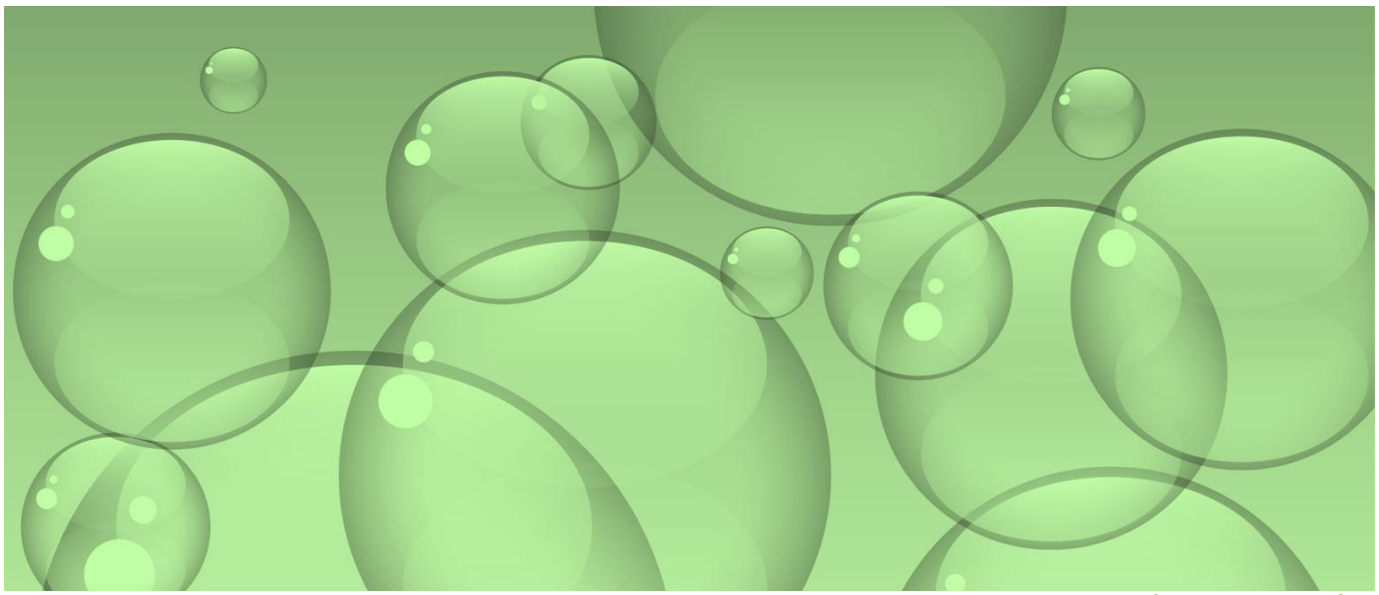
Chemistry 2.6 AS 91166

GZ Science Resources

Demonstrate understanding of chemical reactivity

WORKBOOK

Working to Excellence & NCEA Questions



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All NCEA answers can be found on C2.6 ppt

GZ Science Resources

Writing Excellence answers to Reaction rate Factors – Surface Area questions

Reaction Rate Factors – Surface Area QUESTION
Question: Compare and contrast the reactions of 0.5 g of magnesium ribbon, Mg(s), with 50.0 mL of 0.100 mol L–1 hydrochloric acid, HCl(aq), and 0.5 g of magnesium powder, Mg(s), with 50.0 mL of 0.100 mol L–1 hydrochloric acid, HCl(aq). Refer to collision theory and rates of reaction in your answer.

	ANSWER
1. state the collision theory	
2. Describe the reactants in your reaction and state which factors are the same	
3. Describe the reactants in your reaction and state which factor is different (the factor affecting reaction rate)	
4. link the factor to the collision theory	
5. link the reaction to more successful collisions occurring per unit of time	
6. link to more products (name products) being formed per unit of time AND link to a faster reaction rate	
7. summarize the reaction with the slower reaction rate	
8. Explain that both reactions will produce the same amount of product eventually as they started with the same amount of reactants	

NOTE: The white column is how your answer would appear on your test paper so make sure you write out complete sentences. The grey area is just to help you structure your answer and would not appear in the question.

Writing Excellence answers to Reaction Rate Factors – Temperature questions

Reaction Rate Factors – Temperature QUESTION
Question: A particular reaction is complete when the solution turns cloudy and the paper cross under the flask can no longer be seen. The following experiments were carried out, and the times taken for the cross to disappear recorded. Elaborate on why the reaction in Experiment 2 occurred faster than the reaction in Experiment 1.

experiment		Temperature /ºC	Time for cross to disappear
1	No Cu^{2+} present	25	42
2	No Cu^{2+} present	50	23
3	Cu^{2+} present	25	5

ANSWER	
1. state the collision theory	
2. Describe the reactants in your reaction and state which factors are the same	
3. Describe the reactants in your reaction and state which factor is different (the factor affecting reaction rate)	
4. link the factor to the collision theory (activation energy)	
5. link the reaction to more of the collisions being successful occurring per unit of time	
6. next link the factor to the collision theory (faster moving particles)	
7. link the reaction to more successful collisions occurring per unit of time	
8. link to more products (name products) being formed per unit of time AND link to a faster reaction rate	
9. summarize the reaction with the slower reaction rate	
10. Explain that both reactions will produce the same amount of product eventually as they started with the same amount of reactants	

NOTE: The white column is how your answer would appear on your test paper so make sure you write out complete sentences. The grey area is just to help you structure your answer and would not appear in the question.

Writing Excellence answers to Reaction Rate Factors – Catalyst questions

Reaction Rate Factors – Catalyst QUESTION

Question: A particular reaction is complete when the solution turns cloudy and the paper cross under the flask can no longer be seen. The following experiments were carried out, and the times taken for the cross to disappear recorded. Elaborate on why the reaction in Experiment 3 occurs faster than the reaction in Experiment 1.

experiment		Temperature /ºC	Time for cross to disappear
1	No Cu^{2+} present	25	42
2	No Cu^{2+} present	50	23
3	Cu^{2+} present	25	5

ANSWER

1. state the collision theory	
2. Describe the reactants in your reaction and state which factors are the same	
3. Describe the reactants in your reaction and state which factor is different (the factor affecting reaction rate)	
4. link the factor to the collision theory	
5. link the reaction to more of the collisions being successful occurring per unit of time	
6. link to more products (name products) being formed per unit of time AND link to a faster reaction rate	
7. summarize the reaction with the slower reaction rate	
8. Explain that both reactions will produce the same amount of product eventually as they started with the same amount of reactants	

NOTE: The white column is how your answer would appear on your test paper so make sure you write out complete sentences. The grey area is just to help you structure your answer and would not appear in the question.

Writing Excellence answers to Reaction rate Factors – Concentration questions

Reaction Rate Factors – Catalyst QUESTION

Question: The 'elephant toothpaste' demonstration shows the decomposition of hydrogen peroxide, H_2O_2, into water and oxygen gas.

$2H_2O_{2(aq)} \rightarrow 2H_2O_{(l)} + O_{2(g)}$

This reaction can be observed by adding detergent to the hydrogen peroxide solution. As oxygen gas is produced, the detergent foams up, as seen in the photograph on the right. The time taken for the foam to reach the top of the measuring cylinder can be used to measure the rate of the reaction.

Three experiments were carried out to investigate factors that change the rate of the reaction.

Compare Experiment 3 with Experiment 1.

In your answer, you should:

• identify the factor being changed, and the effect this will have on the rate of reaction

• explain the effect on the rate of reaction by referring to the collision of particles and activation energy, where appropriate.

Experiment	Concentration of H_2O_2	Temperature °C	Presence of small amount of MnO_2
1	20%	20	yes
2	20%	30	yes
3	30%	20	yes

ANSWER

1. state the collision theory	
2. Describe the reactants in your reaction and state which factors are the same	
3. Describe the reactants in your reaction and state which factor is different (the factor affecting reaction rate)	
4. link the factor to the collision theory	
5. link the reaction to more of the collisions being successful occurring per unit of time	
6. link to more products (name products) being formed per unit of time AND link to a faster reaction rate	
8. Explain that both reactions will produce the same amount of product eventually as they started with the same amount of reactants	

NOTE: The white column is how your answer would appear on your test paper so make sure you write out complete sentences. The grey area is just to help you structure your answer and would not appear in the question.

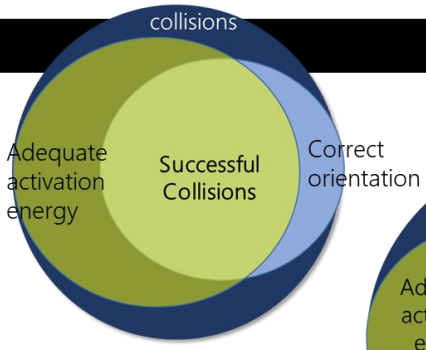
What needs to occur for a collision to be successful?

- ❑ Particles must collide with enough energy – to overcome activation energy requirements
- ❑ Collide in the correct orientation

Factor (increased)	Does it increase frequency of collisions	Does it increase the % of successful collisions?
1. Concentration	Yes More particles in a given area, therefore more chance of colliding	No But more successful collisions (per unit time) – as more frequent collisions
2. Surface Area	Yes More particles in a given area, therefore more chance of colliding	No But more successful collisions(per unit time) – as more frequent collisions
3. Temperature	Yes Particles have more kinetic energy – move faster therefore more chance of colliding	Yes More particles have required energy to overcome activation energy therefore result in successful collision
4. Catalyst	No	Yes A lower activation energy pathway available – "lowers the bar' and a greater proportion of collisions become successful. So, catalysts also assist orientation

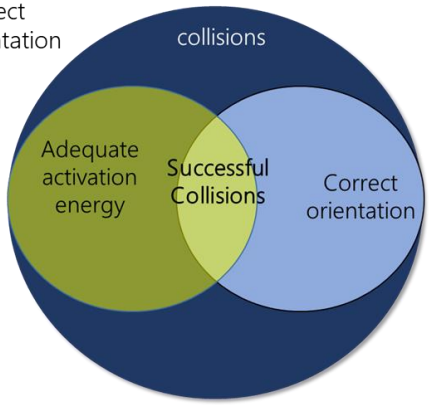
Link answers to increase / decrease in reaction rate

Reaction rates



Catalyst

- ❑ Frequency of collisions not changed
- ❑ Increase in % of successful collisions
- ❑ Due to lowering activation energy pathway
- ❑ Some catalysts also 'align' reactants for collision



Concentration
Surface Area

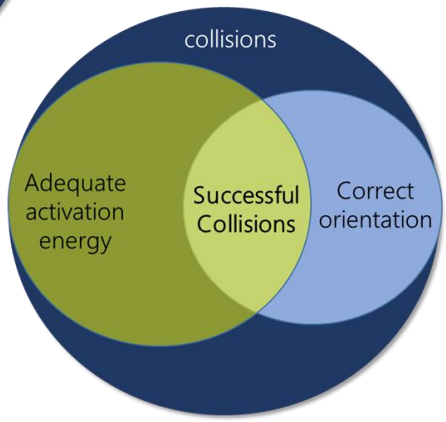
- ❑ Frequency of collisions increased
- ❑ Overall % of successful collisions not changed BUT RATE of successful collisions is

Temperature

- ❑ Frequency of collisions increased

ALSO

- ❑ Increase in % of successful collisions



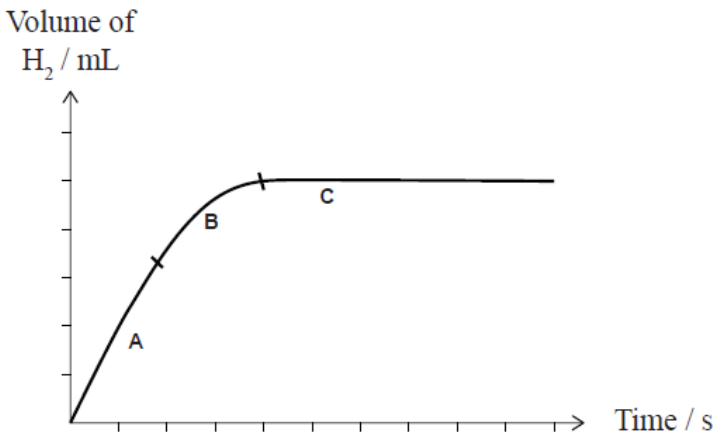
Past NCEA Questions Reaction Rate Graphs and Factors (ONE)

2013: Question 1a.: Hydrochloric acid was reacted with calcium carbonate in the form of marble chips (lumps) and powder (crushed marble chips) in an experiment to investigate factors affecting the rate of a chemical reaction. (i) What is the factor being investigated?
(ii) Explain why the hydrochloric acid would react faster with the powder.

2013: Question 1b: A particular reaction is complete when the solution turns cloudy and the paper cross under the flask can no longer be seen. The following experiments were carried out, and the times taken for the cross to disappear recorded. Elaborate on why the reactions in Experiment 2 and Experiment 3 occur faster than the reaction in Experiment 1.

experiment		Temperature /ºC	Time for cross to disappear
1	No Cu^{2+} present	25	42
2	No Cu^{2+} present	50	23
3	Cu^{2+} present	25	5

2014: Question 3a: The equation for the reaction between zinc granules (lumps), $Zn_{(s)}$, and sulfuric acid, $H_2SO_{4(aq)}$, is represented by:
$Zn_{(s)} + H_2SO_{4(aq)} \rightarrow ZnSO_{4(aq)} + H_{2(g)}$
The graph below shows how the volume of hydrogen gas produced changes with time, when zinc is reacted with excess sulfuric acid at 20°C. Explain the changes in the reaction rate during the periods A, B and C.
In your answer you should refer to collision theory.

