carbonate (g)	15	15	15	25
Initial temperature of acid ($^{\circ}\text{C}$)	30	30	40	40

- 3.2 The results of experiments **1** and **3** are compared in the investigation. Write down the:
- 3.2.1 Independent variable (1)
- 3.2.2 Dependent variable (1)
- 3.3 Use the collision theory to explain why the reaction rate in experiment **4** will be higher than that in experiment **3**. (3)

The learners obtain graphs **A**, **B**, **C** and **D** below from their results.



- 3.4 Which ONE of the graphs (A, B, C or D) represents experiment 1? Fully explain the answer by comparing experiment 1 with experiments 2, 3 and 4. (6)
- 3.5 When the reaction in experiment 4 reaches completion, the volume of gas formed is $4,5 \text{ dm}^3$. Assume that the molar gas volume at 40°C is equal to $25,7 \text{ dm}^3$. Calculate the mass of the impurities present in the calcium carbonate. (5)
- [18]

SECTION B: NOTES ON CONTENT

The rate of reaction can be expressed as:

- i) the rate at which **reactants are used up**
 - ii) the rate at which **products are formed**.
- OR**

Rates of reactions must always be linked to time.

Reactions may be **homogeneous** or **heterogeneous**

- i) homogeneous: reactants and products are in the same phase
- ii) heterogeneous: reactants and products are not in the same phase

Energy involved in Chemical Reactions

When substances react with each other, existing bonds between atoms or molecules are broken and new bonds are formed, which result in new substances being formed.

Energy is required to break bonds between particles, while the formation of new bonds usually goes hand in hand with the liberation of energy.

The net energy liberated or absorbed during a reaction is called the heat of reaction.

The heat of reaction is indicated by the symbol ΔH (enthalpy):

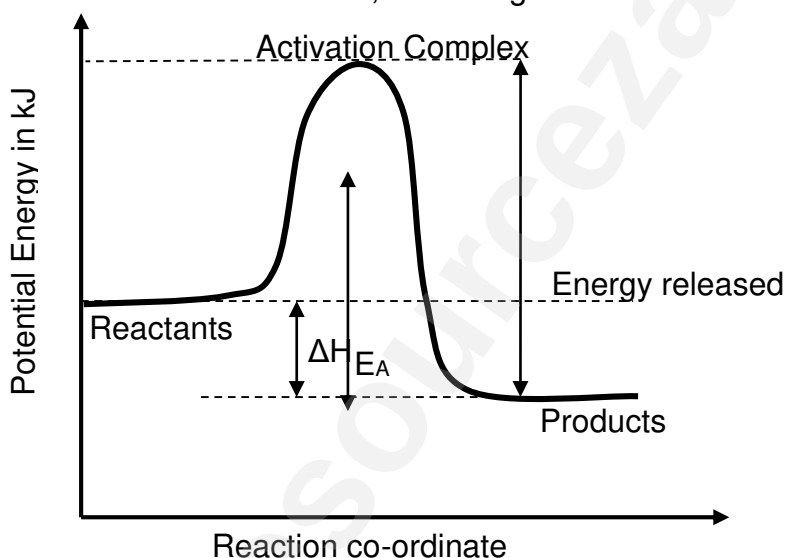
$$\Delta H = E_{\text{products}} - E_{\text{reactants}}$$