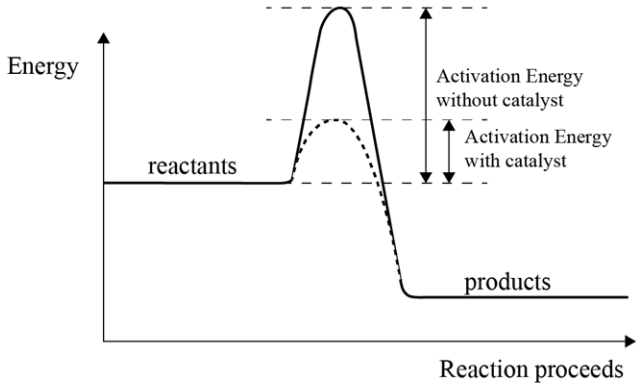


2014: Question 3b: The rate of the reaction between zinc and sulfuric acid can be changed by the addition of small pieces of copper, Cu(s), as a catalyst. Explain the role of the copper catalyst in the reaction between zinc and sulfuric acid. In your answer you should refer to collision theory.

2015: Question: 1a: The 'elephant toothpaste' demonstration shows the decomposition of hydrogen peroxide, H_2O_2, into water and oxygen gas. $2H_2O_{2(aq)} \rightarrow 2H_2O_{(l)} + O_{2(g)}$
This reaction can be observed by adding detergent to the hydrogen peroxide solution. As oxygen gas is produced, the detergent foams up. The time taken for the foam to reach the top of the measuring cylinder can be used to measure the rate of the reaction.
Three experiments were carried out to investigate factors that change the rate of the reaction.
(a) The decomposition reaction of hydrogen peroxide, H_2O_2, is very slow. By adding a small amount of powdered manganese dioxide, MnO_2, the rate of the reaction can be increased.
nly a small amount omanganese dioxide is needed to increase the rate of the reaction.

Past NCEA Questions Reaction Rate Graphs and Factors (TWO)

2015: Question 1a (ii): The diagram below shows the energy diagram for the decomposition reaction ($2H_2O_{2(aq)} \rightarrow 2H_2O_{(l)} + O_{2(g)}$) without manganese dioxide (a catalyst).
Label this diagram and use it to help you explain how the addition of manganese dioxide speeds up the rate of the reaction.

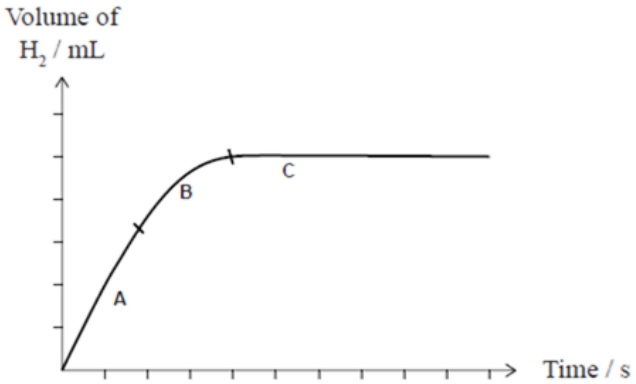


2015: Question 1b: Compare Experiment 2 with Experiment 1. In your answer, you should:
• identify the factor being changed, and the effect this will have on the rate of reaction
• explain the effect on the rate of reaction by referring to the collision of particles and activation energy, where appropriate.

Experiment	Concentration of H_2O_2	Temperature °C	Presence of small amount of MnO_2
1	20%	20	yes
2	20%	30	yes
3	30%	20	yes

2015: Question 1c: Compare Experiment 3 with Experiment 1. (see above) In your answer, you should:
• identify the factor being changed, and the effect this will have on the rate of reaction
• explain the effect on the rate of reaction by referring to the collision of particles and activation energy, where appropriate.

2016: Question 1a: Cleaned magnesium ribbon, Mg(s), reacts with a solution of hydrochloric acid, HCl(aq).
The reaction is represented by the equation:
$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$
The reaction is monitored by measuring the volume of hydrogen gas produced over a given period of time. This is shown in the graph below.
Explain the changes in the rate of reaction between magnesium, Mg(s), and hydrochloric acid, HCl(aq), in terms of collision theory.
Refer to parts A, B, and C of the graph in your answer.



2016: Question 1 (b): Compare and contrast the reactions of 0.5 g of magnesium ribbon, Mg(s), with 50.0 mL of 0.100 mol L–1 hydrochloric acid, HCl(aq), and 0.5 g of magnesium powder, Mg(s), with 50.0 mL of 0.100 mol L–1 hydrochloric acid, HCl(aq).
Refer to collision theory and rates of reaction in your answer.

Past NCEA Questions Reaction Rate Graphs and Factors (THREE)

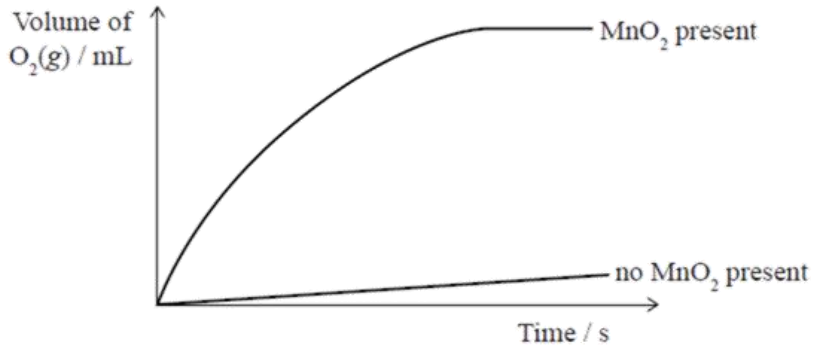
2016: Question 1c: The decomposition reaction of hydrogen peroxide solution, $H_2O_{2(aq)}$, is a slow reaction. This reaction is represented by the equation:

$2H_2O_{2(aq)} \rightarrow 2H_2O_{(l)} + O_{2(g)}$

The rate of the decomposition reaction can be changed by adding a small amount of manganese dioxide, $MnO_{2(s)}$. The graph below shows the volume of oxygen gas formed in the reaction with and without manganese dioxide, $MnO_{2(s)}$.

(i) State the role of manganese dioxide, $MnO_{2(s)}$, in this reaction.

(ii) Elaborate on how manganese dioxide, $MnO_{2(s)}$, changes the rate of the decomposition reaction of the hydrogen peroxide, $H_2O_{2(aq)}$. In your answer you should refer to the activation energy and collision theory.



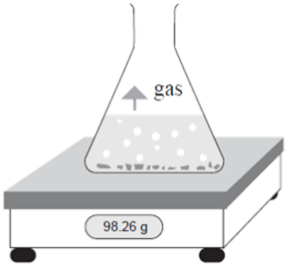
2017: Question 2a: The addition of a small amount of iron to a mixture of nitrogen and hydrogen gases helps to speed up the production of ammonia gas. $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$

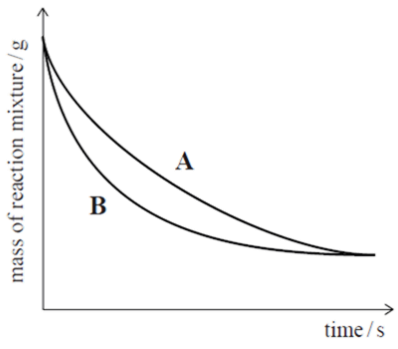
(a) Identify and explain the role of iron in this reaction. In your answer, you should refer to activation energy and collision theory. You may include a diagram or diagrams in your answer.

2017: Question 3a: Consider the reaction between calcium carbonate powder, $CaCO_{3(s)}$, and a solution of hydrochloric acid, $HCl_{(aq)}$. As the reaction proceeds, the mass of the reaction mixture decreases as carbon dioxide gas, $CO_{2(g)}$, escapes. This is represented on the graph below.

Line A represents the reaction occurring at 20°C and line B represents the reaction occurring at 40°C.

Compare and contrast the reaction between calcium carbonate powder, $CaCO_{3(s)}$, and a solution of hydrochloric acid, $HCl_{(aq)}$ at two temperatures: 20°C and 40°C, assuming all other conditions are kept the same. Your answer should refer to collision theory and rates of reaction.





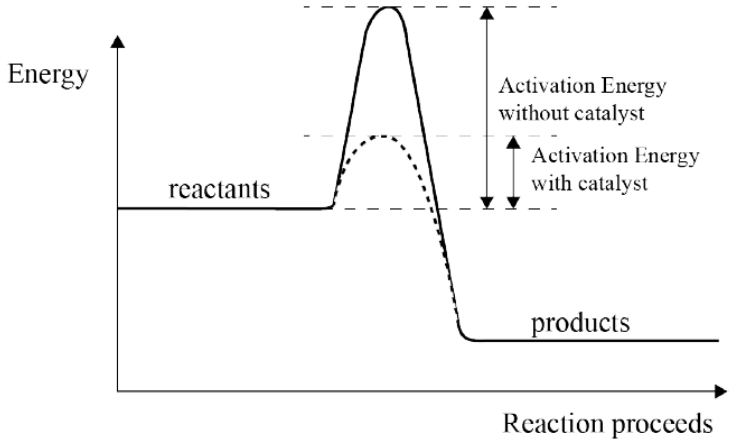
Past NCEA Questions Reaction Rate Graphs and Factors (FOUR)

2017: Question 3a: Compare and contrast the reaction between calcium carbonate powder, $CaCO_{3(s)}$, and a solution of hydrochloric acid, $HCl_{(aq)}$ at two temperatures: 20°C and 40°C, assuming all other conditions are kept the same.

2018: Question 1a: In the iodine clock reaction, a solution of hydrogen peroxide is mixed with a solution containing potassium iodide, starch, and sodium thiosulfate.
After some time, the colourless mixture suddenly turns dark blue.
The table shows the time taken for the reaction performed at different temperatures. The concentration of all reactants was kept constant.
Explain the effect of changing the temperature on the rate of reaction.
Refer to collision theory and activation energy in your answer.

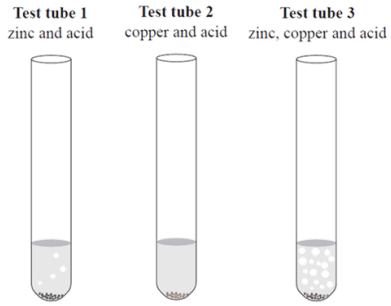
Temperature / °C	Time for dark blue colour to appear/s
20	15
30	9
40	4

2018: Question 1b: Consider the following observations in another experiment using hydrogen peroxide:
• When hydrogen peroxide is mixed with solution X, which contains universal indicator, the colour changes from blue to green to yellow to orange-red over a time of one hour.
• If a crystal of ammonium molybdate is added to solution X before the hydrogen peroxide is added, the same colour changes will be seen in three to four minutes.
(i) Identify and explain the role of ammonium molybdate.
Use a diagram and refer to activation energy in your answer.



Past NCEA Questions Reaction Rate Graphs and Factors (FIVE)

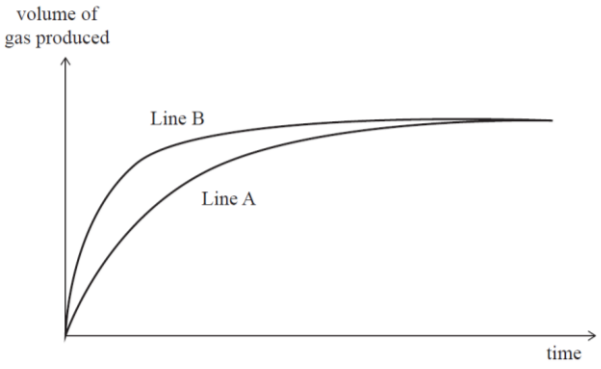
2019: Question 1a: The same volume and concentration of hydrochloric acid, $HCl_{(aq)}$, was added to each of three test tubes. Metal samples were added, according to the table and diagram below.



Test tube	Contents	Observations
1	20 mL hydrochloric acid, $HCl_{(aq)}$, and 1 g zinc granules, $Zn_{(s)}$	Slow rate of bubbles
2	20 mL hydrochloric acid, $HCl_{(aq)}$, and 1 g copper granules, $Cu_{(s)}$	No observable reaction
3	20 mL hydrochloric acid, $HCl_{(aq)}$, 1 g zinc granules, $Zn_{(s)}$, and 1 g copper granules, $Cu_{(s)}$	Fast rate of bubbles

(i) Identify the role of the copper granules, $Cu_{(s)}$, in test tube 3.
(ii) Explain the role of copper, $Cu_{(s)}$, in this reaction.
You should refer to activation energy and collision theory in your answer.

2019: Question 1b: In a second investigation, two 20 mL samples of 0.2 mol L^{-1} sulfuric acid, $H_2SO_{4(aq)}$, were placed in separate conical flasks. One of the flasks was placed in a water bath at 40°C and the other was placed in a water bath at 20°C. To each conical flask, 5.0 g of zinc granules, $Zn_{(s)}$, were added. The gas produced was collected and measured over time and the following graph was produced.



(i) Identify which line on the graph represents the reaction at 40°C, and explain why the two lines still finish in the same position.

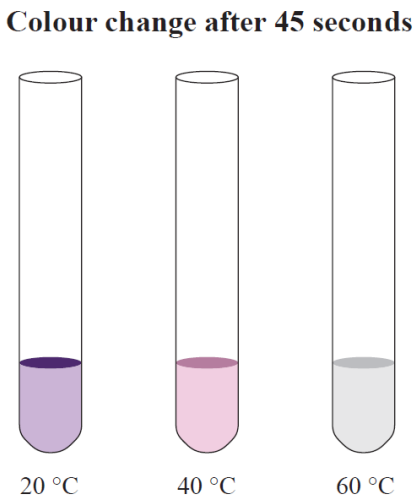
(ii) Elaborate on the effect of increasing temperature on the rate of reaction.

Refer to collision theory and activation energy in your answer.

2020: Question 2a: When oxalic acid solution, $H_2C_2O_{4(aq)}$, reacts with purple acidified potassium permanganate solution, H^+ / $MnO_4^-{}_{(aq)}$, the purple colour fades and the reaction is complete when the mixture turns colourless.

The picture shows the colour changes after 45 seconds for three different temperatures.

(a) Explain how the rate of reaction for this experiment is affected by the temperature at which the reaction occurs. In your answer refer to the information in the picture, collision theory, and activation energy.

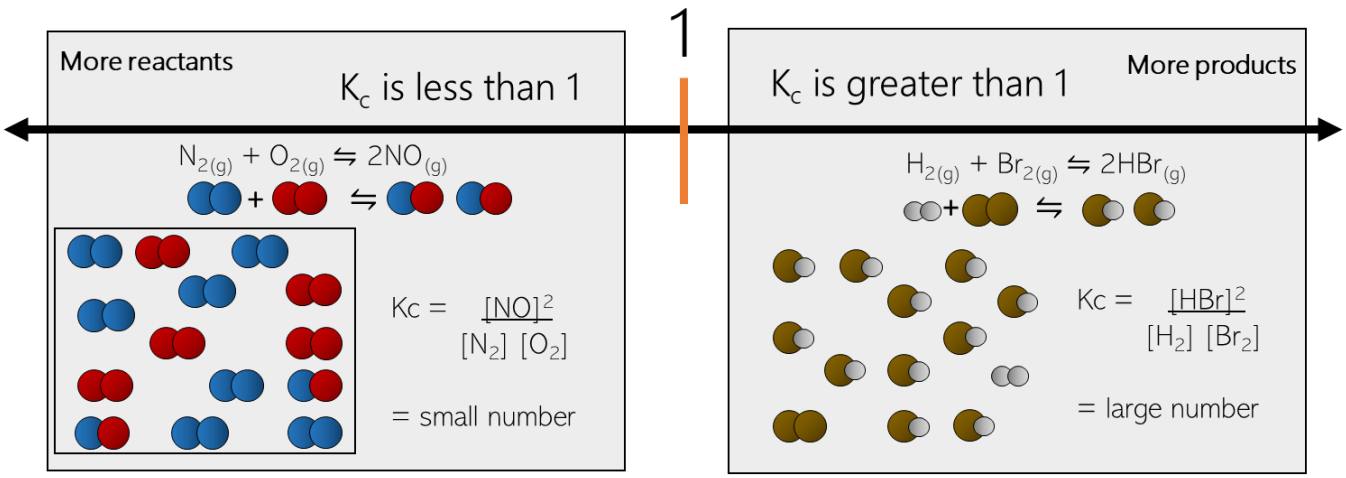


Writing Excellence answers to Equilibrium Expression questions

Equilibrium Expression QUESTION
Question: The following chemical equation represents a reaction that is part of the Contact Process, which produces sulfuric acid. $2SO_{2(g)} + O_{2(g)} \leftrightarrow 2SO_{3(g)}$ $\Delta H = -200$ kJ mol^{-1}, $Kc = 4.32$ at 600°C (i) Write an equilibrium constant expression for this reaction. (ii): A reaction mixture has the following concentration of gases at 600°C: $[SO2_{(g)}] = 0.300$ mol L^{-1} $[O2_{(g)}] = 0.100$ mol L^{-1} $[SO3_{(g)}] = 0.250$ mol L^{-1} Justify why this reaction mixture is not at equilibrium, using the equilibrium expression and the data provided

ANSWER	
1. Write out the equilibrium constant expression in full $K_c = \frac{[C]^c \times [D]^d}{[A]^a \times [B]^b}$ Given $aA + bB \rightleftharpoons cC + dD$	
2. Calculate the Q value by inserting all of the [ ] data given. Show working and remember order of operation and 3sgf Final value will have no units	
3. Write down the Kc value and compare with the Q value stating whether it is equal or not (and therefore is or is not at equilibrium)	
4. Link the Q value as either being bigger (and lying to the products side as the numerator is greater) OR as being smaller (and lying to the reactants side as the numerator is smaller)	

NOTE: The white column is how your answer would appear on your test paper so make sure you write out complete sentences. The grey area is just to help you structure your answer and would not appear in the question.



Some questions will ask you to calculate a value (Q) using the equilibrium constant and provided concentrations [ ]
You then need to compare this value to K_c (at a particular temperature). Use the scale above to compare positions of Q to K_c to see if that value indicates the reaction is at equilibrium (they are the same) or more reactants/products

Past NCEA Questions Equilibrium Expression (ONE)

2014: Question 2a (i): Hydrogen can be produced industrially by reacting methane with water.
An equation for this reaction can be represented by: $CH_{4(g)} + H_2O_{(g)} \leftrightharpoons CO_{(g)} + 3H_{2(g)}$
K_c = 4.7 at 1127°C
(a) (i) Complete the equilibrium constant expression for this reaction:

2014: Question 2a (ii): The concentrations of the four gases in a reaction mixture at 1127°C are found to be: (see below). Use these values to carry out a calculation to determine if the reaction is at equilibrium.
*K*c = 4.7 at 1127°C

Gas	CH_4	H_2O	CO	H_2
Concentration / mol L^{-1}	0.0300	0.0500	0.200	0.300

2015: Question 3a: The equilibrium constant for a reaction involving compounds A, B, C, and D is shown as:
$K_c = \frac{[C]^3[D]}{[A]\ [B]^2}$
Write the chemical equation for this reaction.

2015: Question 3c (i): The following chemical equation represents a reaction that is part of the Contact Process which produces sulfuric acid.
$2SO_{2(g)} + O_{2(g)} \leftrightharpoons 2SO_{3(g)}$ ΔH = −200 kJ mol^{-1}, *K*c= 4.32 at 600°C
(i) Write an equilibrium constant expression for this reaction.

Past NCEA Questions Equilibrium Expression (TWO)

2015: Question 3c (ii): A reaction mixture has the following concentration of gases at 600°C:
$[SO2_{(g)}]$ = 0.300 mol L^{-1}
$[O2_{(g)}]$ = 0.100 mol L^{-1}
$[SO3_{(g)}]$ = 0.250 mol L^{-1}
Justify why this reaction mixture is not at equilibrium. In your answer you should use the equilibrium expression from part (c)(i) and the data provided above to show that the reaction mixture is not at equilibrium.

2016: Question 3a: The equilibrium constant expression for a reaction is:

$$K_c = \frac{[CH_3OH]}{[CO][H_2]^2}$$

Write the equation for this reaction.

2016: Question 3b: The ionisation of water is represented by the equation: $2H_2O(l) \leftrightharpoons H_3O^+(aq) + OH^-(aq)$
Give an account of the extent of ionisation of water, given Kw = 1×10^{-14}.

2016: Question 3d: When hydrogen gas, $H_2(g)$, and iodine gas, $I_2(g)$ are mixed, they react to form HI(g), and an equilibrium is established.
$H_2(g) + I_2(g) \leftrightharpoons 2HI(g)$
Kc = 64 at 445°C.

(i) Calculate the concentration of HI in an equilibrium mixture at 445°C when the concentrations of $H_2(g)$ and $I_2(g)$ are both 0.312 mol L^{-1}.

2017: Question 2b: The reaction described below is an equilibrium reaction, as represented by the following equation: $N_{2(g)} + 3H_{2(g)} \leftrightharpoons 2NH_{3(g)}$
(i) Write the equilibrium constant expression for this reaction.

2017: Question 2b: (ii) The value of the equilibrium constant, Kc, is 640 at 25ºC.
Show, by calculation, using the concentrations of the gases given in the table below, whether or not the reaction is at equilibrium.
Explain your answer.

Gas	N_2	H_2	NH_3
Concentration (mol L^{-1})	0.0821	0.0583	0.105

2017: Question 2c: As the temperature increases, the value of the equilibrium constant, K_c, decreases from 640 at 25ºC to 0.440 at 200ºC.
Justify whether the formation of ammonia, $NH_{3(g)}$, is an endothermic or exothermic reaction.
$N_{2(g)} + 3H_{2(g)} \leftrightharpoons 2NH_{3(g)}$

Past NCEA Questions Equilibrium Expression (THREE)

2018: Question 2a: The Contact Process is used industrially in the manufacture of sulfuric acid. One step in this process is the oxidation of sulfur dioxide, $SO_{2(g)}$, to sulfur trioxide, $SO_{3(g)}$.
$2SO_{2(g)} + O_{2(g)} \leftrightharpoons 2SO_{3(g)}$ (a) Write the equilibrium constant expression for this reaction.

2018: Question 2b: (i) Calculate the equilibrium constant (*K*c) for this reaction at 600ºC using the following concentrations: $[SO_2] = 0.100$ mol L^{-1} $[O_2] = 0.200$ mol L^{-1} $[SO_3] = 0.0930$ mol L^{-1}
(ii) Explain what the size of the K_c value indicates about the extent of the reaction at equilibrium.

2018: Question 2e: When the reaction is carried out at 450ºC, the K_c value is higher than the value at 600°C.
Justify whether the oxidation of sulfur dioxide gas, $SO_{2(g)}$, to sulfur trioxide gas, $SO_{3(g)}$, is exothermic or endothermic. $2SO_{2(g)} + O_{2(g)} \leftrightharpoons 2SO_{3(g)}$

2019: Question 2a: The Haber process combines nitrogen, $N_{2(g)}$, from the air with hydrogen, $H_{2(g)}$, to form ammonia, $NH_{3(g)}$, which is then used in the manufacture of fertiliser.
The equation for this process is $N_{2(g)} + 3H_{2(g)} \leftrightharpoons 2NH_{3(g)}$
(i) Write the equilibrium constant expression for this reaction.

2019: Question 2c: (i) Nitrogen, $N_{2(g)}$, can also be reacted with oxygen, $O_{2(g)}$, to give nitrogen dioxide, $NO_{2(g)}$, and the following K_c expression would apply. The K_c for the reaction at 25°C is 8.30×10^{-10}. Calculate the concentration of nitrogen dioxide, NO_2, if the concentration of oxygen, O_2, is 0.230 mol L^{-1} and the concentration of nitrogen, N_2, is 0.110 mol L^{-1}. Give your answer to appropriate significant figures.

(ii) Explain the effect on K_c if the concentration of nitrogen, $N_{2(g)}$, is increased to 0.200 mol L^{-1} at 25°C (no calculations are necessary). $N_{2(g)} + 2O_{2(g)} \leftrightharpoons 2NO_{2(g)}$

2020: Question 3a: (i) Write the equilibrium constant expression, K_c , for the conversion of gaseous carbonyl fluoride, $COF_{2(g)}$, to the gas carbon tetrafluoride, $CF_{4(g)}$ and carbon dioxide, $CO_{2(g)}$. $2COF_{2(g)} \leftrightharpoons CF_{4(g)} + CO_{2(g)}$

(ii) At equilibrium, carbonyl fluoride, COF_2, has a concentration of 0.040 mol L^{-1}. The concentration of both carbon tetrafluoride, CF_4, and carbon dioxide, CO_2, is 0.80 mol L^{-1}. Calculate the K_c for this equilibrium.

(iii) At a different temperature, the *K*c value is 50. Explain what the value of the *K*c indicates about the extent of this reaction.

(iv) The enthalpy change, $\Delta_r H$, for the decomposition of carbonyl fluoride is –24 kJ mol^{-1}.

Explain what happens to the value of K_c when the temperature is decreased.

Writing Excellence answers to Equilibrium – Pressure questions

Equilibrium – Pressure QUESTION	
Question: The two reactions shown in the following table are both at equilibrium. Compare and contrast the effect of increasing the pressure on both reactions, with reference to the equilibrium positions.	

Reaction	**Equation**	**Affected by increased pressure**
One	$H_{2(g)} + I_{2(g)} \rightarrow 2HI_{(g)}$	no
Two	$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$	yes

ANSWER	
1. State the equilibrium principle	
2. Describe the factor in your question AND Link increasing the principle to how the system responds [some questions will be decreasing]	
3. Generally, explain which side of the equation is favoured (relate to moles) AND the general observations – at visible and particle level.	
4. Specifically, in <u>reaction one</u> describe number of moles in both sides of the equation AND link to which direction of reaction would be favoured (and observation)	
5. Specifically, in <u>reaction two</u> link number of moles in both sides of the equation to observation AND link to which direction of reaction would be favoured	
6. Describe how the system shift in <u>reaction two</u> would affect at particle level AND final observation.	

NOTE: The white column is how your answer would appear on your test paper so make sure you write out complete sentences. The grey area is just to help you structure your answer and would not appear in the question.