Activation Energy and the activated complex

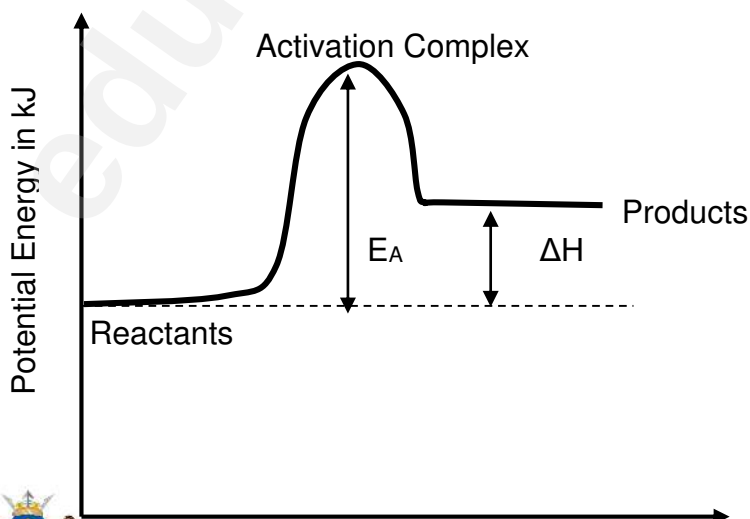
Most reactions need a supply of energy (activation energy) to get the reaction going.

When activation energy is supplied, an **activated complex** is formed (a temporary, unstable, high energy composition of atoms).

- In an exothermic reaction, ΔH is negative because energy is released.



- In an endothermic reaction, ΔH is positive because energy is taken in.



Reaction co-ordinate

CATALYSTS

A catalyst:

- May or may not take part in a reaction but emerges **unchanged** at the end of the reaction.
- Does **not cause** a reaction to occur.
- **Lowers** the "energy hill" by providing an alternative path of lower activation energy.
- **Speeds up** the reaction by increasing the rates of both forward and reverse reactions equally.
- Does **not** affect or alter the **equilibrium**.
- Does **not** affect the **amount of product** formed.

COLLISION THEORY

Not all collisions lead to a reaction. A collision is only effective if the molecules possess the correct amount of **kinetic energy** i.e. **activation energy** and if the orientation of the molecules are correct when collisions occur. Only then, will an effective collision will occur.

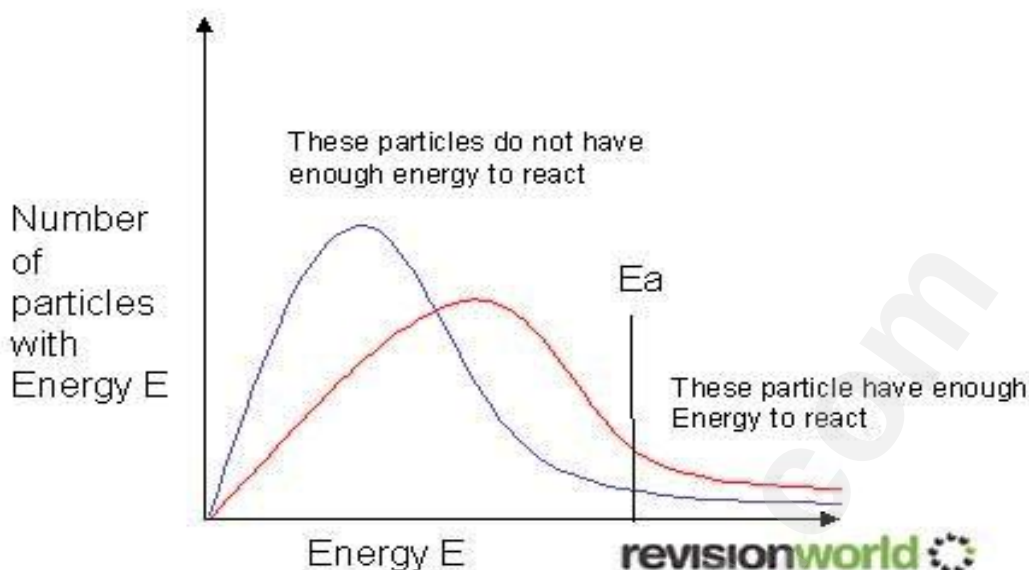
FACTORS THAT INFLUENCE THE RATE OF REACTION