Writing Excellence answers to Equilibrium – Temperature questions

Equilibrium – Temperature QUESTION
Question: In a reaction, the brown gas nitrogen dioxide, $NO_{2(g)}$, exists in equilibrium with the colourless gas dinitrogen tetroxide, $N_2O_{4(g)}$. The equation for this reaction is represented by: $2NO_{2(g)} \leftrightarrow N_2O_{4(g)}$ brown gas colourless gas The table below shows the observations when changes were made to the system. Analyse these experimental observations. In your answer you should: • link all of the observations to equilibrium principles • justify whether the formation of dinitrogen tetroxide from nitrogen dioxide is endothermic or exothermic.

Change		**Observations**
Pressure	increased (by decreasing the volume of the container)	Colour faded
	decreased (by increasing the volume of the container)	Colour darkened
Temperature	container with reaction mixture put into hot water	Colour darkened
	container with reaction mixture put into ice water	Colour faded

ANSWER	
1. State the equilibrium principle	
2. Describe the factor in your question AND Link the principle to how the system responds to cooling or heating	
3. Generally, explain which side of the equation is favoured (relate to endothermic or exothermic)	
4. Specifically, for your reaction with heating, link the observation to which direction of reaction would be favoured (endothermic or exothermic)	
5. Describe how the system shift in heating would affect which products are made AND final observation.	
6. Specifically, for your reaction with cooling, link the observation to which direction of reaction would be favoured (endothermic or exothermic)	
7. Describe how the system shift in cooling would affect which products are made AND final observation.	

Writing Excellence answers to Equilibrium – Concentration questions

Equilibrium – Concentration QUESTION
Question: When acid is added to a yellow solution of chromate ions, $CrO_4^{2-}(aq)$, the following equilibrium is established. $2CrO_4^{2-}(aq) + 2H^+(aq) \leftrightarrow Cr_2O_7^{2-}(aq) + H_2O(l)$ yellow orange Analyse this equilibrium using equilibrium principles to explain the effect on the colour of the solution when: (i) more dilute acid is added <u>AND</u> when (ii) dilute base is added:

ANSWER	
1. State the equilibrium principle	
2. Describe the factor in your question AND Link the principle to how the system responds to increasing or decreasing concentration of reactants	
3. Generally, explain which side of the equation is favoured (relate to reactants or products) by increasing or decreasing concentration	
4. Specifically, for your reaction explain how you are <u>increasing the concentration of reactants</u>, AND link the direction of reaction that would be favoured	
5. Describe how the system shift by <u>increasing the concentration of reactants</u> would affect which substances are made AND final observation.	
6. Specifically, for your reaction explain how you are <u>decreasing the concentration of reactants</u>, AND link the direction of reaction that would be favoured	
7. Describe how the system shift by <u>decreasing the concentration of reactants</u> would affect which substances are made AND final observation.	

NOTE: The white column is how your answer would appear on your test paper so make sure you write out complete sentences. The grey area is just to help you structure your answer and would not appear in the question.

Le Chatelier's Principle

When a change is applied to a system at equilibrium, the system responds so that the effects of the change are minimised

Change in conditions		Direction of change in equilibrium position
Concentration - increase products		In the reverse direction
- decrease products		In the forward direction
- increase reactants		In the forward direction
- decrease reactants		In the reverse direction
Pressure	Increase	In the direction with the least no. of moles of gas
	Decrease	In the direction with the greater no. of moles of gas
Temperature	Increase	In the direction of the endothermic reaction
	Decrease	In the direction of the exothermic reaction
Catalyst added		No change in equilibrium position or in K_c Equilibrium is reached more quickly (i.e. reaction rate changes)

Past NCEA Questions Equilibrium (ONE)

2013: Question 2c: The two reactions shown in the following table are both at equilibrium.

Reaction	Equation	Affected by increased pressure
One	$H_{2(g)} + I_{2(g)} \rightarrow 2HI_{(g)}$	no
Two	$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$	yes

Compare and contrast the effect of increasing the pressure on both reactions, with reference to the equilibrium positions.

2014: Question 2b: The reaction shown in the equation below is at equilibrium.

$CO_{(g)} + 2H_{2(g)} \leftrightharpoons CH_3OH_{(g)}$

Describe the effect of each of the following changes on the equilibrium concentration of methanol (increase, decrease, stay the same).

Justify your answers using equilibrium principles.

(i) *A copper oxide, CuO, catalyst is added.* Amount of $CH_3OH_{(g)}$ would:

(ii) *(ii) $H_{2(g)}$ is removed.* Amount of $CH_3OH_{(g)}$ would:

(i) Explain, using equilibrium principles, the effect of adding more ethanol to the reaction mixture.

Past NCEA Questions Equilibrium (TWO)

2014: Question 2c: In a reaction, the brown gas nitrogen dioxide, $NO_{2(g)}$, exists in equilibrium with the colourless gas dinitrogen tetroxide, $N_2O_{4(g)}$.
The equation for this reaction is represented by:

$2NO_{2(g)} \leftrightharpoons N_2O_{4(g)}$

brown gas colourless gas

The table below shows the observations when changes were made to the system. Analyse these experimental observations.
In your answer you should:

- link all of the observations to equilibrium principles
- justify whether the formation of dinitrogen tetroxide from nitrogen dioxide is endothermic or exothermic.

Change		**Observations**
Pressure	increased (by decreasing the volume of the container)	Colour faded
	decreased (by increasing the volume of the container)	Colour darkened
Temperature	container with reaction mixture put into hot water	Colour darkened
	container with reaction mixture put into ice water	Colour faded

2015: Question 3(b)(i): The reaction between ethanoic acid and ethanol is reversible. Ethyl ethanoate and water are the products formed. In a closed system, a dynamic equilibrium is set up.
ethanoic acid + ethanol ⇋ ethyl ethanoate + water

$CH_3COOH_{(aq)} + C_2H_5OH_{(aq)} \leftrightharpoons CH_3COOC_2H_{5(aq)} + H_2O_{(l)}$

2015: Question 3(b)(ii): The reaction between ethanoic acid and ethanol is reversible. Ethyl ethanoate and water are the products formed. In a closed system, a dynamic equilibrium is set up.
The reaction is quite slow, so a small amount of concentrated sulfuric acid is added as a catalyst.
Explain, using equilibrium principles, the effect of adding this catalyst to the equilibrium mixture.

2016: Question 3(c): When acid is added to a yellow solution of chromate ions, $CrO_4^{2-}(aq)$, the following equilibrium is established.

$2CrO_4^{2-}(aq) + 2H^+(aq) \leftrightharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$

yellow orange

Analyse this equilibrium using equilibrium principles to explain the effect on the colour of the solution when:
(i) more dilute acid is added:
(ii) dilute base is added:

2016: Question 3(d): When hydrogen gas, $H_2(g)$, and iodine gas, $I_2(g)$ are mixed, they react to form $HI(g)$, and an equilibrium is established.

$H_2(g) + I_2(g) \leftrightharpoons 2HI(g)$

$K_c = 64$ at 445°C.
(ii) Explain the effect on the position of equilibrium if the overall pressure of the equilibrium system is increased.

Past NCEA Questions Equilibrium (THREE)

2017: Question 3b: Two different cobalt(II) complex ions, $[Co(H_2O)_6]^{2+}$ and $[CoCl_4]^{2-}$, exist together in a solution in equilibrium with chloride ions, $Cl^-_{(aq)}$.
The forward reaction is endothermic; ΔH is positive. The equation for this equilibrium is shown below.

$[Co(H_2O)_6]^{2+}_{(aq)} + 4Cl^-_{(aq)} \leftrightharpoons [CoCl_4]^{2-}_{(aq)} + 6H_2O_{(l)}$

Pink blue

Explain using equilibrium principles, the effect on the colour of the solution if:
(i) more water is added to the reaction mixture
(ii) a test tube containing the reaction mixture is placed in a beaker of ice-cold water.

2017: Question 3c: Brown nitrogen dioxide gas, $NO_{2(g)}$, exists in equilibrium with the colourless gas, dinitrogen tetroxide, $N_2O_{4(g)}$.

$2NO_{2(g)} \leftrightharpoons N_2O_{4(g)}$

brown colourless

Explain using equilibrium principles, the effect of decreasing the volume of the container (therefore increasing the pressure) on the observations of this equilibrium mixture.

2018: Question 2c: Explain, using equilibrium principles, why it is important for an industrial plant to continue to remove the sulfur trioxide gas, $SO_{3(g)}$, as it is produced.

$2SO_{2(g)} + O_{2(g)} \leftrightharpoons 2SO_{3(g)}$

2018: Question 2d: Predict, using equilibrium principles, the effect on the concentration of sulfur trioxide gas, $SO_{3(g)}$, of carrying out the reaction in a larger reaction vessel.

2019: Question 2a: The Haber process combines nitrogen, $N_{2(g)}$, from the air with hydrogen, $H_{2(g)}$, to form ammonia, $NH_{3(g)}$, which is then used in the manufacture of fertiliser. The equation for this process is $N_{2(g)} + 3H_{2(g)} \leftrightharpoons 2NH_{3(g)}$

(ii) Using equilibrium principles, explain why carrying out the Haber process at high pressure is an advantage to the manufacturer.

(iii) In another part of the process, the ammonia, $NH_{3(g)}$, is removed as it is produced.
Justify this step using equilibrium principles to explain why this would be an advantage to a manufacturer.

2020: Question 3b: The following equilibrium was established in the laboratory by mixing iron(III) nitrate solution, $Fe(NO_3)_{3(aq)}$, with potassium thiocyanate solution, $KSCN_{(aq)}$.

$Fe_3{}^+_{(aq)} + SCN^-_{(aq)} \leftrightharpoons [FeSCN]^{2+}_{(aq)}$

Orange colourless dark red

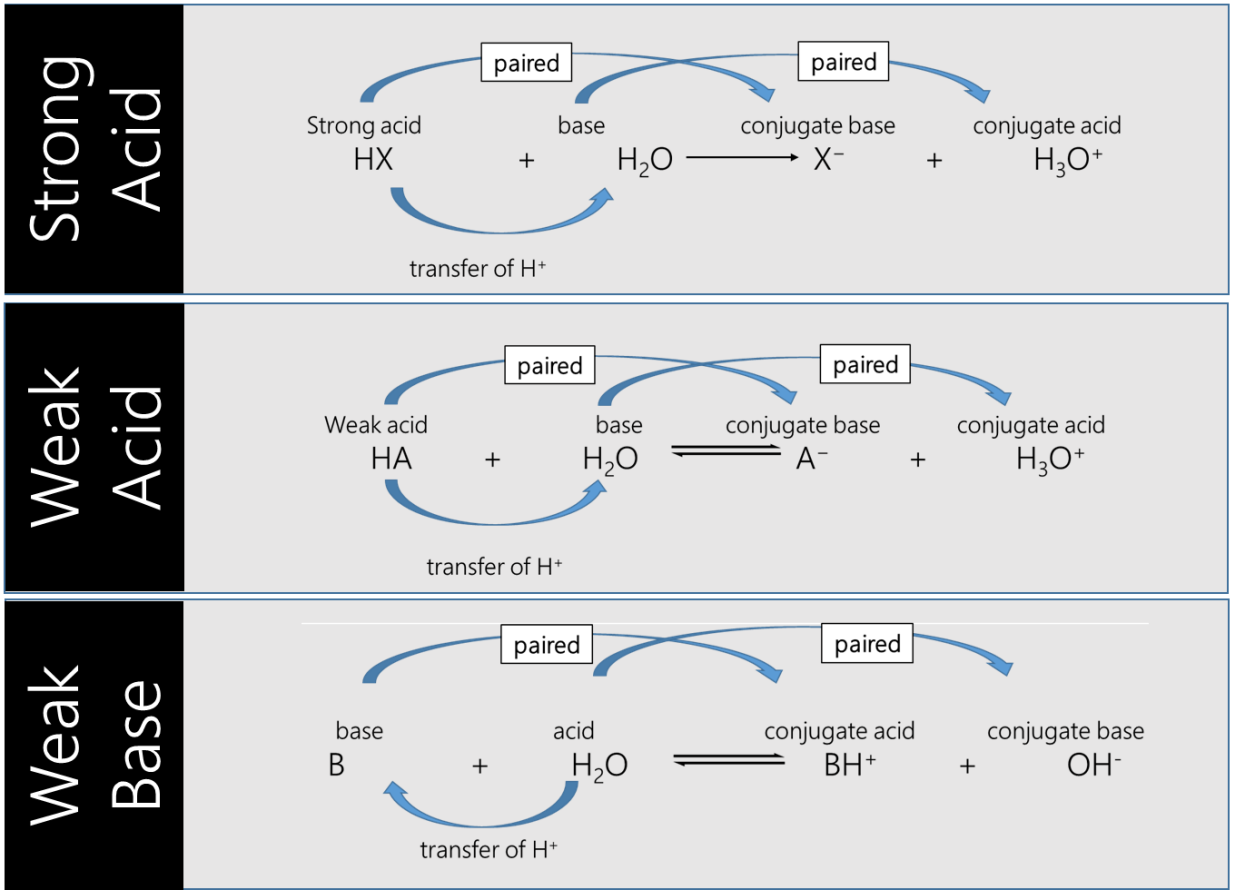
The forward reaction produces heat. Explain, using equilibrium principles, the effect on the colour of the solution if:

(i) More potassium thiocyanate solution, $KSCN_{(aq)}$, is added to the reaction mixture.

(ii) Solid sodium fluoride is added to the mixture. The added F^- ions react with the Fe^{3+} ions.

(iii) A test tube containing the reaction mixture is placed in a beaker of recently boiled water.

Acid and Base Dissociation



Past NCEA Questions Acids and Bases

2014: Question 1a: Ammonia, NH_3, is dissolved in water and the resulting solution has a pH of 11.3.
(i) Complete the equation by writing the formulae of the two products.
$NH_{3(aq)} + H_2O_{(l)} \rightarrow$ +
(ii) Explain what is occurring during this reaction. In your answer you should: identify the acid and its conjugate base, identify the base and its conjugate acid, describe the proton transfer that occurs.

2015: Question 2a: Ammonia solution, $NH_{3(aq)}$, is a common chemical in the school laboratory. (i) Explain, using an equation, whether ammonia solution is acidic or basic.

2015: Question 2a: (ii) Bottles of ammonia solution are often labelled ammonium hydroxide, $NH_4OH_{(aq)}$. Explain why both names, ammonia and ammonium hydroxide, are appropriate.

2015: Question 2b: The hydrogen carbonate ion, HCO_3^-, is an amphiprotic species because it can donate or accept a proton, therefore acting as an acid or base. Write equations for the reactions of HCO_3^- with water: one where it acts as an acid, and one where it acts as a base.

Past NCEA Questions Acids and Bases

2016: Question 2a: Water is an amphiprotic substance because it can accept or donate a proton, therefore acting as an acid or a base. Complete the equations for the reactions of water, H_2O, with ammonia, NH_3, and the ammonium ion, NH_4^+, in the box beside.

H_2O acting as	Equation
an acid	$H_2O(\ell) + NH_3(aq) \rightleftharpoons$
a base	$H_2O(\ell) + NH_4^+(aq) \rightleftharpoons$

2016: Question 2b: Sodium carbonate, $Na_2CO_3(s)$, is a salt. When dissolved in water, it dissociates into ions. Explain whether a solution of sodium carbonate would be acidic or basic. In your answer you should include TWO relevant equations.

2017: Question 1a: Propanoic acid, C_2H_5COOH, is dissolved in water and the resulting solution has a pH of 4.2.
(i) Complete the equation by writing the formulae of the two products.
$C_2H_5COOH_{(aq)} + H_2O_{(l)} \leftrightharpoons$

(i) Explain the proton, H^+, transfer in this reaction, and identify the two conjugate acid-base pairs.

2017: Question 1b: Sodium ethanoate, $CH_3COONa_{(s)}$, is a salt. When dissolved in water, it dissociates into ions. Explain, including TWO relevant equations, whether a solution of sodium ethanoate is acidic or basic.

2018: Question 1b (iv) : Another chemical in solution X is a salt, sodium ethanoate, CH_3COONa. When solid sodium ethanoate is dissolved in water, it separates into ions. Use TWO relevant equations to explain whether the solution is acidic or basic.

2018: Question 3a: The hydrogensulfate ion, HSO_4^-, is an amphiprotic species because it can both accept or donate a proton, thus acting as an acid or base. Complete the equations for the reactions of the hydrogensulfate ion, HSO_4^-, with water in the box beside.

HSO_4^- acting as	Equation
an acid	$HSO_4^-(aq) + H_2O(\ell) \rightleftharpoons$
a base	$HSO_4^-(aq) + H_2O(\ell) \rightleftharpoons$

2019: Question 3a: (a) Nitric acid, $HNO_{3(aq)}$, and ethanoic acid, $CH_3COOH_{(aq)}$, are both acids.

(i) Write equations to show their reactions with water, $H_2O(l)$.

$HNO_3(aq) + H_2O(\ell)$

$CH_3COOH(aq) + H_2O(\ell)$

(ii) Use these equations to explain why they are classified as acids.

2020: Question 1a: (i) Sodium hydrogen carbonate, $NaHCO_3$, is a salt and will dissociate into ions when dissolved in water. Write an equation for this process.

(ii) One of the ions formed from the dissociation is amphiprotic because it can either accept or donate a proton. Write equations for each of these reactions acting as an acid and a base.

Writing Excellence answers to pH and Conductivity questions

pH and Conductivity QUESTION
Question: Some properties of three aqueous solutions A, B and C, of equal concentration are shown in the table below. It is known that the solutions are $NH_{3(aq)}$, $HCl_{(aq)}$ and $NH_4Cl_{(aq)}$ Justify the identification of all three solutions. • refer to both pH and electrical conductivity of the solutions • link your answers to appropriate chemical equations.

Solution	A	B	C
pH	5.15	11.6	1.05
Electrical conductivity	good	poor	good

ANSWER	
1. Identify each solution as either A, B or C by linking to being a weak or strong acid or base and also to the pH	
2. State requirements for conductivity	
3. Solution A (pH 5.15) weak acid salt. Equation 1. [A salt will first dissociate fully into ions] <u>Write equation</u> AND link ions formed to conductivity and level of dissociation	
4. Solution A (pH 5.15) weak acid salt. Equation 2.[One of the products of dissociation will further react as an acid] <u>Write equation</u> AND link ions formed to conductivity and level of dissociation (must form H_3O^+ ions)	
5. Solution B (pH 11.6) weak base. <u>Write equation</u> AND link ions formed to conductivity and level of dissociation (must form OH^- ions)	
6. Solution C (pH 1.05) strong acid. <u>Write equation</u> AND link ions formed to conductivity and level of dissociation (must form H_3O^+ ions)	

Writing Excellence answers to Reaction Rates of Acids questions

Reaction Rates of Acids QUESTION

Question: The pH values of 0.100 mol L^{-1} solutions of two acids, HA and HB, are given in the table below.
(i) Compare the relative strengths of the two acids, $HA_{(aq)}$ and $HB_{(aq)}$, using the information given above.
Your answer should include equations and calculations.
(ii) Predict and compare, with reasons, what would be observed when two 5 g samples of calcium carbonate chips, $CaCO_{3(s)}$, are reacted, separately, with excess HA and HB.

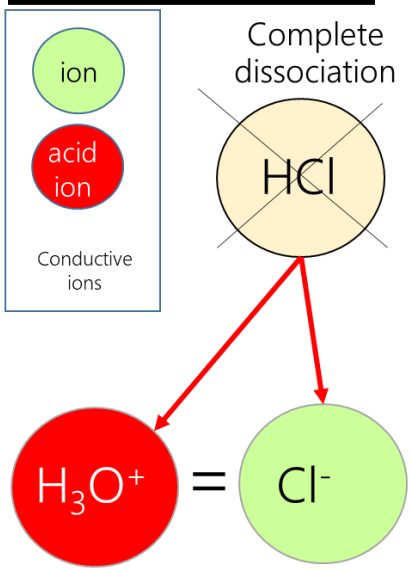
Solution	pH
0.100 mol L^{-1} HA(aq)	1.0
0.100 mol L^{-1} HB(aq)	2.2

ANSWER

1. Write an equation for <u>HA</u> [Remembering H_3O^+ must be produced]	
2. Calculate H_3O^+ for <u>HA</u> $[H_3O^+] = 10^{-pH}$	
3. For HA link concentration of ions formed to level of dissociation AND compare to concentration of acid (are they the same?)	
4. Write an equation for <u>HB</u> [Remembering H_3O^+ must be produced]	
5. Calculate H_3O^+ for <u>HB</u> $[H_3O^+] = 10^{-pH}$	
6. For HB link concentration of ions formed to level of dissociation AND compare to concentration of acid (are they the same?)	
7. For HA link observation of reaction to concentration of ions	
8. then For HA link collision frequency to rate of reaction	
9. For HB link observation of reaction to concentration of ions	
10. then For HB link collision frequency to rate of reaction	

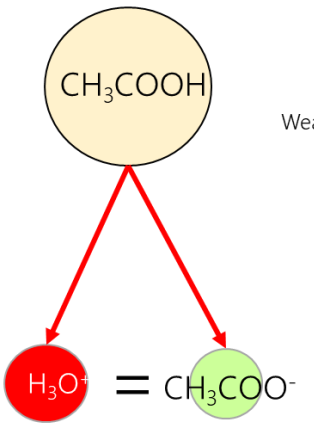
Summary of Species/conductivity in Solution - Acid

Strong Acids



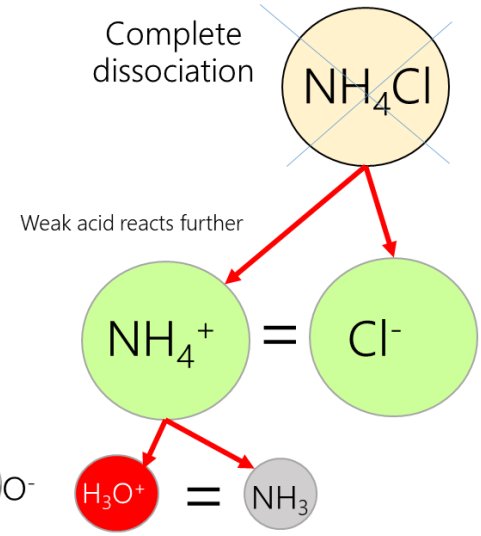
No strong acid remains
High conductivity
Low pH (1-2)

Weak Acids



Most weak acid remains
Low conductivity
High pH (3-6)

Acid salts

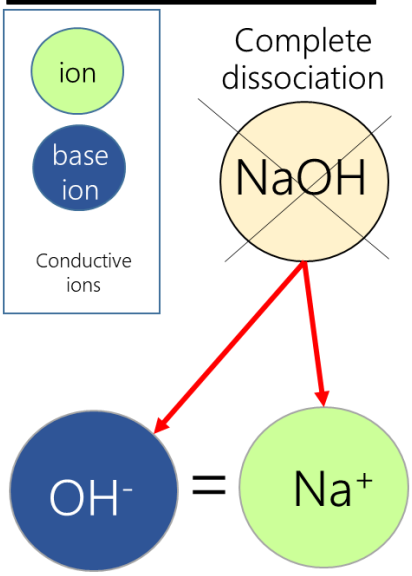


No salt remains
High conductivity
High pH (3-6)

Water concentration is assumed to remain constant so is left out

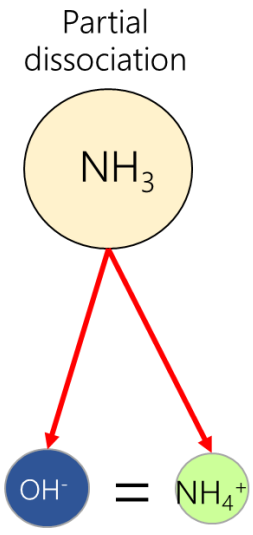
Summary of Species / conductivity in Solution - Base

Strong Bases



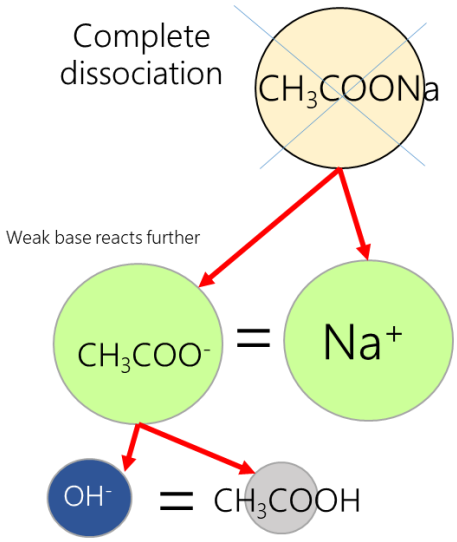
No strong base remains
High conductivity
High pH (12-14)

Weak Bases



Most weak base remains
Low conductivity
Low pH (8-11)

Base salts



No salt remains
High conductivity
Low pH (8-11)

water concentration is assumed to remain constant so is left out

Past NCEA Questions Ions and Conductivity / pH / Reaction Rates of Acids (ONE)

2012: Question 3d: Some properties of three aqueous solutions A, B and C, of equal concentration are shown in the table below. It is known that the solutions are $NH_{3(aq)}$, $HCl_{(aq)}$ and $NH_4Cl_{(aq)}$

Solution	A	B	C
pH	5.15	11.6	1.05
Electrical conductivity	good	poor	good

Justify the identification of all three solutions.
• refer to both pH and electrical conductivity of the solutions
• link your answers to appropriate chemical equations.

2013: Question 3d: The following table shows the concentration and pH of three acids, and the relative rate of reaction with magnesium (Mg) metal.

acid	Concentration / $molL^{-1}$	pH	Relative rate of reaction with Mg
HA	0.100	3.4	slow
HB	0.0100	2	fast
HC	1.00×10^{-5}	5	Very slow

Compare and contrast the reactivity of the three acids with magnesium. In your answer:
• determine the concentration of hydronium ions, H_3O^+, in each acid
• compare the concentration of hydronium ions to the concentration of the acid
• explain the relative rate of reaction for each acid with magnesium

2014: Question 1c: The table below shows the relative electrical conductivity of five solutions of the same concentration, and the colour of pieces of litmus paper which have been dipped into each solution. Identify a strong base and a neutral salt, using the information in the table above.
In your answer you should justify your choices by referring to the properties of the identified solutions.

2014: Question 3c(i): The pH values of 0.100 mol L–1 solutions of two acids, HA and HB, are given in the table below.

Solution	**pH**
0.100 mol L^{-1} $HA(aq)$	1.0
0.100 mol L^{-1} $HB(aq)$	2.2

Compare the relative strengths of the two acids, $HA_{(aq)}$ and $HB_{(aq)}$, using the information given above.
Your answer should include equations and calculations.

Past NCEA Questions Ions and Conductivity / pH / Reaction Rates of Acids (TWO)

2014: Question 3c(i): (ii) Predict and compare, with reasons, what would be observed when two 5 g samples of calcium carbonate chips, $CaCO_{3(s)}$, are reacted, separately, with excess HA and HB.