- **Temperature** – as the temperature increases, the molecules move faster and they have a greater chance of colliding and thus a greater chance of reacting.
- **Pressure** (applies only to gases) – applying Boyle's Law (as the volume of the container decreases, the pressure of the enclosed gas increases) and thus the molecules have a better chance of colliding and thus reacting.
- **Concentration** (applies to solutions) – the more molecules that are present per unit volume, the greater the chance of collisions occurring and thus a greater chance of reacting.
- **State of division** (only applies to solids) – the finer the state of division, implies that there are more molecules available for reaction.
- **Catalyst** – a catalyst lowers the activation energy so more molecules have this lower activation energy and thus more molecules have a chance of reacting.
- **Nature of reacting substances** – this depends on the reactivity series of metals and the phases of matter.

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The graph below shows the number of particles and the energy they possess.

As the temperature increases, the height (peak) of the line decreases.



Adapted from <http://www.revisionworld.com>

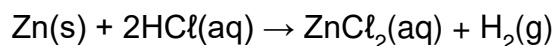
- The activation energy is represented by **E_a**. For collisions to occur, the reaction with the most energy will result in a final reaction.
- Thus by increasing the temperature, the number of collisions per unit time will increase and thus the number of effective collisions per unit time will increase.

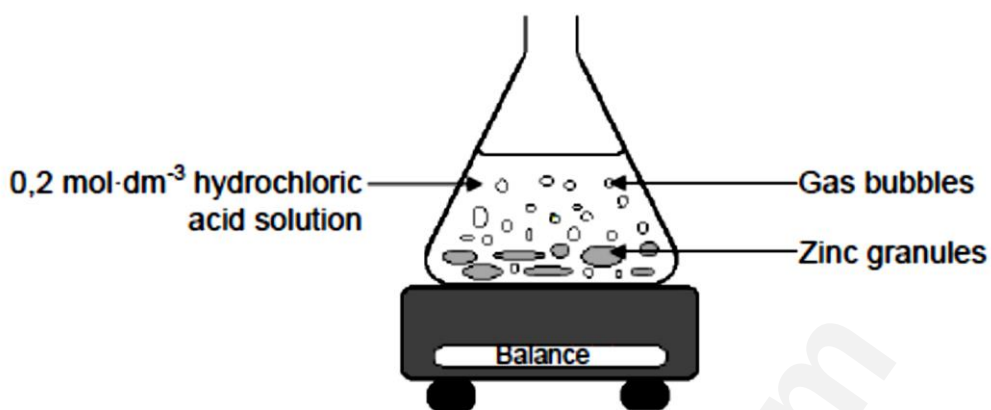
SECTION C: HOMEWORK QUESTIONS

QUESTION 1: 20 minutes

(Taken from NSC Exemplar 2014 Paper 2)

Zinc granules are added to 100 cm³ of a 0,2 mol·dm⁻³ hydrochloric acid solution in an Erlenmeyer flask. The equation for the reaction that takes place is:





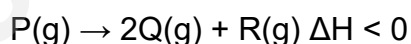
The rate of the reaction is followed by measuring the loss in the mass of the flask and the contents at regular time intervals. After completion of the reaction, it is found that 0,12 g zinc granules did not react.

- 1.1 Which reactant is the limiting reagent? (1)
- 1.2 Give a reason for the loss in mass of the flask and its contents. (1)
- 1.3 Sketch a graph of the mass of zinc versus time for the above reaction. Label this graph P. (2)
- 1.4 On the same set of axes as in QUESTION 5.3, sketch graph Q which represents the same reaction at a HIGHER TEMPERATURE. (1)
- 1.5 Use the collision theory to explain why graph Q differs from graph P. (2)
- 1.6 Calculate the mass of zinc initially present in the flask. (6)

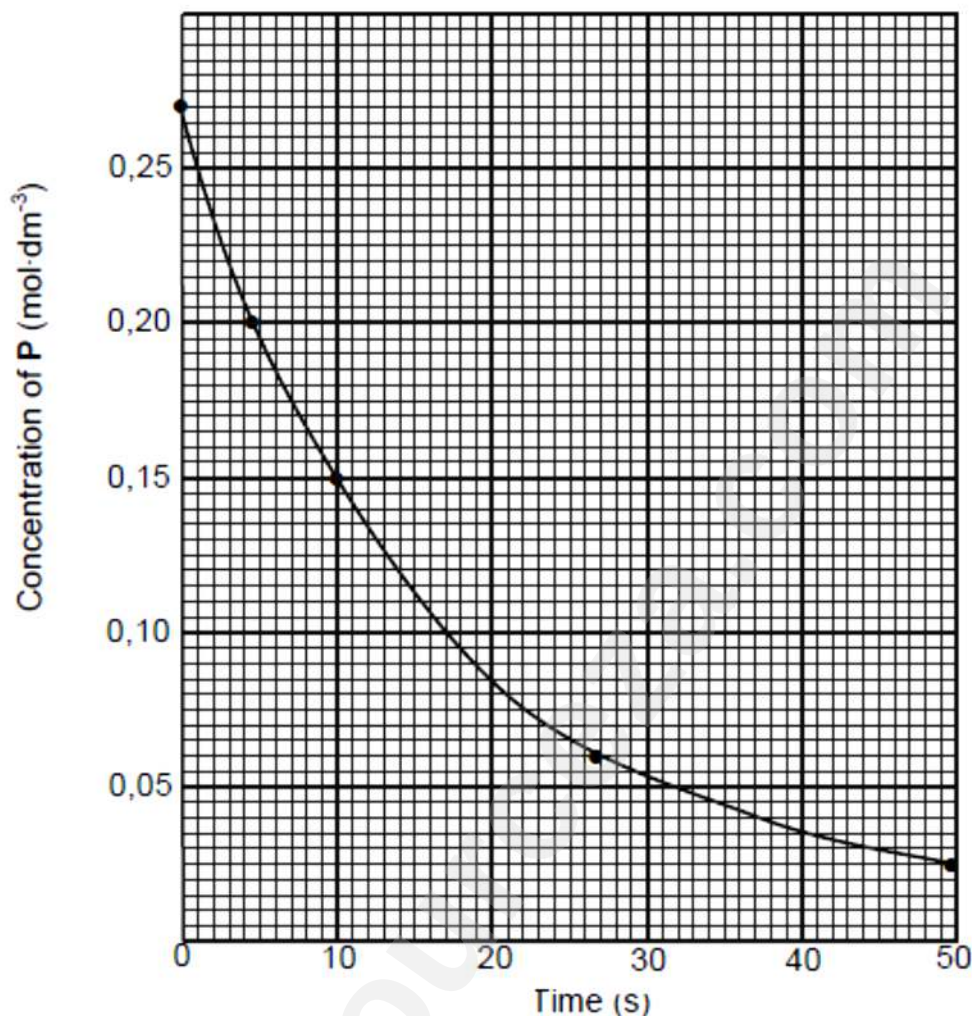
[13]

QUESTION 2: 20 minutes (Taken from NSC Feb/March 2014 Paper 2)

The following graph shows the decomposition of gas **P** according to the following equation:



Graph of concentration of P versus time



- 2.1 Define the term *rate of reaction* in words by referring to the graph. (2)
- 2.2 At which time, 10 s or 30 s, does the decomposition take place at a higher rate? Refer to the graph to give a reason for the answer. (2)
- 2.3 Write down the initial concentration of P(g). (1)
- 2.4 The decomposition is carried out in a 2 dm³ container.
Calculate the average rate (in mol·s⁻¹) at which P(g) is decomposed in the first 10 s. (6)
- 2.5 Draw a potential energy diagram for the reaction. Clearly indicate the following on the diagram: (3)
- Positions of the reactants and products
 - Activation energy (E_a) for the forward reaction
- 2.6 An increase in temperature will increase the rate of decomposition of P(g).
Explain this statement in terms of the collision theory. (2)
- [16]**

SESSION NO: 8
TOPIC: CHEMICAL EQUILIBRIUM

Note to Learner: You need to be able to distinguish between an open and closed system, as well as to identify a reversible reaction and understand dynamic equilibrium. You need to list the factors that influence the position of an equilibrium. The calculation of K_c is normally the higher order question. You will need to be able to interpret equilibrium and rate graphs as well as apply Le Chatelier's Principle.