2014: Question 1c: The table below shows the relative electrical conductivity of five solutions of the same concentration, and the colour of pieces of litmus paper which have been dipped into each solution. Identify a strong base and a neutral salt, using the information in the table above.
In your answer you should justify your choices by referring to the properties of the identified solutions.

Solution	A	B	C	D	E
Electrical conductivity	poor	good	good	poor	good
Red litmus paper	turns blue	stays red	stays red	stays red	turns blue
Blue litmus paper	stays blue	turns red	stays blue	turns red	stays blue

2015: Question 2d: Ethanoic acid solution, $CH_3COOH_{(aq)}$, and ammonium chloride solution, $NH_4Cl_{(aq)}$, are both weakly acidic.

(i) Identify and justify, using equations, which acid solution has greater electrical conductivity.

(ii) Explain why the solution of ammonium chloride, $NH_4Cl(aq)$, is a good conductor of electricity, while the solution of propanoic acid, $C_2H_5COOH(aq)$, is a poor conductor of electricity.

2015: Question 2e: The table shows the pH of two acidic solutions, methanoic acid, HCOOH, and hydrochloric acid, HCl, which both have a concentration of 0.1 mol L^{-1}.Compare and contrast the pH of each solution, and their expected rate of reaction with a 2 cm strip of cleaned magnesium ribbon, Mg.

Solution	HCOOH(*aq*)	HCl(*aq*)
pH	2.4	1

2015: Question 3c (ii): Use the concentrations below to predict the rate of reaction of each acid with a 2 cm strip of cleaned magnesium ribbon, Mg.
Refer to the collision theory in your answer.
$[H_3O^+]$ of $HNO_3 = 10^{-0.7} = 0.200$ mol L^{-1}
$[H_3O^+]$ of $CH_3COOH = 10^{-2.73} = 0.00186$ mol L^{-1}

2017: Question 1d: Solutions of ammonia, $NH_{3(aq)}$, and sodium carbonate, $Na_2CO_{3(aq)}$, are both basic. Compare and contrast the electrical conductivity of these two solutions.

Past NCEA Questions Ions and Conductivity / pH / Reaction Rates of Acids (THREE)

2018: Question 3a: The pH and relative electrical conductivity of aqueous solutions of potassium hydroxide, $KOH_{(aq)}$, and ammonia, $NH_{3(aq)}$, are shown in the table below. Both have concentrations of 0.100 mol L^{-1}. Explain the difference in pH and conductivity of these two solutions. Use relevant equations in your answer.

Chemical	pH	Conductivity
$KOH(aq)$	13	good
$NH_3(aq)$	11.1	poor

2019: Question 3c: The table below provides information about solutions A to D.

Solution	A	B	C	D
Concentration (mol L^{-1})	0.100	0.100	0.100	0.100
pH	5.62	1	7	13

The solutions are known to be hydrochloric acid, $HCl_{(aq)}$, ammonium chloride, $NH_4Cl_{(aq)}$, sodium hydroxide, $NaOH_{(aq)}$ and sodium chloride, $NaCl_{(aq)}$. (i) Identify solutions A to D.

(ii) Justify your choices by comparing relative amounts of hydronium ion concentrations, $[H_3O+]$, in the solutions. Include relevant equations in your answer.

(iii) Elaborate on the electrical conductivity of the four solutions.

2020: Question 1c: The table below shows the concentration and pH of three basic solutions, sodium ethanoate, $CH_3COONa_{(aq)}$, ammonia, $NH_{3(aq)}$, and sodium hydroxide, $NaOH_{(aq)}$.

	$CH_3COONa(aq)$	$NH_3(aq)$	$NaOH(aq)$
Concentration (mol L^{-1})	0.1	0.1	0.1
pH	8.88	10.6	13.0

(i) Explain why each of these solutions has a different pH value, yet they are the same concentration. Use equations to support your answer.

Past NCEA Questions Ions and Conductivity / pH / Reaction Rates of Acids (FOUR)

2020: Question 2b: (ii) 2.0 g of powdered calcium carbonate, $CaCO_{3(s)}$, is added to each of the three solutions, A, B, and C, below. The volume of acid in each solution is the same.

Solution	Acid	pH	$[H_3O^+]$ mol L^{-1}
A	HCl(aq)	0.89	0.129 mol L^{-1}
B	HCl(aq)	1.80	0.0158
C	HCl(aq)	2.94	0.00115 mol L^{-1} or 1.15 x 10^{-3} mol L^{-1}

Identify which solution would have the highest rate of reaction with $CaCO_{3(s)}$.

Explain your answer, with reference to collision theory.

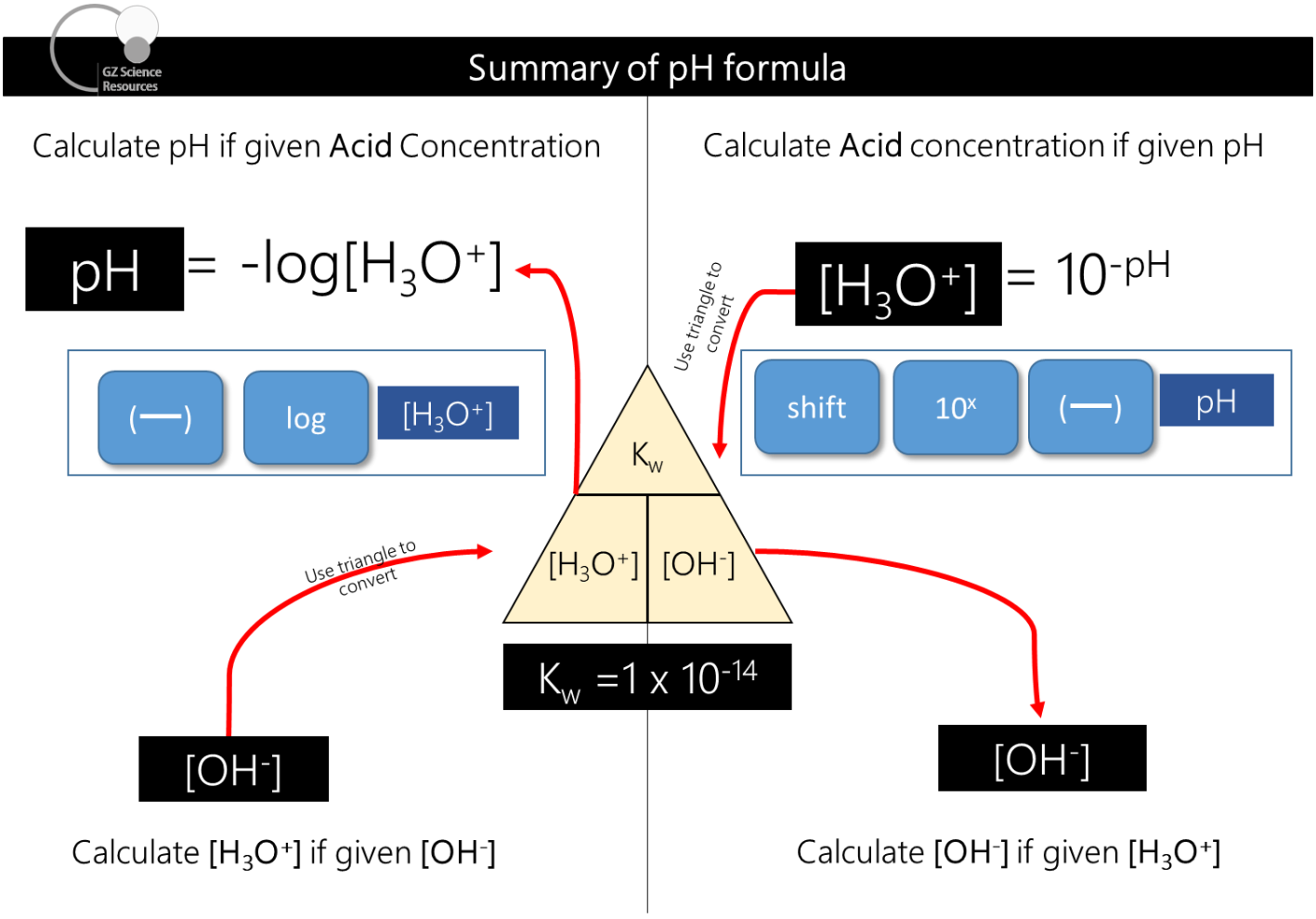
2020: Question 2c: Compare the electrical conductivity of a hydrochloric acid solution, $HCl_{(aq)}$, with a solution of ethanoic acid, $CH_3COOH_{(aq)}$, of the same concentration.

Use equations to support your answer.

Conductive acids and bases	Poorly conductive acids and bases
HCl (hydrochloric acid) H_2SO_4 (sulfuric acid) HNO_3 (nitric acid) NaOH (sodium hydroxide) $NaCO_3$ (sodium carbonate) Na_2O (sodium oxide)	NH_3 (ammonia) CH_3COOH (ethanoic acid)

Writing Excellence answers to pH Calculations questions

pH calculations QUESTION 1	
Question: In a solution of potassium hydroxide, KOH, the pH is found to be 12.8. (i) Calculate the hydronium ion concentration, $[H_3O^+]$, and the hydroxide ion concentration, $[OH^-]$, in the solution. $K_w = 1 \times 10^{-14}$ (ii) Calculate the pH of a 2.25×10^{-4} mol L^{-1} sodium hydroxide, NaOH, solution.	
ANSWER	
STEP 1. Calculate H_3O^+ for <u>KOH</u> $[H_3O^+] = 10^{-pH}$ (units and 3sgf)	
STEP 2. Calculate OH^- for <u>KOH</u> $[OH^-] = K_w / [H_3O^+]$ ($K_w = 1 \times 10^{-14}$) (units and 3sgf)	
STEP 1. Calculate pOH for <u>NaOH</u> $pOH = -\log[OH^-]$ (3sgf)	
STEP 2. Calculate pH for <u>NaOH</u> pH = 14 - pOH (3sgf)	
pH calculations QUESTION 2	
Question: (i) A solution of nitric acid, $HNO_{3(aq)}$, has a hydronium ion, H_3O^+, concentration of 0.0243 mol L^{-1}. Determine, by calculation, the pH and the concentration of hydroxide ions, OH^-, in this solution. $K_w = 1 \times 10^{-14}$ (ii) Determine the hydroxide ion concentration, $[OH^-]$, of a solution of potassium hydroxide, $KOH_{(aq)}$, with a pH of 11.8.	
ANSWER	
STEP 1. Calculate pH for <u>HNO_3</u> $pH = -\log[H_3O^+]$ (3sgf)	
STEP 2. Calculate OH^- for <u>HNO_3</u> $[OH^-] = K_w / [H_3O^+]$ ($K_w = 1 \times 10^{-14}$) (units and 3sgf)	
STEP 1. Calculate H_3O^+ for <u>KOH</u> $[H_3O^+] = 10^{-pH}$ (units and 3sgf)	
STEP 2. Calculate OH^- for <u>KOH</u> $[OH^-] = K_w / [H_3O^+]$ ($K_w = 1 \times 10^{-14}$) (units and 3sgf)	



Past NCEA Questions pH Calculations

2014: Question 1b: (i) In a solution of potassium hydroxide, KOH, the pH is found to be 12.8.
Calculate the hydronium ion concentration, $[H_3O^+]$, and the hydroxide ion concentration, $[OH^-]$, in the solution.
$K_w = 1 \times 10^{-14}$

2014: Question 1b: (ii) Calculate the pH of a 2.25×10^{-4} mol L^{-1} sodium hydroxide, NaOH, solution.

2015: Question 2c: (i) A solution of nitric acid, $HNO_{3(aq)}$, has a hydronium ion, H_3O^+, concentration of 0.0243 mol L^{-1}.
Determine, by calculation, the pH and the concentration of hydroxide ions, OH^-, in this solution.
$K_w = 1 \times 10^{-14}$

2015: Question 2c: (ii) (ii) Determine the hydroxide ion concentration, $[OH^-]$, of a solution of potassium hydroxide, $KOH_{(aq)}$, with a pH of 11.8.

Past NCEA Questions pH Calculations

2016: Question 2c: (i) Calculate the pH of a 0.0341 mol L–1 hydrochloric acid, HCl(*aq*), solution.

2016: Question 2c: (ii) A solution of sodium hydroxide, NaOH(*aq*), has a pH of 12.4.
Calculate the concentrations of both hydronium ions, H_3O+, and hydroxide ions, OH^-, in this solution.

2017: Question 1c: (i) A solution of sodium hydroxide, $NaOH_{(aq)}$, has a pH of 11.6.
Calculate the hydronium ion concentration $[H_3O^+]$, and the hydroxide ion concentration, $[OH^-]$, in the solution.
*K*w = 1 × 10–14

2017: Question 1c: (ii) Calculate the pH of a 2.96×10^{-4} mol L^{-1} solution of potassium hydroxide, $KOH_{(aq)}$.

2018: Question 1b (ii) : The pH of the original solution X is 10.8.
Calculate the hydronium ion concentration, $[H_3O^+]$, and the hydroxide ion concentration, $[OH^-]$, in the solution.

2018: Question 1b (iii): The sodium hydroxide solution, $NaOH_{(aq)}$, used to prepare solution X has a concentration of 0.0125 mol L^{-1}.
Calculate the pH of the sodium hydroxide solution.