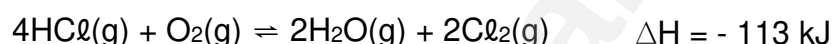
You need to apply your stoichiometry calculations from Grade 10 and 11 to calculate number of moles, mass and concentrations of substances.

SECTION A: TYPICAL EXAM QUESTIONS

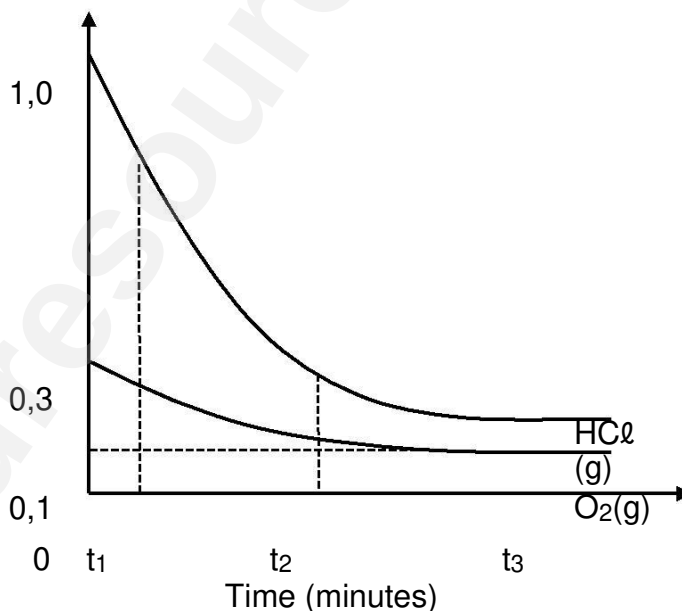
QUESTION 1: 25 minutes

(Taken from NSC Feb/Mar 2013 Paper 2)

The reaction between hydrogen chloride and oxygen reaches equilibrium in a closed container according to the following balanced equation:



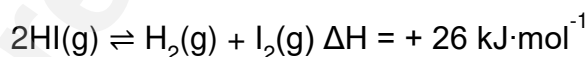
- 1.1 Is this reaction exothermic or endothermic? Give a reason for the answer. (2)
- 1.2 The graphs below, not drawn to scale, show how the amounts of reactants present in the container change with time at a specific temperature. The volume of the container is 5 dm^3 .



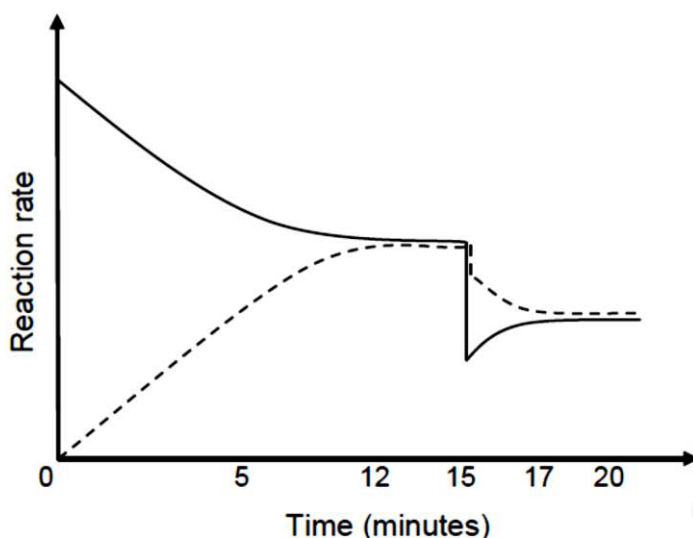
- 1.2.1 How does the rate of the forward reaction at time t_1 compare to that at time t_2 ? Write down GREATER THAN, SMALLER THAN or EQUAL TO. Use the graphs to give a reason for the answer. (2)
- 1.2.2 How does the rate of the forward and the reverse reactions compare at time t_3 ? Write down only GREATER THAN, SMALLER THAN or EQUAL TO. (1)
- 1.2.3 Calculate the equilibrium constant (K_c) for this reaction at this temperature. (9)
- 1.3 The temperature is NOW increased. How will this change affect the value of the equilibrium constant?
Write down INCREASES, DECREASES or REMAINS THE SAME. Explain the answer. (4)
- 1.4 How will each of the following changes affect the equilibrium concentration of $\text{Cl}_2(\text{g})$? Write down INCREASES, DECREASES or REMAINS THE SAME.
- 1.4.1 Water vapour is added into the container. (1)
- 1.4.2 A catalyst is added. (1)
- 1.4.3 The volume of the container is increased. (1)
- [21]**

QUESTION 2: 20 minutes*(Taken from NSC Feb/March 2015 Paper 2)*

Pure hydrogen iodide, sealed in a 2 dm^3 container at 721 K, decomposes according to the following balanced equation:



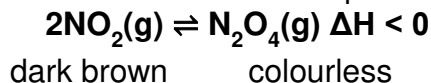
The following graph shows how reaction rate changes with time for this reversible reaction.



- 2.1 Write down the meaning of the term *reversible reaction*. (1)
- 2.2 How does the concentration of the reactant change between the 12th and the 15th minute? Write down only INCREASES, DECREASES or NO CHANGE. (1)
- 2.3 The rates of both the forward and the reverse reactions suddenly change at $t = 15$ minutes.
- 2.3.1 Give a reason for the sudden change in reaction rate. (1)
- 2.3.2 Fully explain how you arrived at the answer to QUESTION 2.3.1. (3)
- The equilibrium constant (K_c) for the forward reaction is 0,02 at 721 K.
- 2.4 At equilibrium it is found that 0,04 mol HI(g) is present in the container. Calculate the concentration of $H_2(g)$ at equilibrium. (6)
- 2.5 Calculate the equilibrium constant for the reverse reaction. (1)
- 2.6 The temperature is now increased to 800 K. How will the value of the equilibrium constant (K_c) for the forward reaction change? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)
- [14]**

QUESTION 3: **20 minutes** *(Taken from NSC November 2014 Paper 2)*

A certain amount of nitrogen dioxide gas (NO_2) is sealed in a gas syringe at 25°C . When equilibrium is reached, the volume occupied by the reaction mixture in the gas syringe is 80 cm^3 . The balanced chemical equation for the reaction taking place is:



3.1 Define the term *chemical equilibrium*. (1)

3.2 At equilibrium, the concentration of the $\text{NO}_2(\text{g})$ is $0,2\text{ mol}\cdot\text{dm}^{-3}$.
The equilibrium constant for the reaction is 171 at 25°C .
Calculate the initial number of moles of $\text{NO}_2(\text{g})$ placed in the gas syringe. (8)

3.3 The diagram below shows the reaction mixture in the gas syringe after equilibrium is established.



The pressure is now increased by decreasing the volume of the gas syringe at constant temperature as illustrated in the next diagram.



3.3.1 IMMEDIATELY after increasing the pressure, the colour of the reaction mixture in the gas syringe appears darker than before. Give a reason for this observation. (1)

After a while a new equilibrium is established as illustrated below. The colour of the reaction mixture in the gas syringe now appears lighter than the initial colour.



3.3.2 Use Le Chatelier's principle to explain the colour change observed

in the gas syringe. (3)

3.4 The temperature of the reaction mixture in the gas syringe is now increased and a new equilibrium is established. How will each of the following be affected?