2018: Question 3c (i): The table below gives the pH of solutions of ethanoic acid, $CH_3COOH_{(aq)}$, and nitric acid, $HNO_{3(aq)}$, of concentrations of 0.200 mol L^{-1}.
Use the pH values to analyse the strength of the acids by calculating the concentration of their H_3O^+ ions.

2019: Question 3b: (i) A solution of hydrochloric acid, $HCl_{(aq)}$, has a hydronium ion concentration, $[H_3O^+]$, of 0.0164 mol L^{-1}. Calculate the pH and hydroxide ion concentration, $[OH^-]$, of the solution.

(ii) Calculate the hydroxide ion concentration, $[OH^-]$, of a solution of potassium hydroxide, $KOH_{(aq)}$, with a pH of 9.4.

2020: Question 1b: (i) A solution of sodium hydroxide, $NaOH_{(aq)}$, has a pH of 11.8. Calculate the concentration of hydroxide ions, OH^-, in this solution.

(ii) The ionisation constant of water, K_w , like all equilibrium constants, varies with temperature.
Calculate the pH of pure water at 0 °C when $K_w = 0.114 \times 10^{-14}$ $K_w = [H_3O^+][OH^-]$

2020: Question 2b: (i) Complete the table below by calculating either the pH or the hydronium ion concentration, $[H_3O^+]$, for the three hydrochloric acid solutions, $HCl_{(aq)}$.

Solution	Acid	pH	$[H_3O^+]$ mol L^{-1}
A	HCl(aq)	0.89	
B	HCl(aq)		0.0158
C	HCl(aq)	2.94	

Writing Excellence answers to Reaction rate Factors – Surface Area questions

Reaction Rate Factors – Surface Area QUESTION
Question: Compare and contrast the reactions of 0.5 g of magnesium ribbon, Mg(s), with 50.0 mL of 0.100 mol L–1 hydrochloric acid, HCl(aq), and 0.5 g of magnesium powder, Mg(s), with 50.0 mL of 0.100 mol L–1 hydrochloric acid, HCl(aq). Refer to collision theory and rates of reaction in your answer.

ANSWER	
1. state the collision theory	Chemical reactions between particles of substances only occur when the following conditions have been met: Particles must collide with enough energy (called activation energy EA) and with the correct orientation. If these conditions are met the collision will be considered successful.
2. Describe the reactants in your reaction and state which factors are the same	In the reaction of hydrochloric acid with Mg ribbon and Mg powder, both form the same products, magnesium chloride and hydrogen gas. $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ The concentration and amount of the hydrochloric acid is the same in both reactions as is the mass of magnesium. (we assume the temperature is also the same)
3. Describe the reactants in your reaction and state which factor is different (the factor affecting reaction rate)	However, since Mg powder has a larger surface area than Mg ribbon
4. link the factor to the collision theory	the powder will have more Mg particles immediately available to collide than the magnesium ribbon
5. link the reaction to more successful collisions occurring per unit of time	And therefore there will be more effective collisions per second (unit of time)
6. link to more products (name products) being formed per unit of time AND link to a faster reaction rate	and more H_2 gas will be produced initially in the magnesium powder, resulting in a faster rate of reaction.
7. summarize the reaction with the slower reaction rate	Mg ribbon will take longer to react because fewer particles are immediately available to collide, so will have a slower rate of reaction.
8. Explain that both reactions will produce the same amount of product eventually as they started with the same amount of reactants	Both reactions will eventually produce the same volume of hydrogen gas as the same amounts of each reactant are used.

NOTE: The white column is how your answer would appear on your test paper so make sure you **write out complete sentences**. The grey area is just to help you structure your answer and would not appear in the question.

Writing Excellence answers to Reaction Rate Factors – Temperature questions

Reaction Rate Factors – Temperature QUESTION

Question: A particular reaction is complete when the solution turns cloudy and the paper cross under the flask can no longer be seen. The following experiments were carried out, and the times taken for the cross to disappear recorded. Elaborate on why the reaction in Experiment 2 occurred faster than the reaction in Experiment 1.

experiment		Temperature /ºC	Time for cross to disappear
1	No Cu^{2+} present	25	42
2	No Cu^{2+} present	50	23
3	Cu^{2+} present	25	5

ANSWER

1. state the collision theory	Chemical reactions between particles of substances only occur when the following conditions have been met: Particles must collide with enough energy (called activation energy EA) and with the correct orientation. If these conditions are met, the collision will be considered successful.
2. Describe the reactants in your reaction and state which factors are the same	In the reaction of experiment 1 and experiment 2, both have no catalyst added.(we assume the concentration is also the same)
3. Describe the reactants in your reaction and state which factor is different (the factor affecting reaction rate)	The only change is an increase in temperature in Experiment 2 compared to experiment 2. An increase in temperature means a faster rate of reaction.
4. link the factor to the collision theory (activation energy)	The activation energy is the energy that is required to start a reaction. When the temperature is higher, the particles have more kinetic energy.
5. link the reaction to more of the collisions being successful occurring per unit of time	because the particles are moving with more kinetic energy, it will be more likely that when collisions occur they are more likely to be effective as a greater proportion of collisions overcome the activation energy of the reaction.
6. next link the factor to the collision theory (faster moving particles)	When the temperature is higher, the particles have more kinetic energy; the particles are moving faster
7. link the reaction to more successful collisions occurring per unit of time	Because the particles are moving faster, there will be also more frequent collisions. Experiment 2 has more effective collisions per unit of time. (than experiment 1.
8. link to more products (name products) being formed per unit of time AND link to a faster reaction rate	Experiment 2 will produce more products initially resulting in the solution turning cloudy and the cross disappearing quicker (23s compared to 42s), resulting in a faster reaction rate
9. summarize the reaction with the slower reaction rate	Experiment 1 is at a lower temperature so will take longer to react (cross to disappear) as the particles are moving slower than in experiment 1, so will have a slower rate of reaction.
10. Explain that both reactions will produce the same amount of product eventually as they started with the same amount of reactants	Both reactions will eventually produce the same amount of products if the same amounts of each reactant are used.

Writing Excellence answers to Reaction rate Factors – Catalyst questions

Reaction Rate Factors – Catalyst QUESTION	
Question: A particular reaction is complete when the solution turns cloudy and the paper cross under the flask can no longer be seen. The following experiments were carried out, and the times taken for the cross to disappear recorded. Elaborate on why the reaction in Experiment 3 occurs faster than the reaction in Experiment 1.	

experiment		Temperature /ºC	Time for cross to disappear
1	No Cu^{2+} present	25	42
2	No Cu^{2+} present	50	23
3	Cu^{2+} present	25	5

ANSWER	
1. state the collision theory	Chemical reactions between particles of substances only occur when the following conditions have been met: Particles must collide with enough energy (called activation energy EA) and with the correct orientation. If these conditions are met, the collision will be considered successful.
2. Describe the reactants in your reaction and state which factors are the same	In the reaction of experiment 1 and experiment 3, both are carried out under the same temperature. (we assume the concentration is also the same)
3. Describe the reactants in your reaction and state which factor is different (the factor affecting reaction rate)	The only change is the addition of a catalyst in Experiment 3 compared to experiment 1. An added catalyst means a faster rate of reaction.
4. link the factor to the collision theory	Particles must collide with enough energy to overcome the activation energy of the reaction. The activation energy is the energy that is required to start a reaction. When a catalyst is used, the activation energy is lowered. This is because the catalyst provides an alternative pathway for the reaction to occur in which the activation energy is lowered.
5. link the reaction to more of the collisions being successful occurring per unit of time	Now that the activation energy has been lowered, more reactant particles will collide with sufficient energy to overcome this lowered activation energy therefore more effective collisions are occurring more frequently.
6. link to more products (name products) being formed per unit of time AND link to a faster reaction rate	Experiment 3 will produce more products initially resulting in the solution turning cloudy and the cross disappearing quicker (5s compared to 42s), resulting in a faster reaction rate
7. summarize the reaction with the slower reaction rate	Experiment 1 has no catalyst so will take longer to react (cross to disappear) as less of the collisions are effective, so will have a slower rate of reaction than experiment 3.
8. Explain that both reactions will produce the same amount of product eventually as they started with the same amount of reactants	Both reactions will eventually produce the same amount of products if the same amounts of each reactant are used.

Writing Excellence answers to Reaction rate Factors – Concentration questions

Reaction Rate Factors – Concentration QUESTION

Question: The 'elephant toothpaste' demonstration shows the decomposition of hydrogen peroxide, H_2O_2, into water and oxygen gas.

$2H_2O_{2(aq)} \rightarrow 2H_2O_{(l)} + O_{2(g)}$

This reaction can be observed by adding detergent to the hydrogen peroxide solution. As oxygen gas is produced, the detergent foams up, as seen in the photograph on the right. The time taken for the foam to reach the top of the measuring cylinder can be used to measure the rate of the reaction.

Three experiments were carried out to investigate factors that change the rate of the reaction.

Compare Experiment 3 with Experiment 1.

In your answer, you should:

• identify the factor being changed, and the effect this will have on the rate of reaction

• explain the effect on the rate of reaction by referring to the collision of particles and activation energy, where appropriate.

Experiment	Concentration of H_2O_2	Temperature °C	Presence of small amount of MnO_2
1	20%	20	yes
2	20%	30	yes
3	30%	20	yes

ANSWER

1. state the collision theory	Chemical reactions between particles of substances only occur when the following conditions have been met: Particles must collide with enough energy (called activation energy EA) and with the correct orientation. If these conditions are met, the collision will be considered successful.
2. Describe the reactants in your reaction and state which factors are the same	The reactants are hydrogen peroxide, temperature and presence of a catalyst are the same in experiments 1 and 3
3. Describe the reactants in your reaction and state which factor is different (the factor affecting reaction rate)	the concentration of hydrogen peroxide has been increased in experiment 3 compared to experiment 1
4. link the factor to the collision theory	This will increase the rate of reaction in experiment 3 because there are more hydrogen peroxide molecules per unit volume.
5. link the reaction to more of the collisions being successful occurring per unit of time	This means there will be more frequent collisions in a given time due to having more reactant particles available to collide.
6. link to more products (name products) being formed per unit of time AND link to a faster reaction rate	This will increase the rate of decomposition of the hydrogen peroxide, leading to a faster reaction rate for experiment 3 compared to experiment 1
8. Explain that both reactions will produce the same amount of product eventually as they started with the same amount of reactants	If both experiment 1 and 3 started with the same amount of reactants then they will both finish with the same amount of products formed, just at different times.

NOTE: The white column is how your answer would appear on your test paper so make sure you **write out complete sentences**. The grey area is just to help you structure your answer and would not appear in the question.

Writing Excellence answers to Equilibrium Expression questions

Equilibrium Expression QUESTION
Question: The following chemical equation represents a reaction that is part of the Contact Process, which produces sulfuric acid. $2SO_{2(g)} + O_{2(g)} \leftrightarrow 2SO_{3(g)}$ $\Delta H = -200$ kJ mol^{-1}, $Kc = 4.32$ at 600°C (i) Write an equilibrium constant expression for this reaction. (ii): A reaction mixture has the following concentration of gases at 600°C: $[SO2_{(g)}] = 0.300$ mol L^{-1} $[O2_{(g)}] = 0.100$ mol L^{-1} $[SO3_{(g)}] = 0.250$ mol L^{-1} Justify why this reaction mixture is not at equilibrium, using the equilibrium expression and the data provided

ANSWER	
1. Write out the equilibrium constant expression in full $K_c = \frac{[C]^c \times [D]^d}{[A]^a \times [B]^b}$ Given $aA + bB \rightleftharpoons cC + dD$	$2SO_{2(g)} + O_{2(g)} \leftrightarrow 2SO_{3(g)}$ $K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$
2. Calculate the Q value by inserting all of the [ ] data given. Show working and remember order of operation and 3sgf Final value will have no units	$Q = \frac{0.250^2}{0.300^2 \times 0.100} = 6.94$
3. Write down the Kc value and compare with the Q value stating whether it is equal or not (and therefore is or is not at equilibrium)	Since $K_c = 4.32$, $Q \neq K_c$, so this reaction mixture is not at equilibrium.
4. Link the Q value as either being bigger (and lying to the products side as the numerator is greater) OR as being smaller (and lying to the reactants side as the numerator is smaller)	This number is greater than the K_c value, 4.32, which indicates that the reaction lies to the products side as the larger the K_c or Q value, the greater the numerator (products).

Writing Excellence answers to Equilibrium - Pressure questions

Equilibrium – Pressure QUESTION

Question: The two reactions shown in the following table are both at equilibrium.
Compare and contrast the effect of increasing the pressure on both reactions, with reference to the equilibrium positions.

Reaction	Equation	Affected by increased pressure
One	$H_{2(g)} + I_{2(g)} \rightarrow 2HI_{(g)}$	no
Two	$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$	yes

ANSWER

1. State the equilibrium principle	When a change is made to a system that is at equilibrium, the system responds to reduce the effect of that change.
2. Describe the factor in your question AND Link increasing the principle to how the system responds [some questions will be decreasing]	The factor in the question above is pressure. If there is an increase in pressure, the system responds by decreasing the pressure.
3. Generally, explain which side of the equation is favoured (relate to moles) AND the general observations – at visible and particle level.	This occurs by favouring the reaction, either forward or reverse direction, that produces fewer gas particles. Because there are now fewer particles hitting the sides of the container, there is less pressure.
4. Specifically, in <u>reaction one</u> describe number of moles in both sides of the equation AND link to which direction of reaction would be favoured (and observation)	In <u>Reaction One</u> there are two moles of gas particles on each side of the equation. Because there are the same numbers of gas particles on both sides of the reaction, then a change in pressure will have no effect as neither reaction will be favoured.
5. Specifically, in <u>reaction two</u> link number of moles in both sides of the equation to observation AND link to which direction of reaction would be favoured	In <u>Reaction Two</u> however, there are four moles of gas particles on the reactant side of the equation and two moles of gas particles on the product side of the equation. Therefore, when there is an increase in pressure, the system would shift and favour the forward reaction
6. Describe how the system shift in <u>reaction two</u> would effect at particle level AND final observation.	meaning there are now fewer gas particles overall and hence fewer gas particles hitting the sides of the container and therefore less pressure overall.