3.4.1 Colour of the reaction mixture (1)
Write down only DARKER, LIGHTER or REMAINS THE SAME.

3.4.2 Value of the equilibrium constant (K_c). (1)
Write down only INCREASES, DECREASES or REMAINS THE SAME. [16]

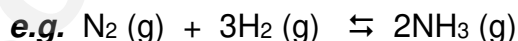
SECTION B: NOTES ON CONTENT

In a **closed system**, none of the reactants and/or products are lost so, none of them escape the container or system that they are in, e.g.: a gas has **not escaped**.

In an **open system**, a reaction will reach completion and one of the reactants will be used up and a gas **could be escaping**.

A **reversible reaction**, is a chemical system where the reactants are reacting to form the products, the products are reacting to form the reactants again.

A reaction is in **equilibrium** when the forward and reverse reactions proceed at the same rate:



Factors which affect equilibrium:

- i) Change in concentration
 - ii) Change in pressure
 - iii) Change in temperature
-
- i) so if the concentration of any substance is increased, the system tries to decrease the concentration of that substance. The opposite is also true.
 - ii) so if the pressure is increased, the system tries to decrease the pressure by favouring the reaction that produces less gas and vice versa.
 - iii) so if the temperature is increased, the system tries to decrease the temperature by favouring the endothermic reaction and visa versa.

NB: A catalyst does not affect the equilibrium position of a reaction.

Changing equilibrium conditions

Le Chatelier's Principle: When the equilibrium in a closed system is disturbed by changing the conditions surrounding the equilibrium i.e either temperature,

concentration or pressure, the equilibrium will shift in such a direction as to cancel the effect of the change.

The Equilibrium Constant

For a reaction: $aA + bB \rightarrow cC + dD$, $K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$

Concentrations of solids and liquids remain constant, thus they are left out of the equation.

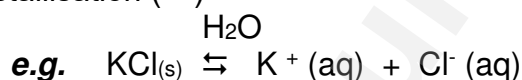
Calculations with K_c

- Equilibrium concentrations given, $\rightarrow$ substitute into the equation and get K_c
- Original concentrations given, you need to calculate the equilibrium concentrations first and then substitute and solve for K_c
- If initial mol is given, then you have to work out the equilibrium mol and then convert to equilibrium concentration.

If $K_c > 1$, then the equilibrium lies to the product side. If $K_c < 1$, then the equilibrium lies towards the reactants side.

Equilibrium in Solutions

When an ionic substance is dissolved in water, equilibrium is reached when the solution is saturated with dissolved solid, *i.e.* rate of solution ($\rightarrow$) is the same as rate of crystallisation ($\leftarrow$)



Temperature is important.

The common ion effect:

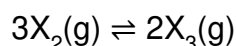
Often used to precipitate a substance in solution (deposit).

SECTION C: HOMEWORK QUESTIONS

QUESTION 1: 20 minutes

(Taken from NCS Nov 2015 Paper 2)

An unknown gas, $X_2(g)$, is sealed in a container and allowed to form $X_3(g)$ at 300°C . The reaction reaches equilibrium according to the following balanced equation:



- 1.1 How will the rate of formation of $X_3(g)$ compare to the rate of formation of $X_2(g)$ at equilibrium? Write down only HIGHER THAN, LOWER THAN or EQUAL TO. (1)

The reaction mixture is analysed at regular time intervals. The results obtained are shown in the table below.