Writing Excellence answers to Equilibrium – Temperature questions

Equilibrium – Temperature QUESTION

Question: In a reaction, the brown gas nitrogen dioxide, $NO_{2(g)}$, exists in equilibrium with the colourless gas dinitrogen tetroxide, $N_2O_{4(g)}$. The equation for this reaction is represented by:

$2NO_{2(g)}$ ↔ $N_2O_{4(g)}$

brown gas colourless gas

The table below shows the observations when changes were made to the system. Analyse these experimental observations.

In your answer you should:

• link all of the observations to equilibrium principles

• justify whether the formation of dinitrogen tetroxide from nitrogen dioxide is endothermic or exothermic.

Change		**Observations**
Pressure	increased (by decreasing the volume of the container)	Colour faded
	decreased (by increasing the volume of the container)	Colour darkened
Temperature	container with reaction mixture put into hot water	Colour darkened
	container with reaction mixture put into ice water	Colour faded

ANSWER

1. State the equilibrium principle	When a change is made to a system that is at equilibrium, the system responds to reduce the effect of that change.
2. Describe the factor in your question AND Link the principle to how the system responds to cooling or heating	The factor in the question above is temperature. If there is an increase in temperature, the system responds by absorbing more (heat) energy. If there is a decrease in temperature, the system responds by releasing more (heat) energy.
3. Generally, explain which side of the equation is favoured (relate to endothermic or exothermic)	With Heating (increasing temperature) this occurs by favouring the reaction, either forward or reverse direction, that is endothermic. With cooling (decreasing temperature) this occurs by favouring the reaction, either forward or reverse direction, that is exothermic.
4. Specifically, for your reaction with <u>heating</u>, link the observation to which direction of reaction would be favoured (endothermic or exothermic)	With heating In this case, the colour darkened, indicating that this favoured the reverse reaction, which must be the endothermic direction.
5. Describe how the system shift in <u>heating</u> would affect which products are made AND final observation.	So more $2NO_{2(g)}$, nitrogen dioxide, which is a brown gas, would be formed and there would be less $N_2O_{4(g)}$ dinitrogen tetroxide, which is a colourless gas
6. Specifically, for your reaction with <u>cooling</u>, link the observation to which direction of reaction would be favoured (endothermic or exothermic)	With cooling In this case, the colour lightened, indicating that this favoured the forward reaction, which must be the exothermic direction.
7. Describe how the system shift in <u>cooling</u> would affect which products are made AND final observation.	So more $N_2O_{4(g)}$ dinitrogen tetroxide, which is a colourless gas would be formed and there would be less $2NO_{2(g)}$, nitrogen dioxide, which is a brown gas,

Writing Excellence answers to Equilibrium - Concentration questions

Equilibrium – Concentration QUESTION
Question: When acid is added to a yellow solution of chromate ions, $CrO_4^{2-}(aq)$, the following equilibrium is established. $2CrO_4^{2-}(aq) + 2H^+(aq) \leftrightarrow Cr_2O_7^{2-}(aq) + H_2O(l)$ yellow orange Analyse this equilibrium using equilibrium principles to explain the effect on the colour of the solution when: (i) more dilute acid is added AND when (ii) dilute base is added:

ANSWER	
1. State the equilibrium principle	When a change is made to a system that is at equilibrium, the system responds to reduce the effect of that change.
2. Describe the factor in your question AND Link the principle to how the system responds to increasing or decreasing concentration of reactants	The factor in the question above is concentration of reactants. If there is an increase in concentration of reactants, the system responds by increasing the rate products are made. If there is a decrease in concentration of reactants, the system responds by decreasing the rate products are made.
3. Generally, explain which side of the equation is favoured (relate to reactants or products) by increasing or decreasing concentration	An increase in concentration of reactants favours the forward reaction, and a decrease in concentration of reactants favours the reverse reaction.
4. Specifically, for your reaction explain how you are increasing the concentration of reactants, AND link the direction of reaction that would be favoured	Adding dilute acid increases the concentration of the acid, one of the reactants, so the reaction moves in the forward direction and favours the products, therefore it will increase the rate that the added acid is 'used up'
5. Describe how the system shift by increasing the concentration of reactants would affect which substances are made AND final observation.	More $Cr_2O_7^{2-}(aq)$ would be produced and the solution would turn more orange.
6. Specifically, for your reaction explain how you are decreasing the concentration of reactants, AND link the direction of reaction that would be favoured	Adding base means that acid that reacts with the base is removed from the equilibrium (by neutralisation) and the concentration of the acid decreases. This will drive the equilibrium in the backwards direction and this favours the reactants to increase the rate of replacing the H^+ "used up"
7. Describe how the system shift by decreasing the concentration of reactants would affect which substances are made AND final observation.	More $CrO_4^{2-}(aq)$, would be produced and the solution would turn more yellow.

Writing Excellence answers to pH and Conductivity questions

pH and Conductivity QUESTION

Question: Some properties of three aqueous solutions A, B and C, of equal concentration are shown in the table below. It is known that the solutions are $NH_{3(aq)}$, $HCl_{(aq)}$ and $NH_4Cl_{(aq)}$
Justify the identification of all three solutions.
• refer to both pH and electrical conductivity of the solutions
• link your answers to appropriate chemical equations.

Solution	A	B	C
pH	5.15	11.6	1.05
Electrical conductivity	good	poor	good

ANSWER

1. Identify each solution as either A, B or C by linking to being a weak or strong acid or base and also to the pH	Solution A with a pH of 5.15 is a weak acid (salt) and is $NH_4Cl_{(aq)}$ Solution B with a pH of 11.6 is a weak base and is $NH_{3(aq)}$ Solution C with a pH of 1.05 is a strong acid and is $HCl_{(aq)}$
2. State requirements for conductivity	In order to conduct electricity there needs to be the presence of free moving charged particles. The more charged particles there are available the better conductivity there will be. Ions in solution provide the charged particle.
3. Solution A (pH 5.15) weak acid salt. Equation 1. [A salt will first dissociate fully into ions] Write equation AND link ions formed to conductivity and level of dissociation	$NH_4Cl \rightarrow NH_4^+ + Cl^-$ $NH_4Cl_{(aq)}$ is solution A: good conductor of electricity – it fully dissociates in solution into ammonium and chloride ions, which conduct electricity.
4. Solution A (pH 5.15) weak acid salt. Equation 2.[One of the products of dissociation will further react as an acid] Write equation AND link ions formed to conductivity and level of dissociation (must form H_3O^+ ions)	$NH_4^+ + H_2O \rightarrow NH_3 + H_3O^+$ Its pH (5.15) is that of a weak acid, as the ammonium ion is a weak acid and partially dissociates in water, producing hydronium ions.
5. Solution B (pH 11.6) weak base. Write equation AND link ions formed to conductivity and level of dissociation (must form OH^- ions)	$NH_3 + H_2O \rightarrow NH_4^+ + OH$ $NH_{3(aq)}$ is solution B: its pH (11.6) is that of a weak base as NH_3 so it partially dissociates in water, producing hydroxide ions. It is a poor conductor of electricity as it is only partially dissociated into ions in water. The remaining NH_3 molecules are neutral and do not conduct electricity.
6. Solution C (pH 1.05) strong acid. Write equation AND link ions formed to conductivity and level of dissociation (must form H_3O^+ ions)	$HCl + H_2O \rightarrow H_3O^+ + Cl^-$ $HCl_{(aq)}$ is solution C: low pH (1.05) is that of a strong acid, HCl fully dissociates in water, producing hydronium ions. It is a good conductor of electricity as it fully dissociates into ions in solution which conduct electricity.

Writing Excellence answers to Reaction Rates of Acids questions

Reaction Rates of Acids QUESTION
Question: The pH values of 0.100 mol L^{-1} solutions of two acids, HA and HB, are given in the table below. (i) Compare the relative strengths of the two acids, $HA_{(aq)}$ and $HB_{(aq)}$, using the information given above. Your answer should include equations and calculations. (ii) Predict and compare, with reasons, what would be observed when two 5 g samples of calcium carbonate chips, $CaCO_{3(s)}$, are reacted, separately, with excess HA and HB.

Solution	pH
0.100 mol L^{-1} HA(*aq*)	1.0
0.100 mol L^{-1} HB(*aq*)	2.2

ANSWER	
1. Write an equation for <u>HA</u> [Remembering H_3O^+ must be produced]	$HA + H_2O \rightarrow A^- + H_3O^+$
2. Calculate H_3O^+ for <u>HA</u> $[H_3O^+] = 10^{-pH}$	pH = 1.0 $[H_3O^+]$ = 0.100 mol L^{-1}
3. For HA link concentration of ions formed to level of dissociation AND compare to concentration of acid (are they the same?)	HA is a strong acid since it fully dissociates, as shown by concentration of hydronium ions in HA solution – same as original concentration of HA (both 0.100 mol L^{-1}).
4. Write an equation for <u>HB</u> [Remembering H_3O^+ must be produced]	$HB + H_2O \rightleftharpoons B^- + H_3O^+$
5. Calculate H_3O^+ for <u>HB</u> $[H_3O^+] = 10^{-pH}$	pH = 2.2 $[H_3O^+]$ = 0.00631 mol L^{-1}
6. For HB link concentration of ions formed to level of dissociation AND compare to concentration of acid (are they the same?)	HB is a weak acid since it only partially dissociates; as shown by the concentration of hydronium ions in HB solution – concentration is only 0.00631 mol L^{-1}.
7. For HA link observation of reaction to concentration of ions	Expect reaction to be more vigorous; rapidly produces gas / bubbles (CO_2) – since the concentration of hydrogen ions is high,
8. then For HA link collision frequency to rate of reaction	there will be more frequent collisions resulting in a faster rate of reaction.
9. For HB link observation of reaction to concentration of ions	Expect a slower reaction, taking longer to produce the same volume of gas – since the concentration of hydrogen ions is low,
10. then For HB link collision frequency to rate of reaction	there will be less frequent collisions resulting in a slower rate of reaction.

Writing Excellence answers to pH Calculations questions

pH calculations QUESTION 1	
Question: In a solution of potassium hydroxide, KOH, the pH is found to be 12.8. (i) Calculate the hydronium ion concentration, $[H_3O^+]$, and the hydroxide ion concentration, $[OH^-]$, in the solution. $K_w = 1 \times 10^{-14}$ (ii) Calculate the pH of a 2.25×10^{-4} mol L^{-1} sodium hydroxide, NaOH, solution.	
ANSWER	
STEP 1. Calculate H_3O^+ for KOH $[H_3O^+] = 10^{-pH}$ (units and 3sgf)	$[H_3O^+] = 10^{-pH}$ $[H_3O^+] = 1.58 \times 10^{-13}$ molL^{-1}
STEP 2. Calculate OH^- for KOH $[OH^-] = K_w / [H_3O^+]$ ($K_w = 1 \times 10^{-14}$) (units and 3sgf)	$[OH^-] = K_w / [H_3O^+]$ $[OH^-] = 0.0633$ molL^{-1}
STEP 1. Calculate pOH for NaOH $pOH = -\log[OH^-]$ (3sgf)	$pOH = -\log[OH^-]$ $pOH = 3.60$
STEP 2. Calculate pH for NaOH pH = 14 - pOH (3sgf)	pH = 14 - pOH pH = 14 - 3.60 pH = 10.4
pH calculations QUESTION 2	
Question: (i) A solution of nitric acid, $HNO_{3(aq)}$, has a hydronium ion, H_3O^+, concentration of 0.0243 mol L^{-1}. Determine, by calculation, the pH and the concentration of hydroxide ions, OH^-, in this solution. $K_w = 1 \times 10^{-14}$ (ii) Determine the hydroxide ion concentration, $[OH^-]$, of a solution of potassium hydroxide, $KOH_{(aq)}$, with a pH of 11.8.	
ANSWER	
STEP 1. Calculate pH for HNO_3 $pH = -\log[H_3O^+]$ (3sgf)	$pH = -\log[H_3O^+]$ pH = 1.61
STEP 2. Calculate OH^- for HNO_3 $[OH^-] = K_w / [H_3O^+]$ ($K_w = 1 \times 10^{-14}$) (units and 3sgf)	$[OH^-] = K_w / [H_3O^+]$ $[OH^-] = 4.12 \times 10^{-13}$ molL^{-1}
STEP 1. Calculate H_3O^+ for KOH $[H_3O^+] = 10^{-pH}$ (units and 3sgf)	$[H_3O^+] = 10^{-pH}$ $[H_3O^+] = 1.58 \times 10^{-12}$ molL^{-1}
STEP 2. Calculate OH^- for KOH $[OH^-] = K_w / [H_3O^+]$ ($K_w = 1 \times 10^{-14}$) (units and 3sgf)	$[OH^-] = K_w / [H_3O^+]$ $[OH^-] = 6.31 \times 10^{-3}$ molL^{-1}