TIME (s)	[X_2] (mol·dm ⁻³)	[X_3] (mol·dm ⁻³)
0	0,4	0
2	0,22	0,120
4	0,08	0,213
6	0,06	0,226
8	0,06	0,226
10	0,06	0,226

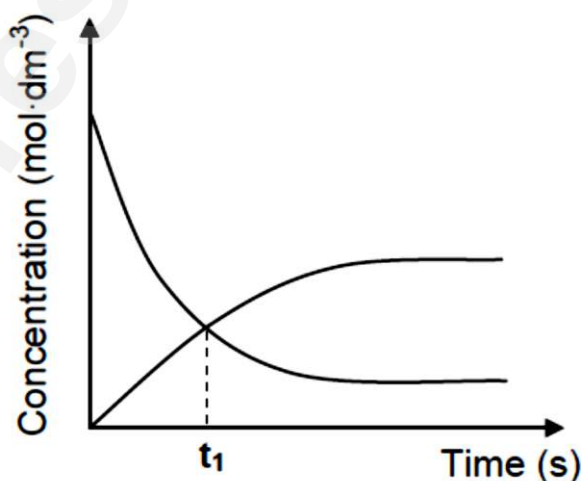
- 1.2 Calculate the equilibrium constant, K_c , for this reaction at 300 °C. (4)

- 1.3 More $X_3(g)$ is now added to the container.

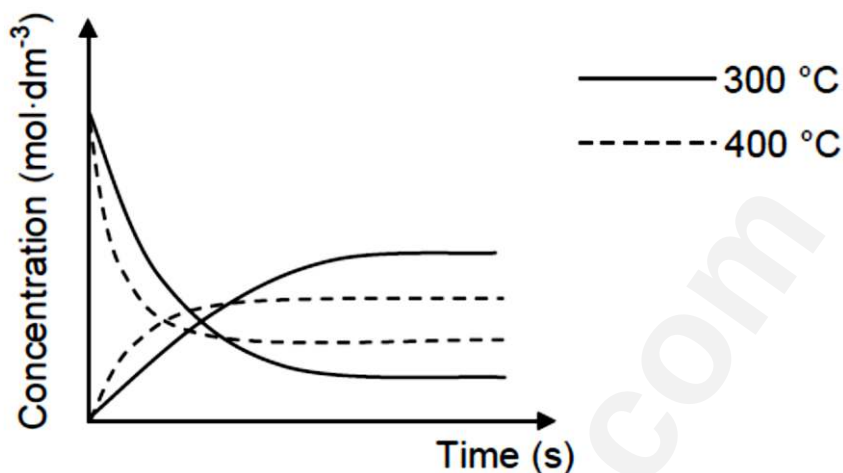
- 1.3.1 How will this change affect the amount of $X_2(g)$? Write down INCREASES, DECREASES or REMAINS THE SAME. (1)

- 1.3.2 Use Le Chatelier's principle to explain the answer to QUESTION 1.3.1. (2)

The curves on the set of axes below (not drawn to scale) was obtained from the results in the table.

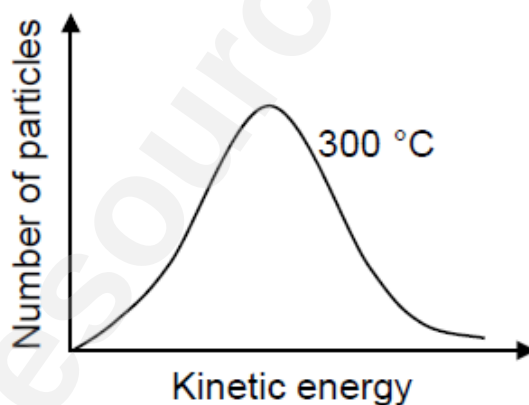


The reaction is now repeated at a temperature of 400 °C. The curves indicated by the dotted lines below were obtained at this temperature.



- 1.5 Is the forward reaction EXOTHERMIC or ENDOTHERMIC? Fully explain how you arrived at the answer. (4)

The Maxwell-Boltzmann distribution curve below represents the number of particles against kinetic energy at 300 °C.



- 1.6 Redraw this curve in the ANSWER BOOK. On the same set of axes, sketch the curve that will be obtained at 400 °C. Clearly label the curves as 300 °C and 400 °C respectively. (2)

[15]